Introduction to Neural Networks

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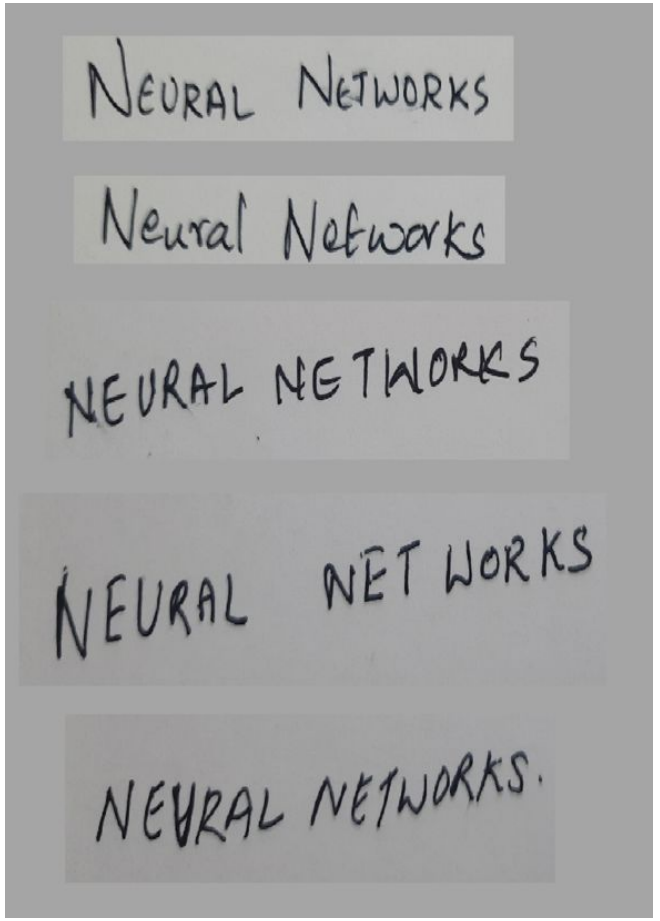
Introduction

Have a good look at the image. What do you observe?

- Five different styles are used to write the words "Neural Networks"
- Five different people may have contributed to it or a single person could have done it in five different ways.



- Humans are able to interpret different writing styles because we operate on a highly interconnected, complex set of neurons that supports our reading, eating, breathing, etc

Introduction

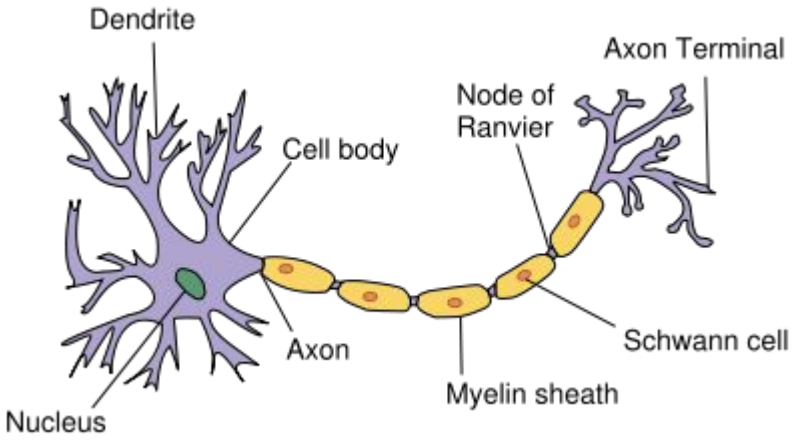
- In order for computers to mimic us, they must be provided with software implementations of the neuronal structure of our brains

- This software is commonly known as Artificial Neural Networks (ANN)

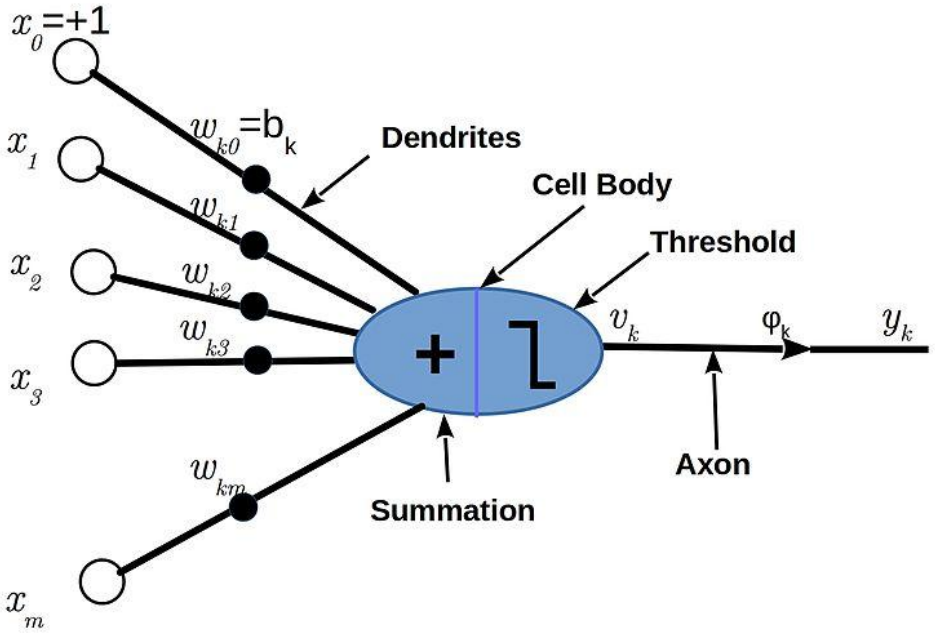
- Our discussion will cover the principles of ANNs, their structure, and how they work

