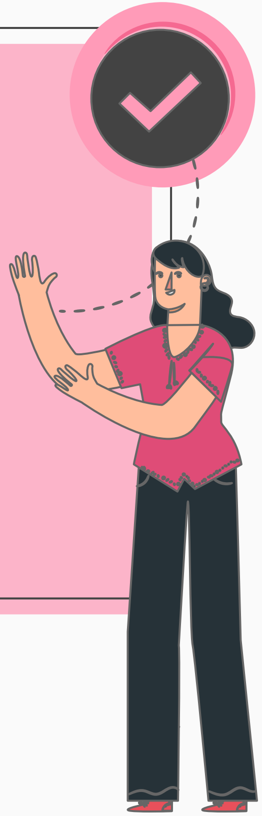
ACTIVATION FUNCTIONS



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ACTIVATION FUNCTION

An activation function is a **nonlinear function** applied by a neuron to introduce non-linear properties in the network.

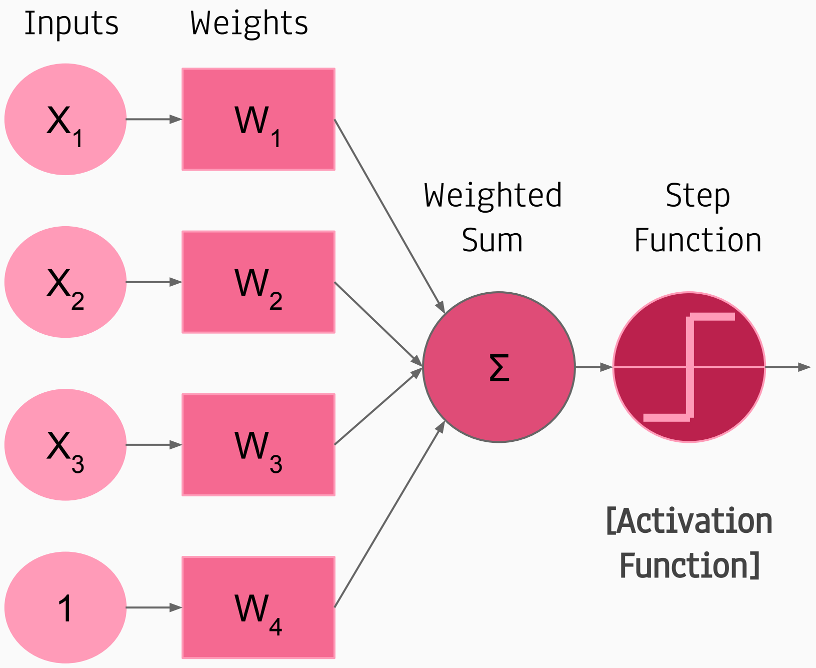
The activation functions basically decide whether the certain neuron should be activated or not.

The choice of activation function in the hidden layer controls *how well the network model learns the training dataset*.

The choice of activation function in the output layer will define the *type of predictions* the model can make.

All hidden layers typically use the same activation function.

The output layer will typically use a different activation function from the hidden layers and is dependent upon the type of prediction required by the model.

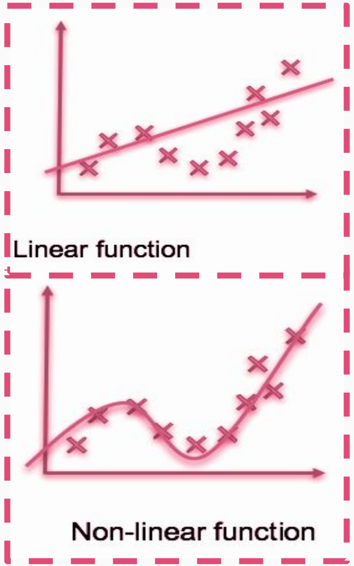


LINEAR VS NONLINEAR RELATIONSHIP

LINEAR RELATIONSHIP

In a linear relationship, a change in the first variable corresponds to a constant change in the second variable.

