Introduction to Neural Networks

Agenda

- Neural Networks Quiz
- Deep Learning vs Machine Learning
- Neural Network Architecture
- Activation Functions
- Loss Functions
- Gradient Descent and Backpropagation

Let's begin the discussion by answering a few questions on neural networks

Neural Networks Quiz

Which of the following statements are true about Deep Learning in general?

A. In Deep Learning, feature extraction is performed manually, and in Machine Learning it is performed automatically

B. In Deep Learning, feature extraction is performed automatically, and in Machine Learning it is performed manually

C. Deep Learning models are typically less interpretable when compared to Machine Learning models

D. Deep Learning requires comparatively less computational power than Machine Learning

Neural Networks Quiz

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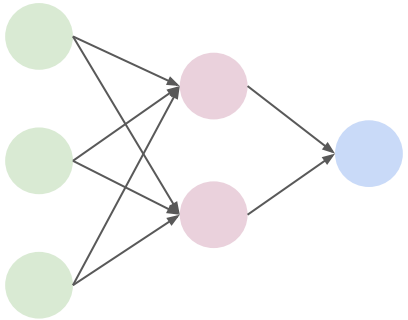
Deep Learning vs Machine Learning

Machine Learning	Deep Learning
Requires manual feature extraction and selection	Automatically does feature extraction
Less effective when working with unstructured data	More effective when working with unstructured data
Requires comparatively less computational power and memory	Requires comparatively more computational power and memory *
Are generally more interpretable	Are generally less interpretable

* Depends on the neural network architecture

Neural Networks Quiz

How many parameters (including bias) will be trained in a fully connected neural network architecture shown below?



A. 8

B. 11

C. 6

D. 9

Neural Networks Quiz

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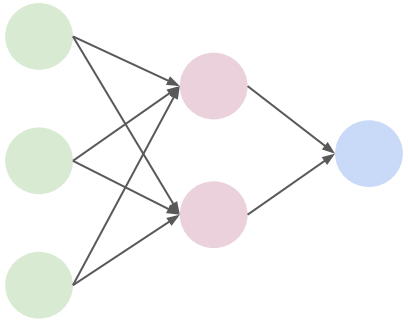

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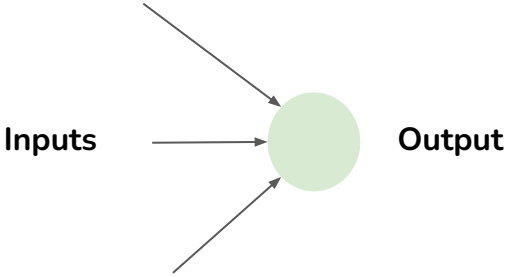
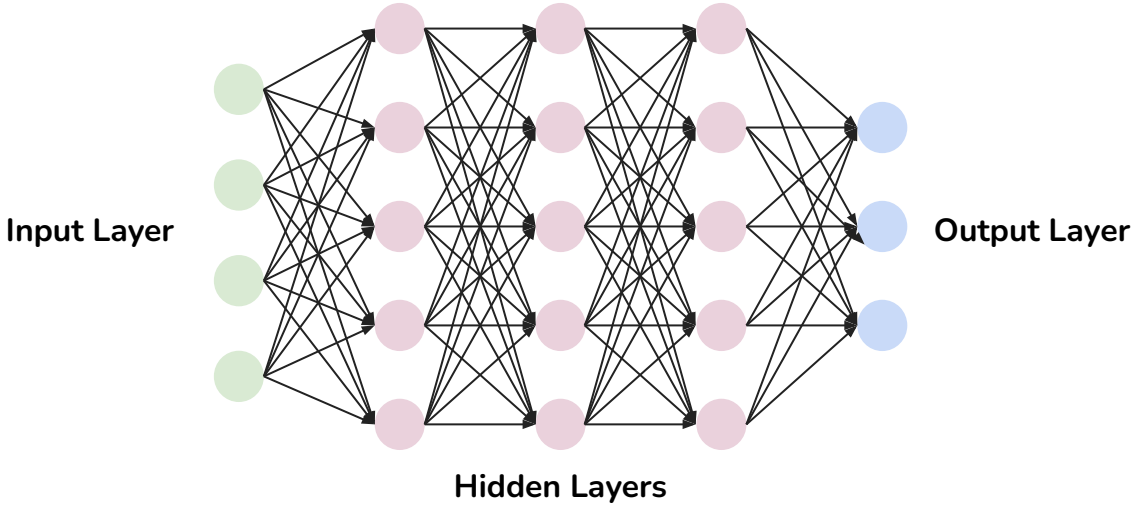
Neural Network