Biological Neuron Vs Artificial Neuron

Biological Neuron



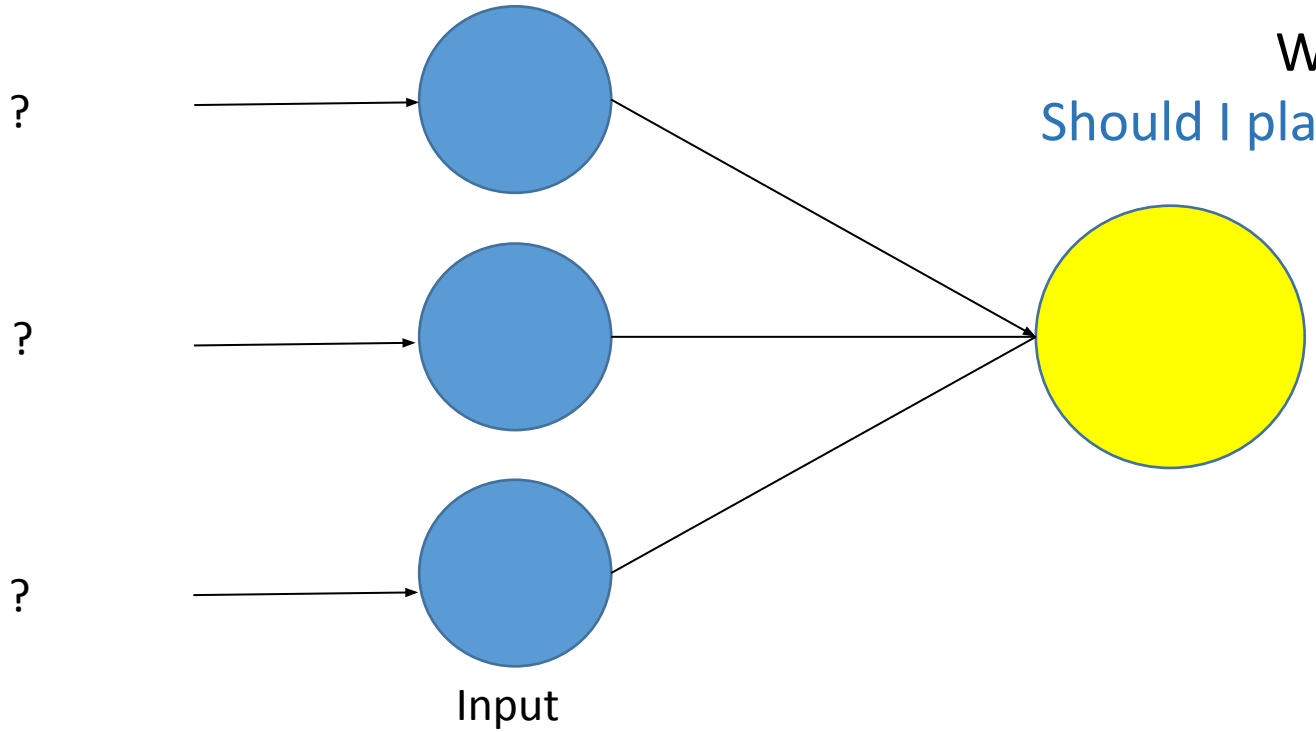
Artificial Neuron



Weights

Neurons each have their own weight, which determines how strongly they affect each other.

Let’s consider the following example –



What would you consider when deciding -
Should I play football right now ?

Weights

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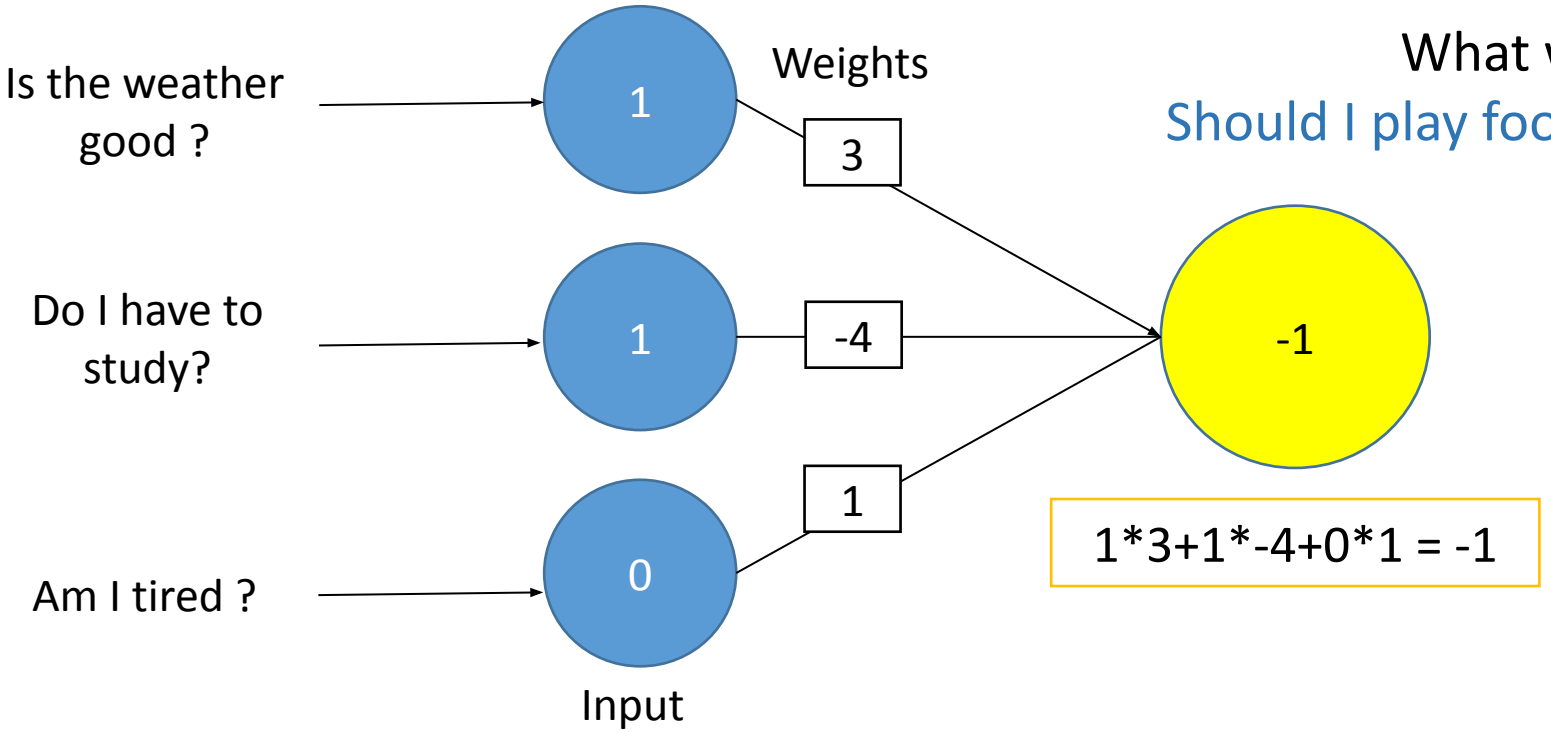
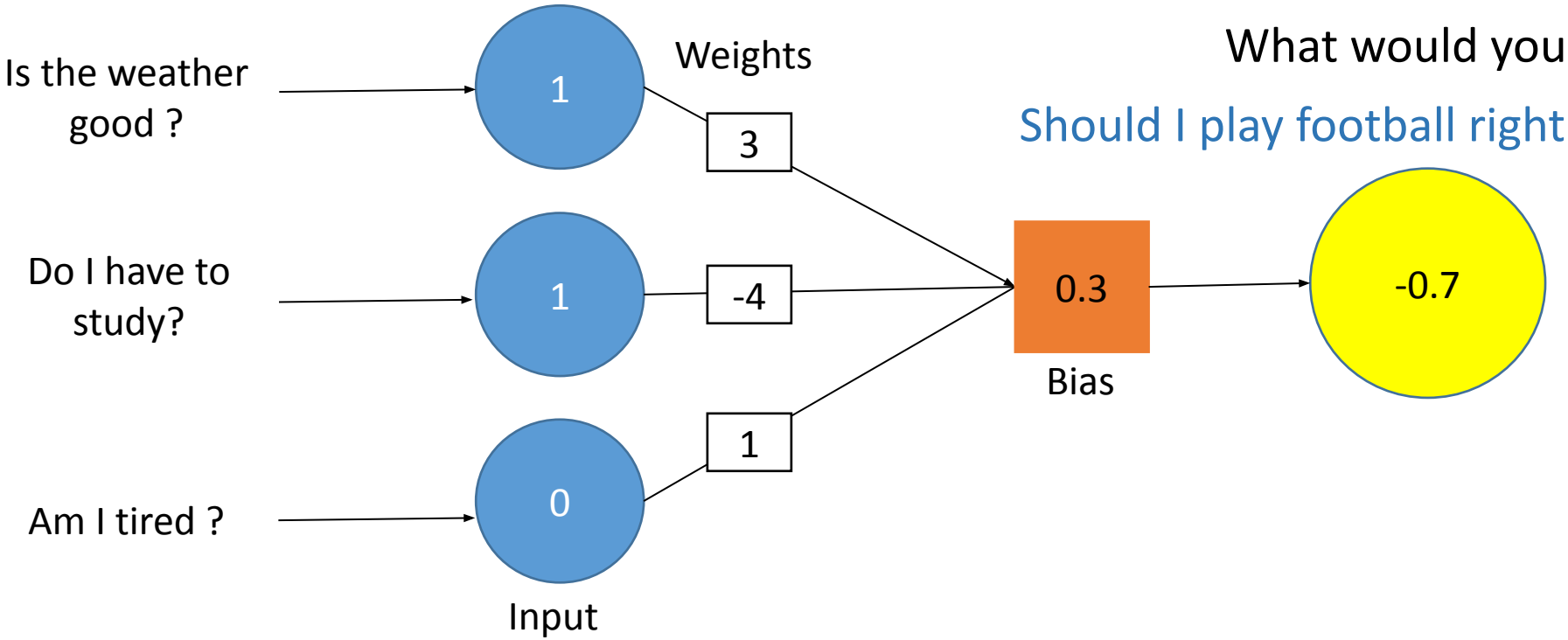