- A straight-line function
- Values can get very large
- The linear function alone doesn't capture complex patterns



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NONLINEAR RELATIONSHIP

In a non-linear relationship, the first variable doesn't necessarily correspond with a constant change in the second. However, they may impact each other but it appears to be unpredictable.

- A nonlinear function can capture more complex patterns.
- Output values are bounded, so that they don't get too large.
- Can suffer from "vanishing gradient".

Vanishing gradient? – For very low values of input X, there is almost no change to the prediction, causing a vanishing gradient problem. This can result in the network refusing to learn further or being too slow to reach an accurate prediction.

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ACTIVATION LAYERS

FOR HIDDEN LAYERS

The most commonly used activation layer for hidden layers are -

Rectified Linear Activation (ReLU)
Logistic (Sigmoid)
Hyperbolic Tangent (Tanh)

Multilayer Perceptron: ReLU
Convolutional Neural Network: ReLU
Recurrent Neural Network: Tanh and/or Sigmoid

FOR OUTPUT LAYERS

The most commonly used activation layer for output layers are -

Linear
Logistic (Sigmoid)
Softmax

REGRESSION

One node, linear activation

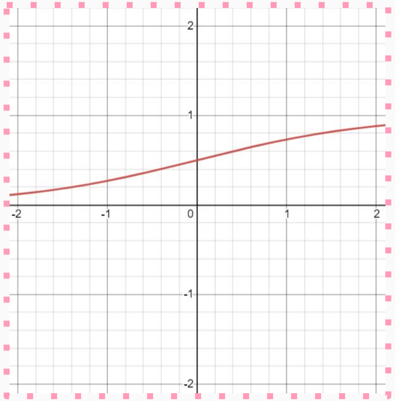
CLASSIFICATION

Binary Classification: One node, sigmoid activation.
Multiclass Classification: One node per class, softmax activation.
Multilabel Classification: One node per class, sigmoid activation.

ACTIVATION FOR HIDDEN LAYERS

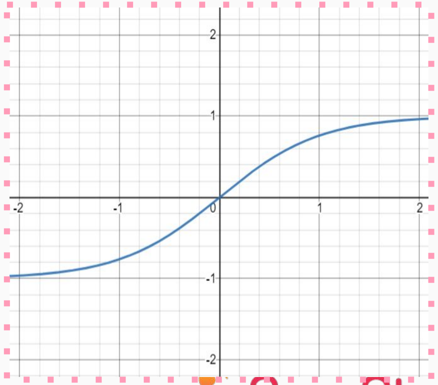
LOGISTIC (SIGMOID)

- Uses: Can be used for hidden layers but mostly used for output layers of a binary classification, where result is either 0 or 1. Value for sigmoid function lies between 0 and 1, result can be predicted to be 1 if value is greater than 0.5 and 0 otherwise.
- Value Range: 0 to 1
- Nature: Non-linear. Notice that X values lies between -2 to 2, Y values are very steep. This means, small changes in x would also bring about large changes in the value of Y.
- Smooth gradient, preventing “jumps” in output values.



HYPERBOLIC TANGENT (TANH)

- Uses: In hidden layers, as an activation function.
- Value Range: Output values bound between -1 and 1.
- Nature: A nonlinear function.
- Zero centered– Usually used in hidden layers of a neural network as its values lie between -1 to 1 hence the mean for the hidden layer comes out be 0 (or very close to 0) and helps in centering the data by bringing mean close to 0. *This makes learning easier to the model inputs that have strongly negative, neutral, and strongly positive values.*