A neural network architecture comprising interconnected input, hidden, and output layers, facilitating the learning of complex relationships between input and output data

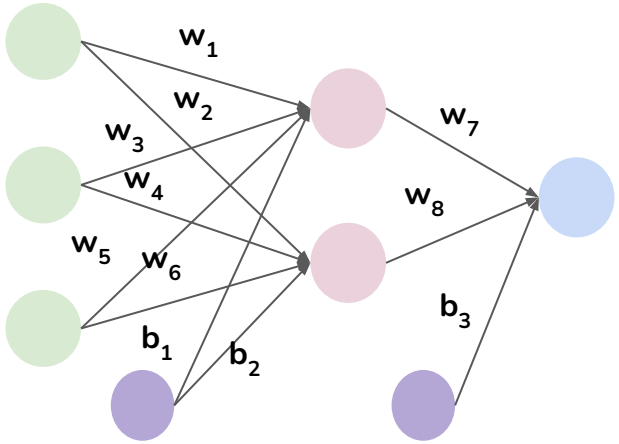


Neuron



Neural Network

Neural Network Architecture



Input Layer x Hidden Layer: 3 neurons of input layer connected to 2 neurons in the hidden layer | 3 x 2 = 6 connections, i.e., 6 weight parameters | 1 bias parameter for each neuron in the hidden layer | 6 + 2 = 8 parameters in total between input and hidden layers

Hidden Layer x Output Layer: 2 neurons of hidden layer connected to 1 neuron in the output layer | 2 x 1 = 2 connections, i.e., 2 weight parameters | 1 bias parameter for the neuron in the output layer | 2 + 1 = 3 parameters in total between hidden and output layers

So, we have a total of 11 parameters.

Neural Networks Quiz

What is the purpose of an activation function in a neural network?

A. To compute the gradient of the loss function during backpropagation.

B. To regulate the magnitude of weights and biases in the network.

C. To introduce non-linearity into the network, enabling it to learn complex patterns.

D. To normalize the input data before feeding it into the neural network.

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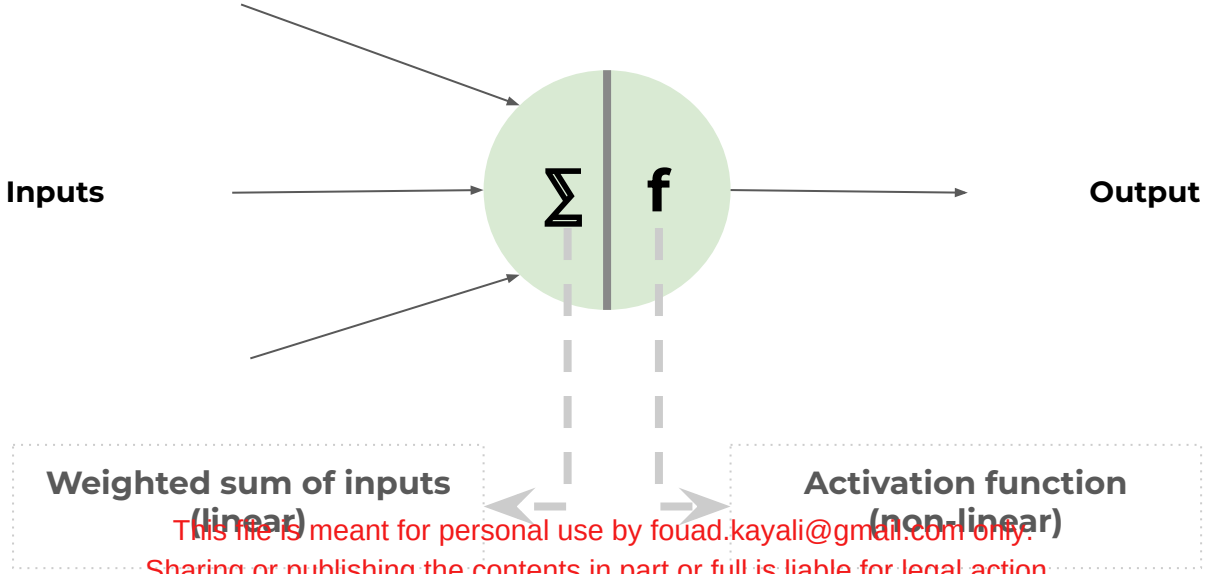
Activation Function