What would you consider when deciding - Should I play football right now ?

1*3+1*-4+0*1 = -1

Bias

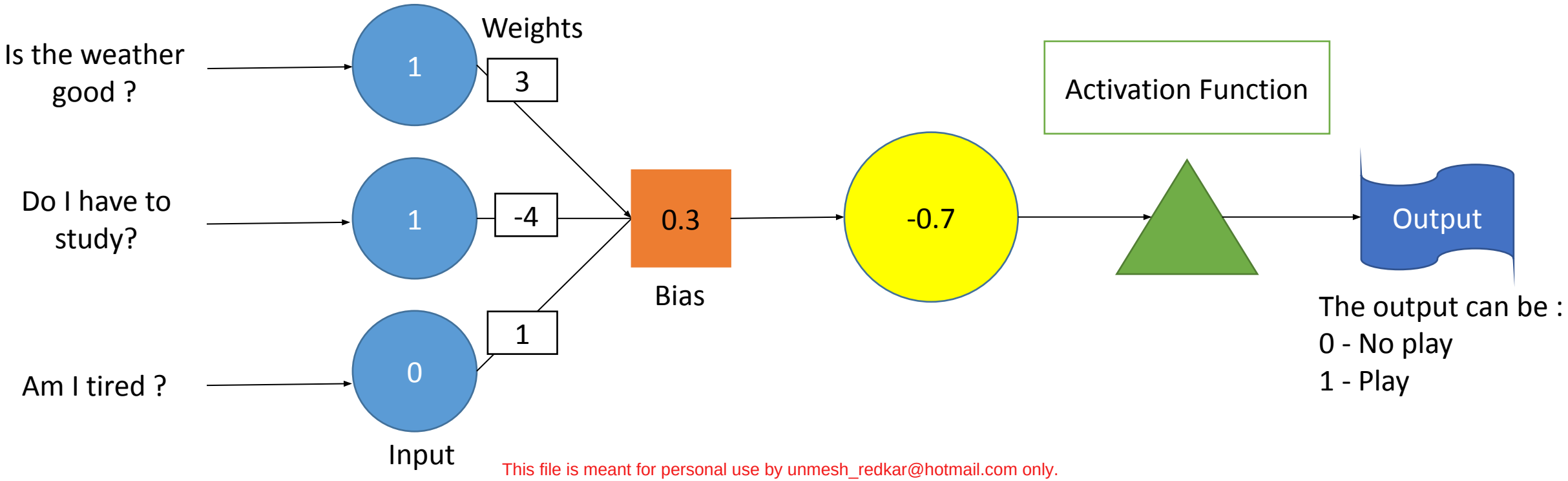
In a Neural Network, bias is a parameter that is used in conjunction with the weighted summation of the inputs for the neuron to adjust the output.



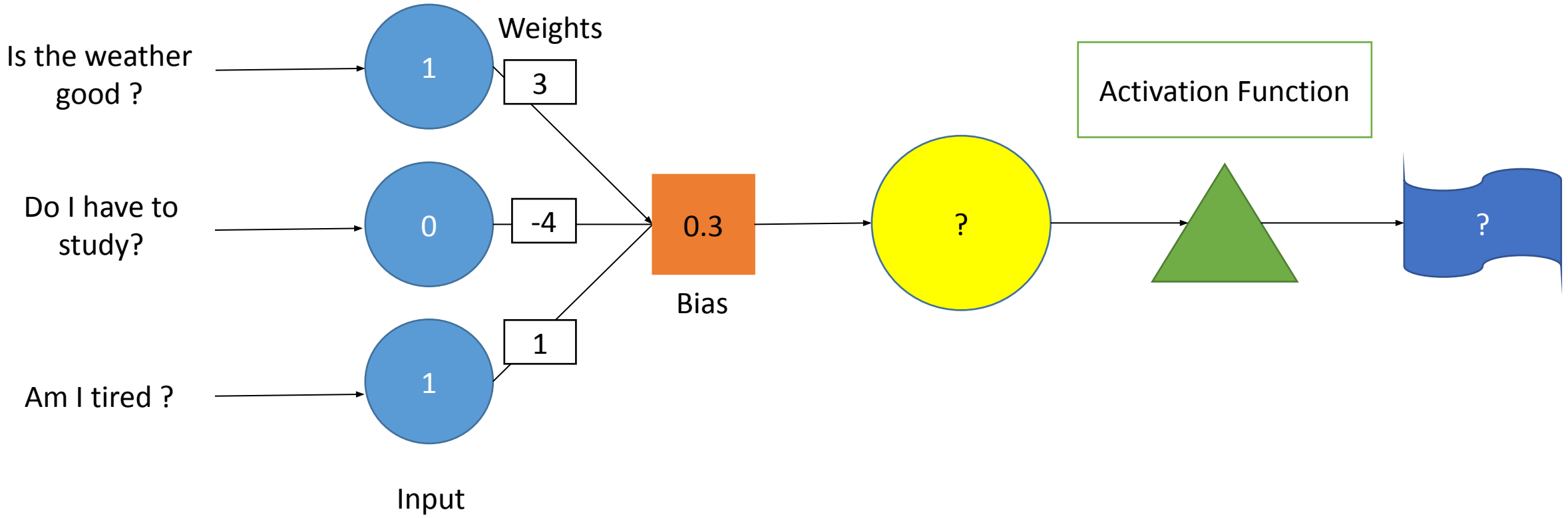
Activation function

The activation function determines whether a neuron should be activated or not by calculating a weighted sum and then adding bias to it.

If the total signal is positive, the output is 1. If the total signal is negative, the output is 0.



Try it yourself ….