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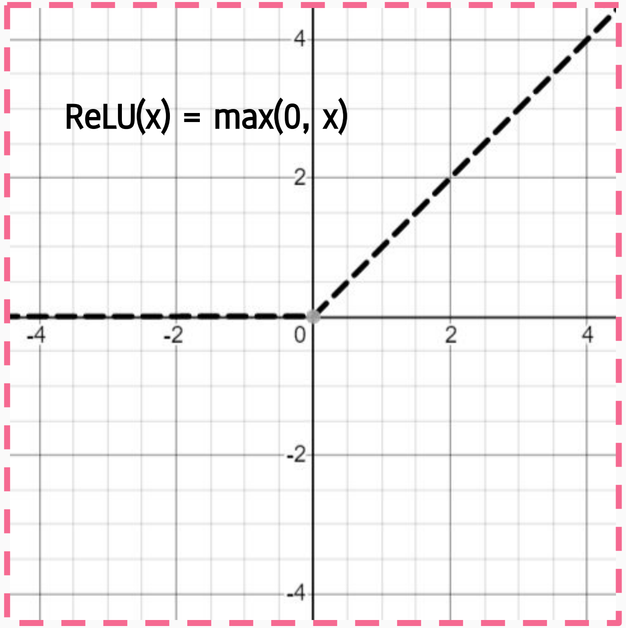
ACTIVATION FOR HIDDEN LAYERS - RELU

RECTIFIED LINEAR ACTIVATION (RELU)

It is the most widely used activation function. Mainly implemented in hidden layers of neural network

- Value Range: $[0, \infty)$
- Nature: non-linear, which means we can easily backpropagate the errors and have multiple layers of neurons being activated by the ReLU function.
- Uses:
    - ReLU is less computationally expensive than tanh and sigmoid because it involves simpler mathematical operations.
    - At a time only a few neurons are activated because of the characteristic of output 0 for negative values of input. This makes the network sparse (the strong activation of a relatively small set of neurons) making it efficient and easy for computation.
    - ReLU learns much faster than sigmoid and Tanh function.

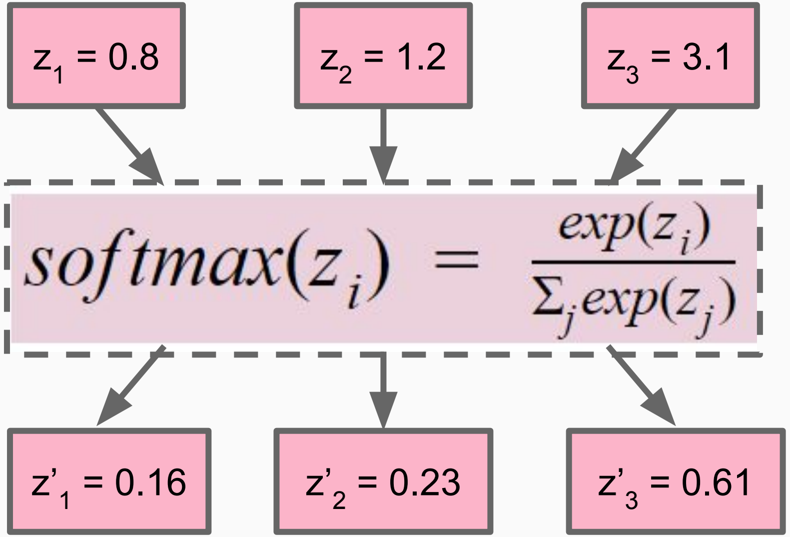


ACTIVATION FOR OUTPUT LAYERS: SOFTMAX

SOFTMAX

The softmax function is also a type of sigmoid function and is handy when we are trying to handle classification problems.

- Value Range: [0, 1]
- Nature: non-linear
- Uses:
  - The softmax function is ideally used in the output layer of the classifier where we are actually trying to attain the probabilities to define the class of each input.
  - The softmax function would squeeze the outputs for each class between 0 and 1 and would also divide by the sum of the outputs.
  - Usually used when trying to handle multiple classes.



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RELATION BETWEEN ACTIVATION FUNCTION WITH LOSS FUNCTION

PROBLEM TYPE	OUTPUT TYPE	FINAL ACTIVATION FUNCTION	LOSS FUNCTION
Regression	Numerical value	Linear	Mean Squared Error [MSE]
Classification	Binary outcome	Sigmoid	Binary Cross Entropy
Classification	Single label, multiple classes	Softmax	Cross Entropy
Classification	Multiple label, multiple classes	Sigmoid	Binary Cross Entropy

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