Determines the output of a neuron based on the input

Introduces non-linearity and enables the neural network to learn complex patterns in the data



Neural Networks Quiz

Which of the following activation functions can be used in a hidden layer?

A. Sigmoid

B. TanH

C. ReLU

D. Leaky ReLU

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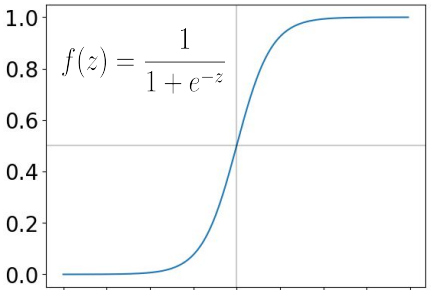
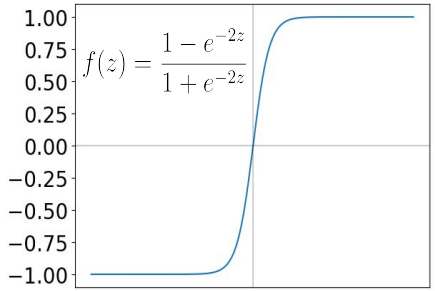
Activation Functions for Hidden Layers

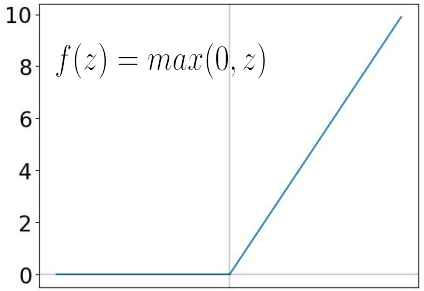
Sigmoid



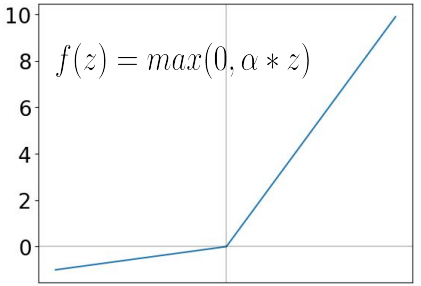
Tanh



ReLU



Leaky ReLU



Neural Networks Quiz

Consider a neural network built to predict whether a student will pass or fail in an exam. Which of the following activation functions would be most appropriate to use in the output layer?

A. Sigmoid

B. Softmax

C. Linear

D. Leaky ReLU

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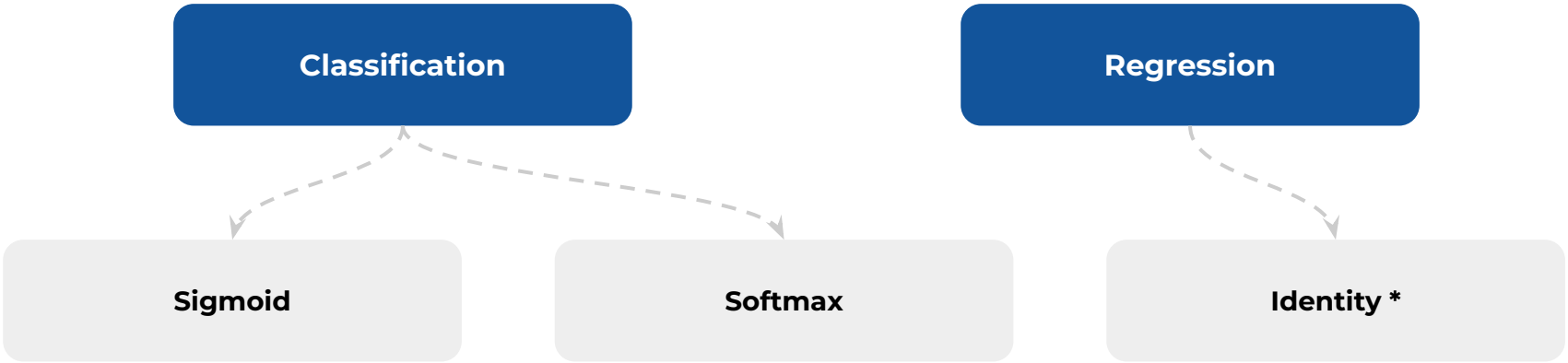
Activation Functions for Output Layer