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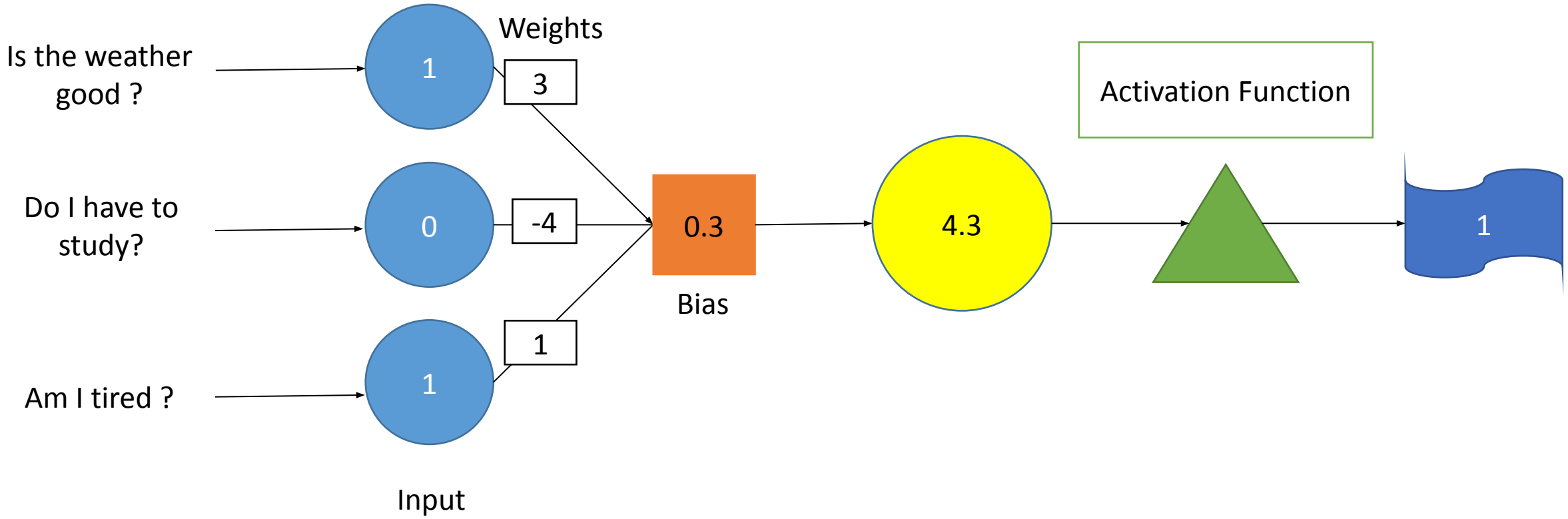
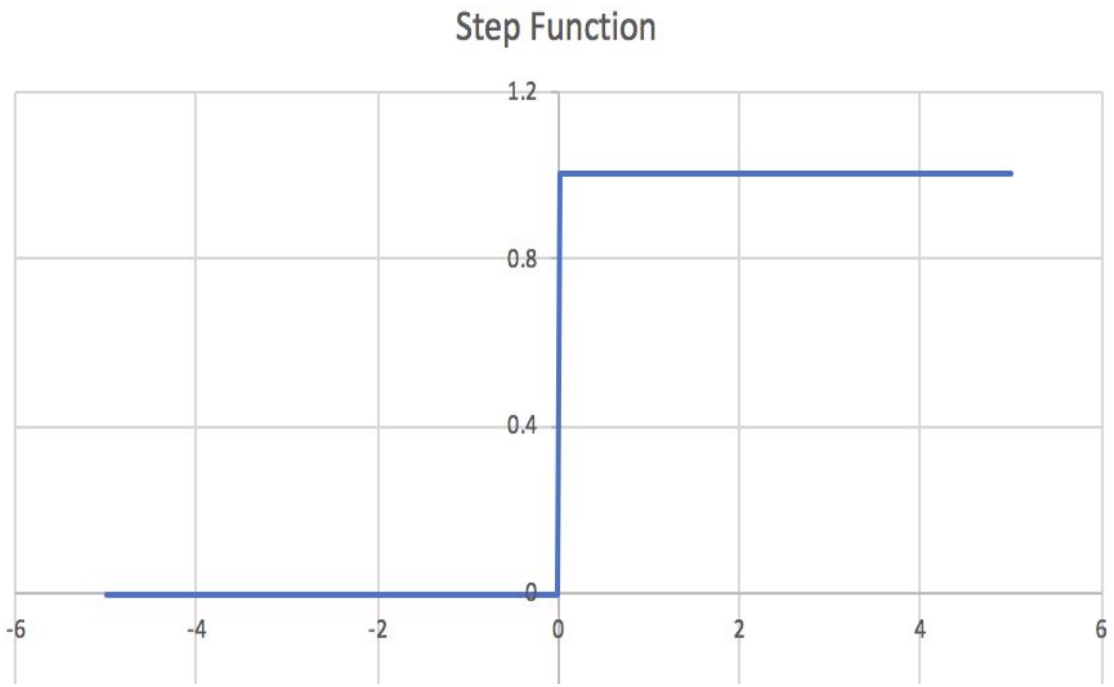


Activation function

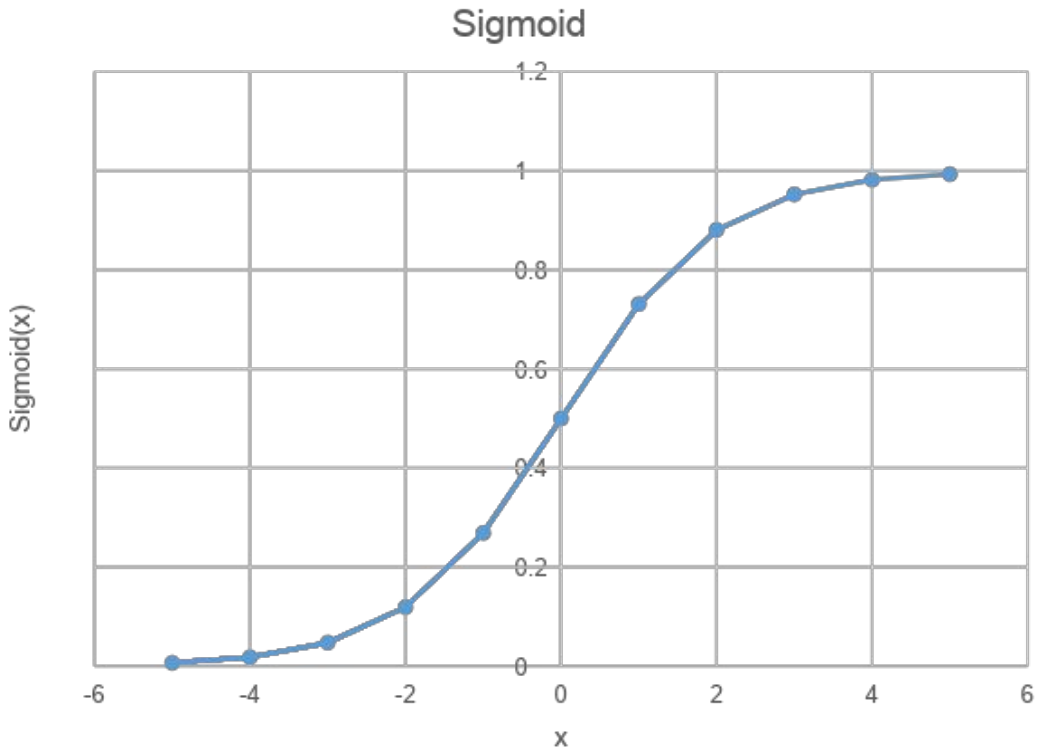
Step function activation



- Step function activation
- Everything left of zero is zero
- Everything right of zero is 1

Activation function

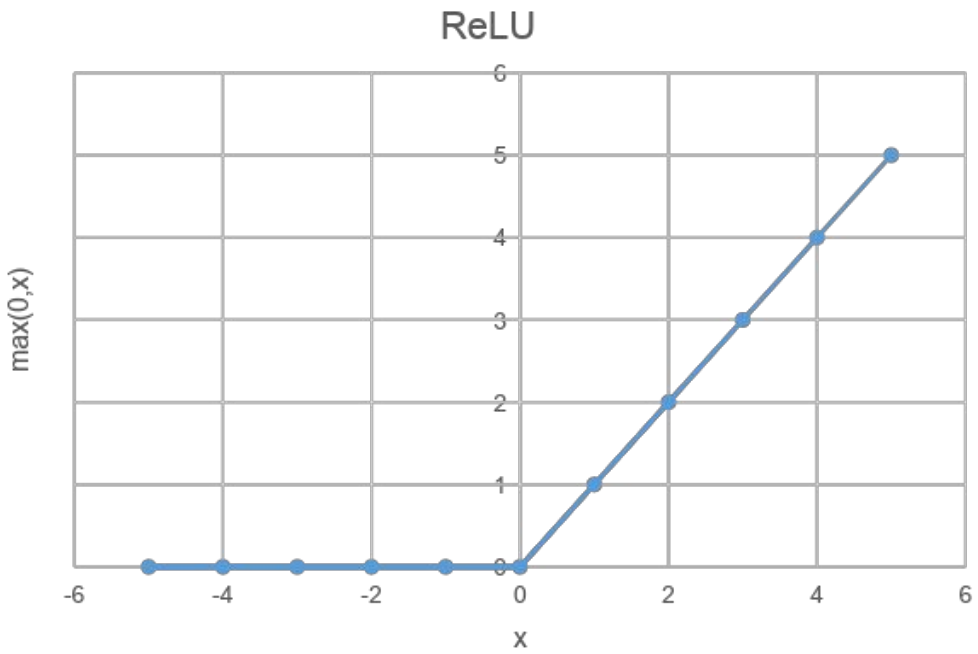
Sigmoid Activation Function



- Also known as the logistic function
  - $\frac{1}{1+e^{-x}}$
- Sigmoid function values never fall below 0 and never exceed 1