$$f(z) = \frac{1}{1 + e^{-z}} \qquad f(z_i) = \frac{e^{z_i}}{\sum_{j=1}^{K} e^{z_j}} \quad for\ i = 1, 2, \ldots, K \qquad f(z) = z$$

* This means no activation is applied in the output layer

Neural Networks Quiz

Which of the following statements best describes the role of a loss function in training a neural network?

A. The loss function adjusts the learning rate during training

B. The loss function measures the accuracy of the model's predictions compared to the true labels

C. The loss function initializes the weights and biases of the neural network

D. The loss function measures the accuracy of the model

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Loss Functions

In training a neural network, the loss function plays a critical role in evaluating how well the model is performing by measuring the difference between the predicted output of the model and the actual target output (true labels).

Regression

Mean Squared Error

$$\sum_{i=1}^{D}(x_i - y_i)^2$$

Classification

Cross-Entropy Loss

$$-\sum_{c=1}^{M} y_{o,c}\log(p_{o,c})$$

Neural Networks Quiz

Which of the following describes the learning rate in gradient descent?

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B. The magnitude of the gradient

C. The step size for each iteration

D. The number of iterations required for convergence

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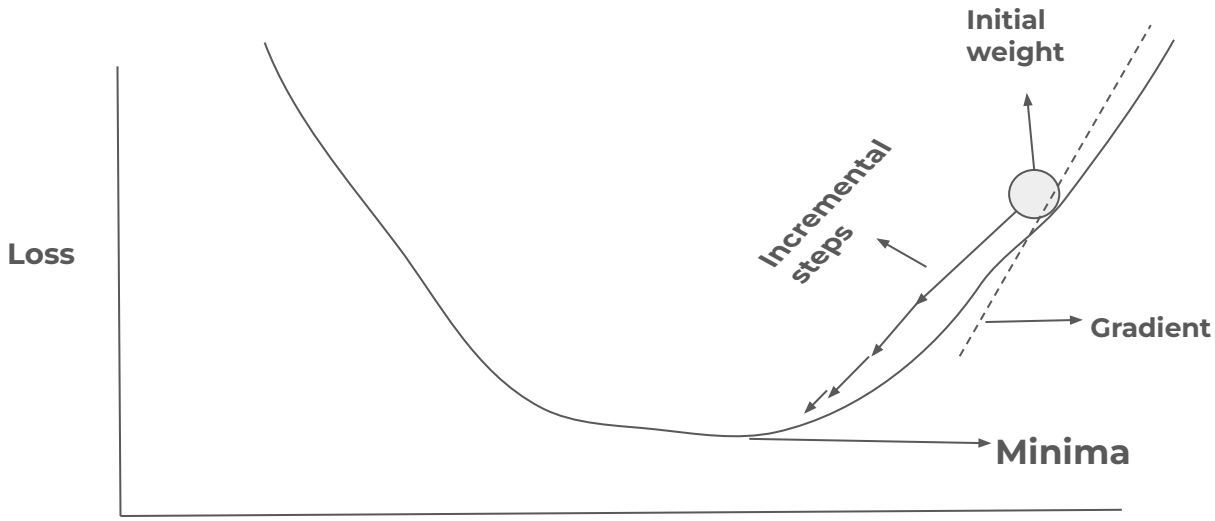
Gradient Descent