Activation function

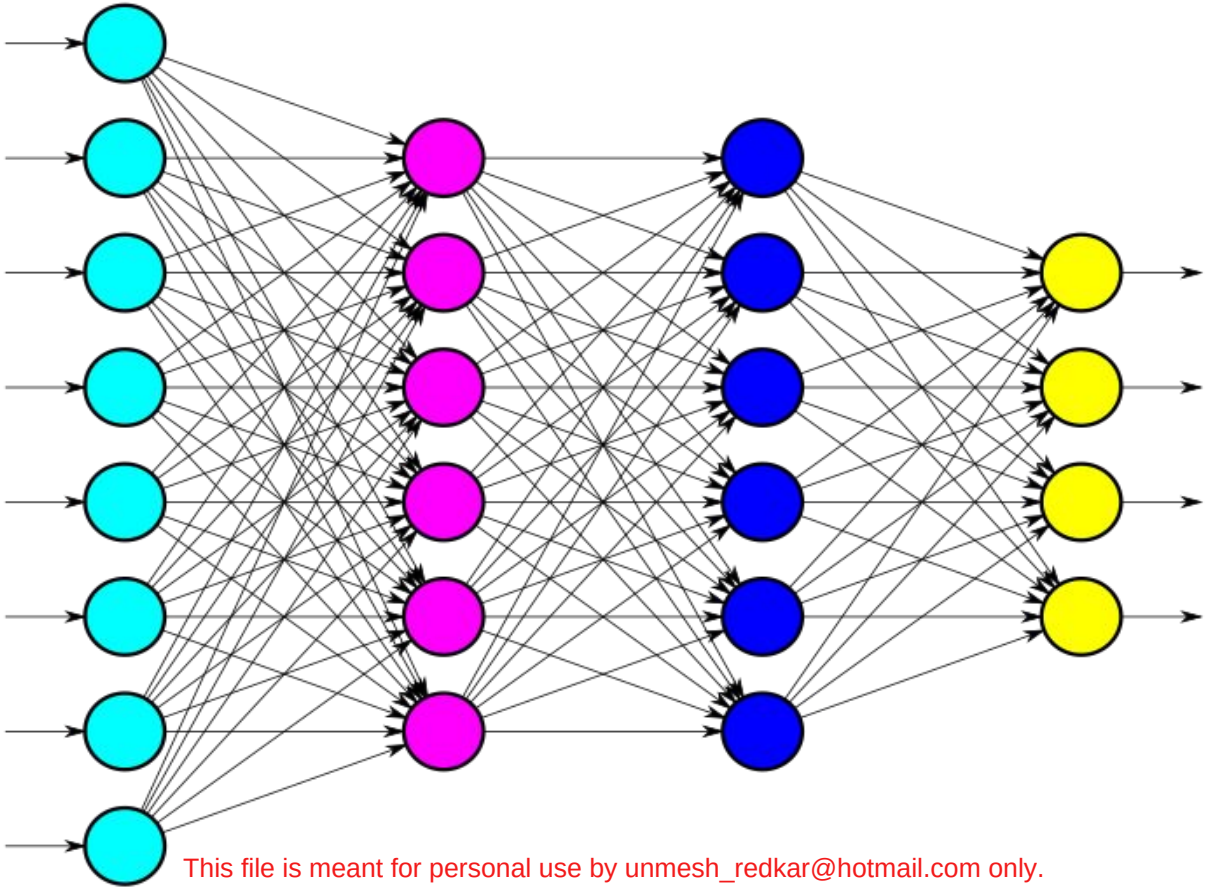
ReLU Activation Function



- Rectified Linear Unit
- Will output 0 if the input values are negative

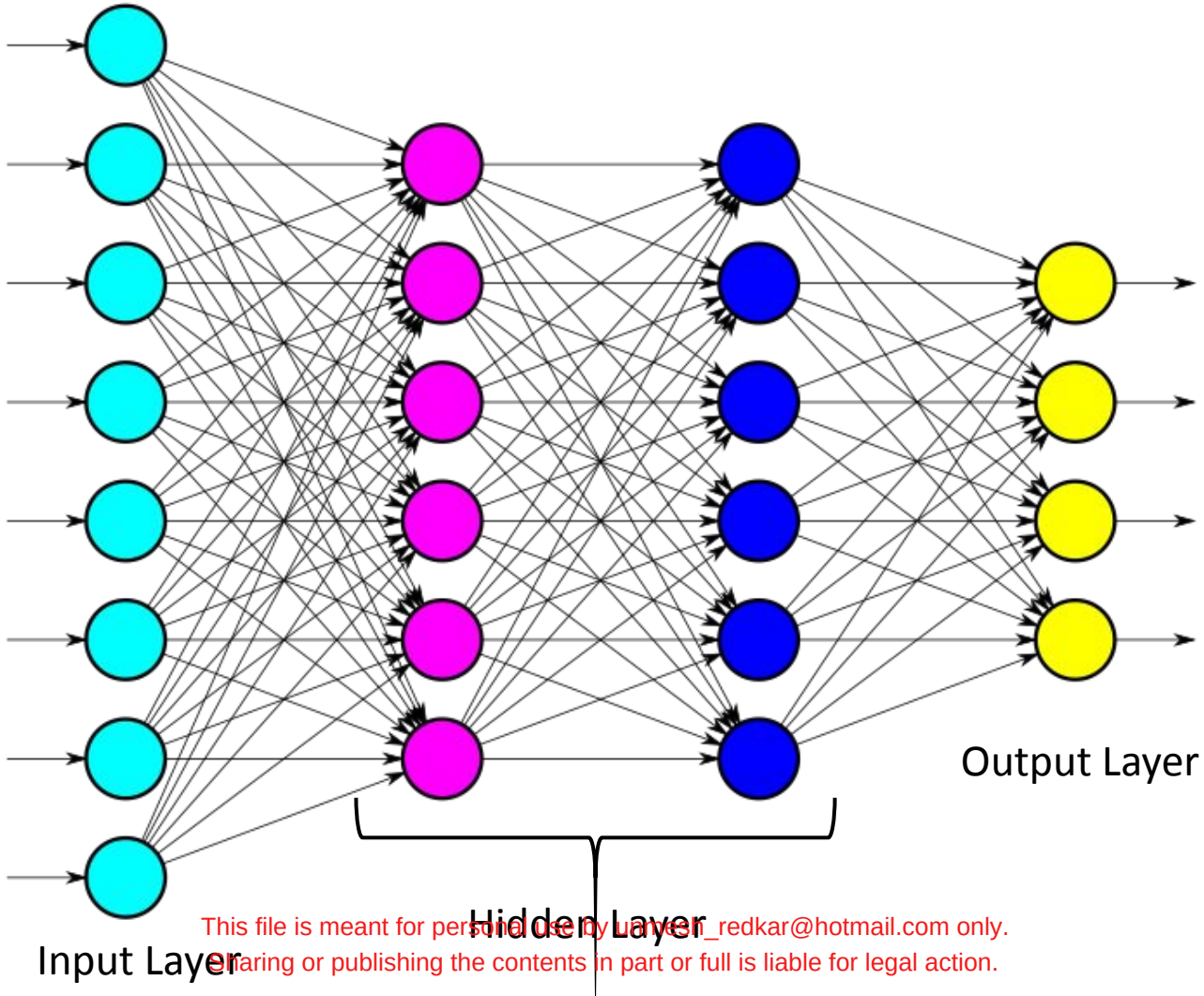
Neural Network

- Neurons are the building blocks of a neural network.
- Multiple layers of Neurons make a *feed forward* neural network.



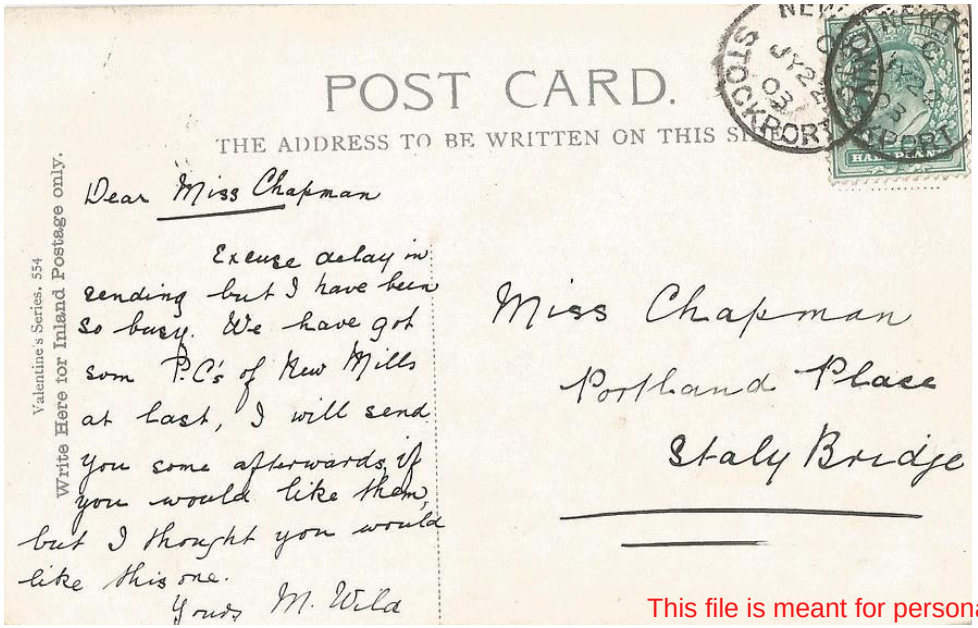
Layers in a Neural Network

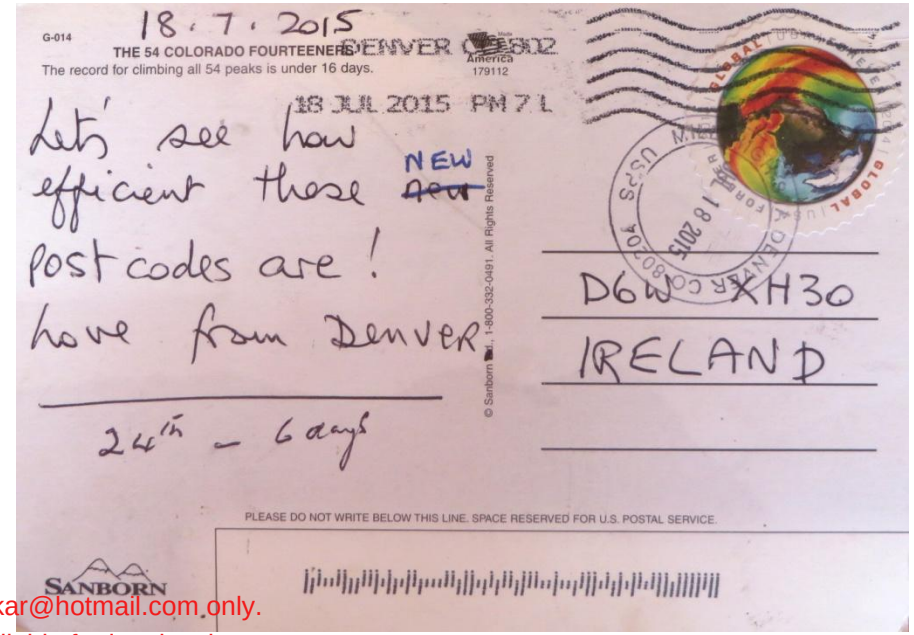
- A Neural Network is made of 3 types of layers – Input, hidden and output layers



How can we use Neural Networks to recognize characters ?

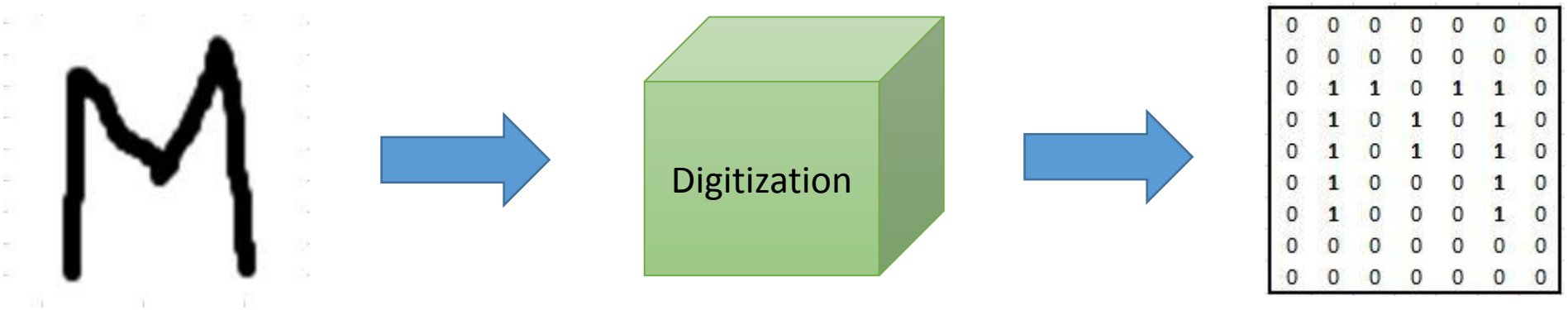
- What is character recognition?
  - Character recognition is the process of electronically identifying written characters.
  - Neural networks can be used to interpret handwritten characters or words into a format that the computer understands.
  - Character recognition algorithms can be used for reading forms, bank checks and postal address.





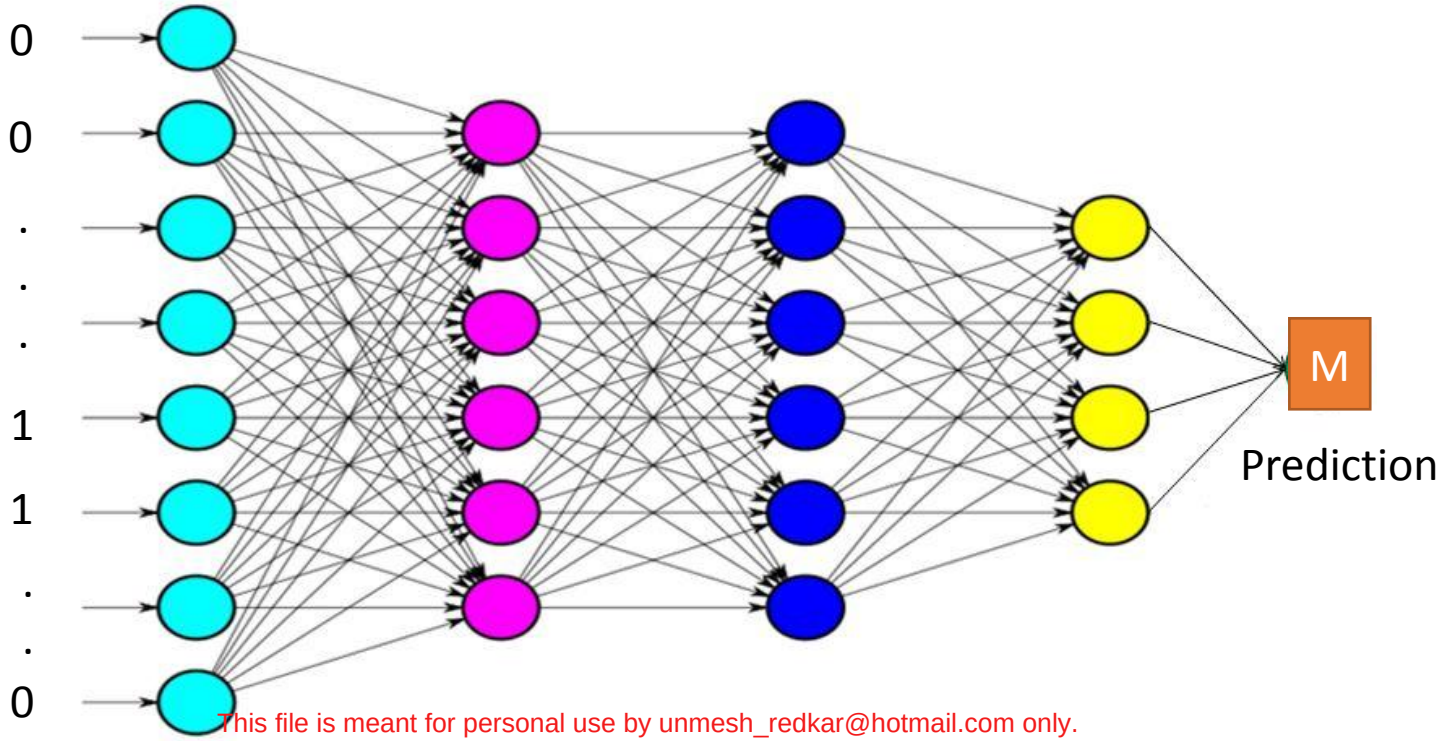
How can we use Neural Networks to recognize characters ?

- Character recognition begins with the digitization of images
- Digitization of an image is done to transform it into a format that computers can understand
- As part of the process, a window is created from the input image that is fed into the digitization system



How can we use Neural Networks to recognize characters ?

- The digitized image is then fed into the neural network.
- The network is designed to have weights and biases that hopefully can identify an image as a character based on its pixels



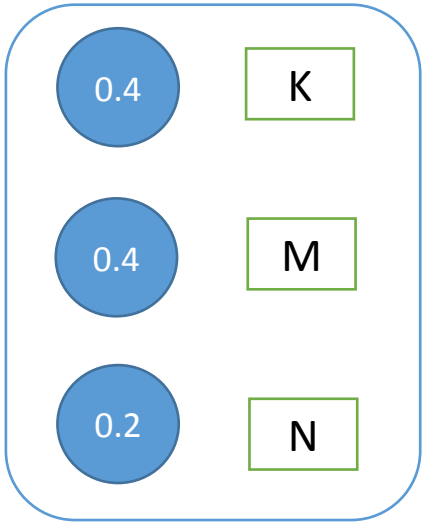
Training a Neural Network

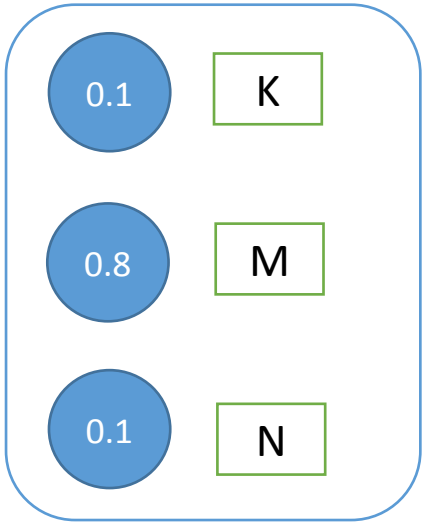
- The training process involves finding good values of the weights and bias terms of each neuron.