An **optimization algorithm** used to minimize the loss function

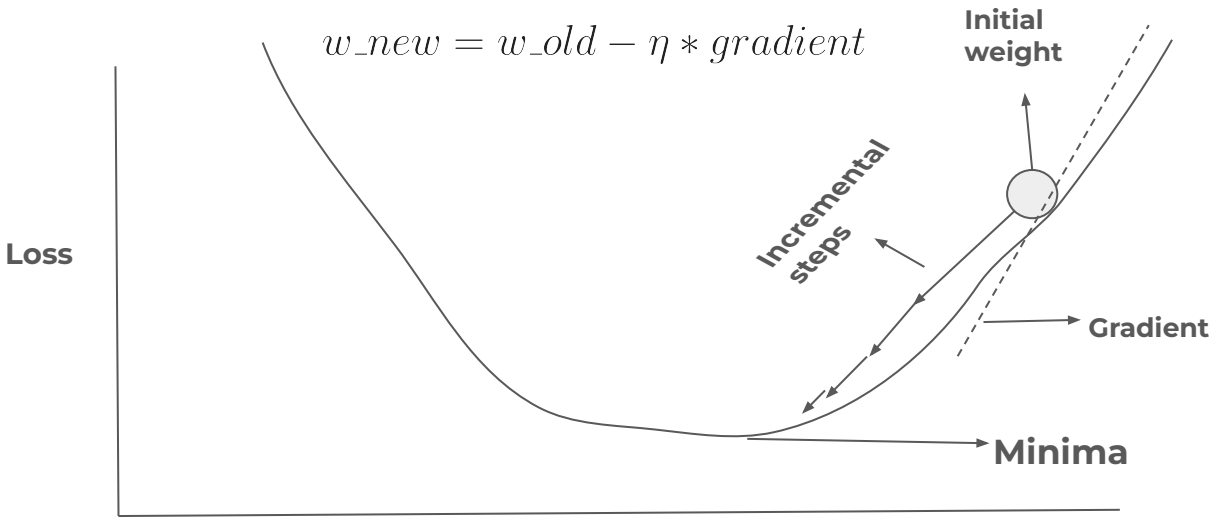
Adjusts model parameters iteratively in the direction of steepest descent of the gradient



Learning Rate

How big a step to take? => Decided by the **learning rate**

Smaller the learning rate, smaller the step



Neural Networks Quiz

During backpropagation, which of the following parameters of the model gets updated?

A. Input layer parameters

B. Output layer parameters

C. Hidden layer parameters

D. All the model parameters

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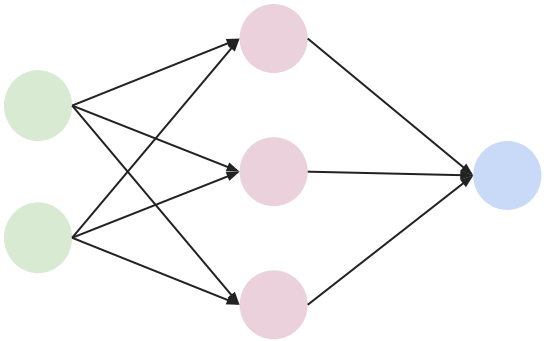
Backpropagation

An **algorithm** used to efficiently compute gradients of the loss function with respect to model parameters



Input layer Hidden layer Output layer

Forward Propagation

Gradient of error is calculated with respect to each weight

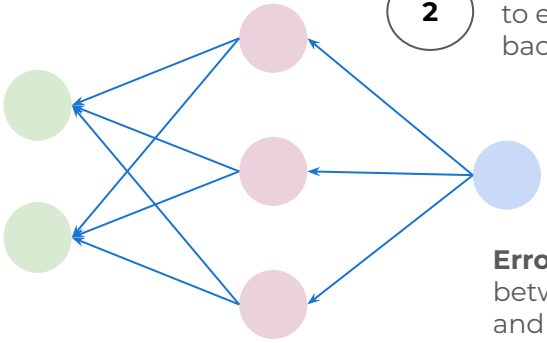
3

2

Error is sent back to each neuron in backward direction

1

Error - difference between predicted and actual output



Input layer Hidden layer Output layer

Backpropagation

Great Learning

Happy Learning !