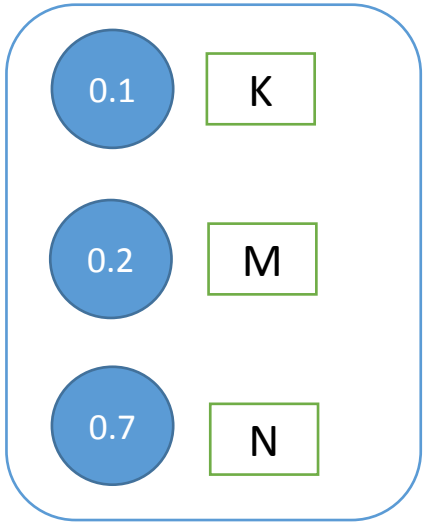
How can we tell if our weights are good?

- Below are the results of 3 different neural networks, these values depict the predicted probability of the handwritten character being "M".

Input Image





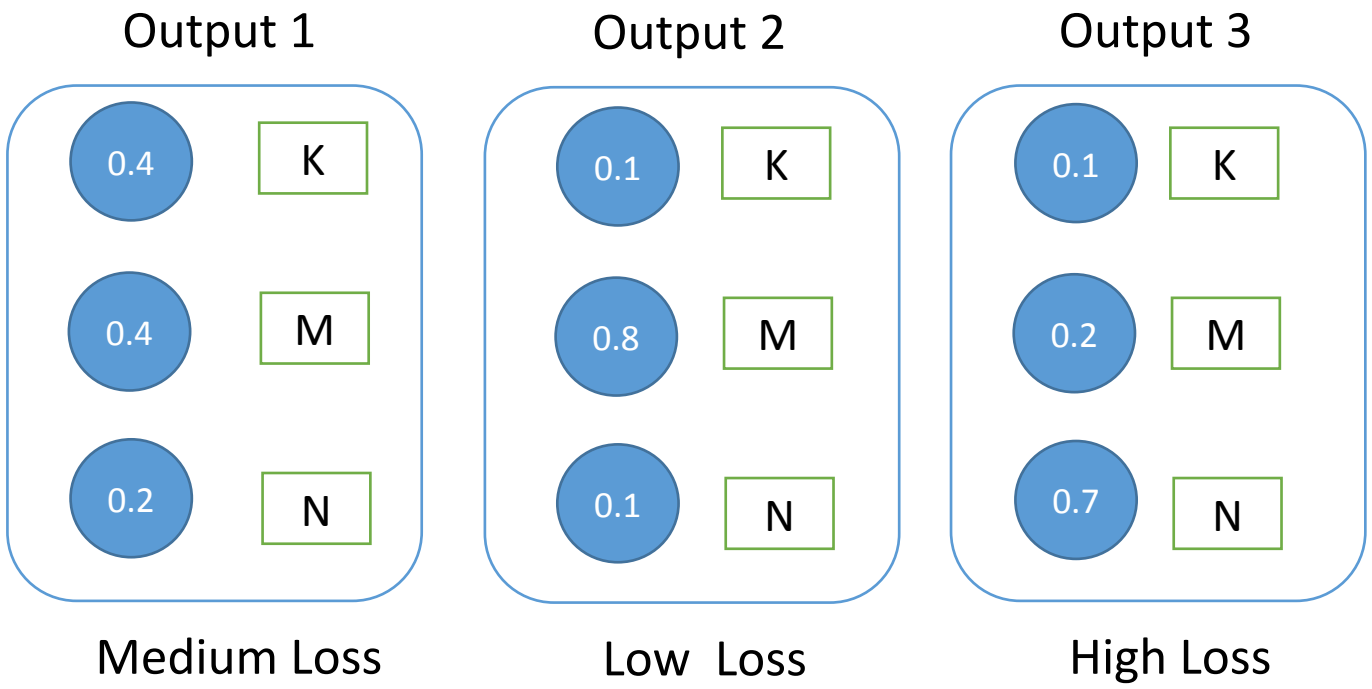


Which network do you consider to be the best?

Training a Neural Network – Loss

- Loss is a measure of how far the predicted value deviates from reality.

Input Image



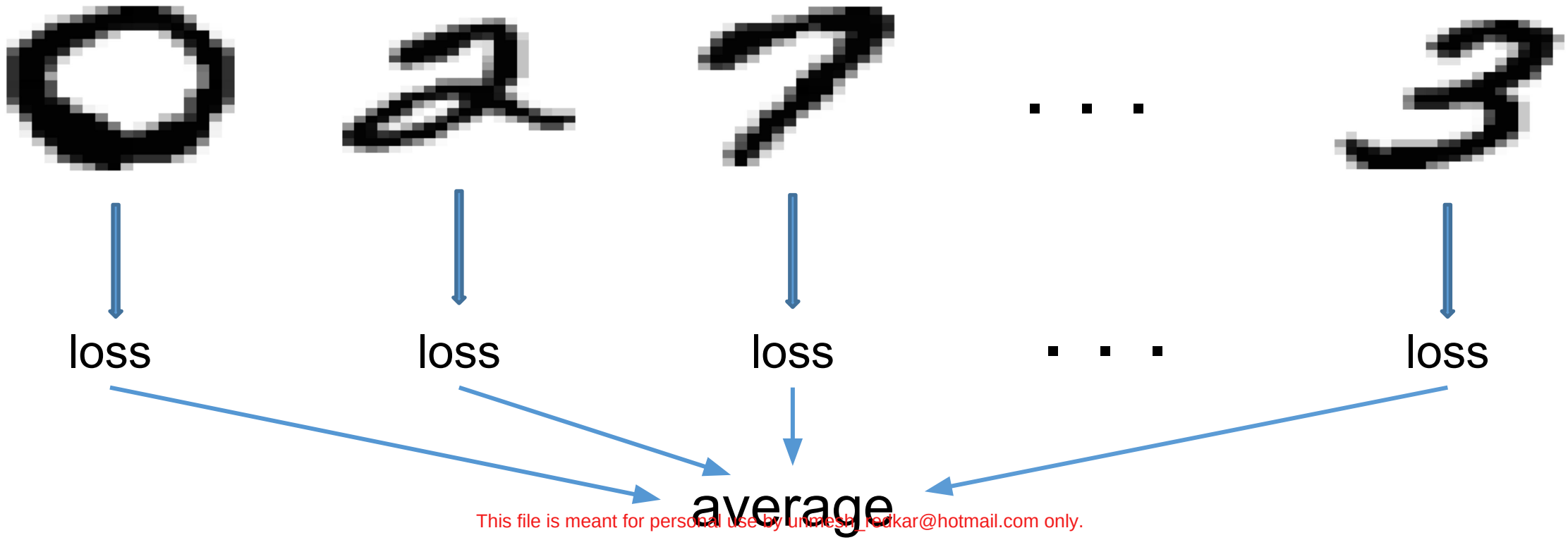
Medium Loss

Low Loss

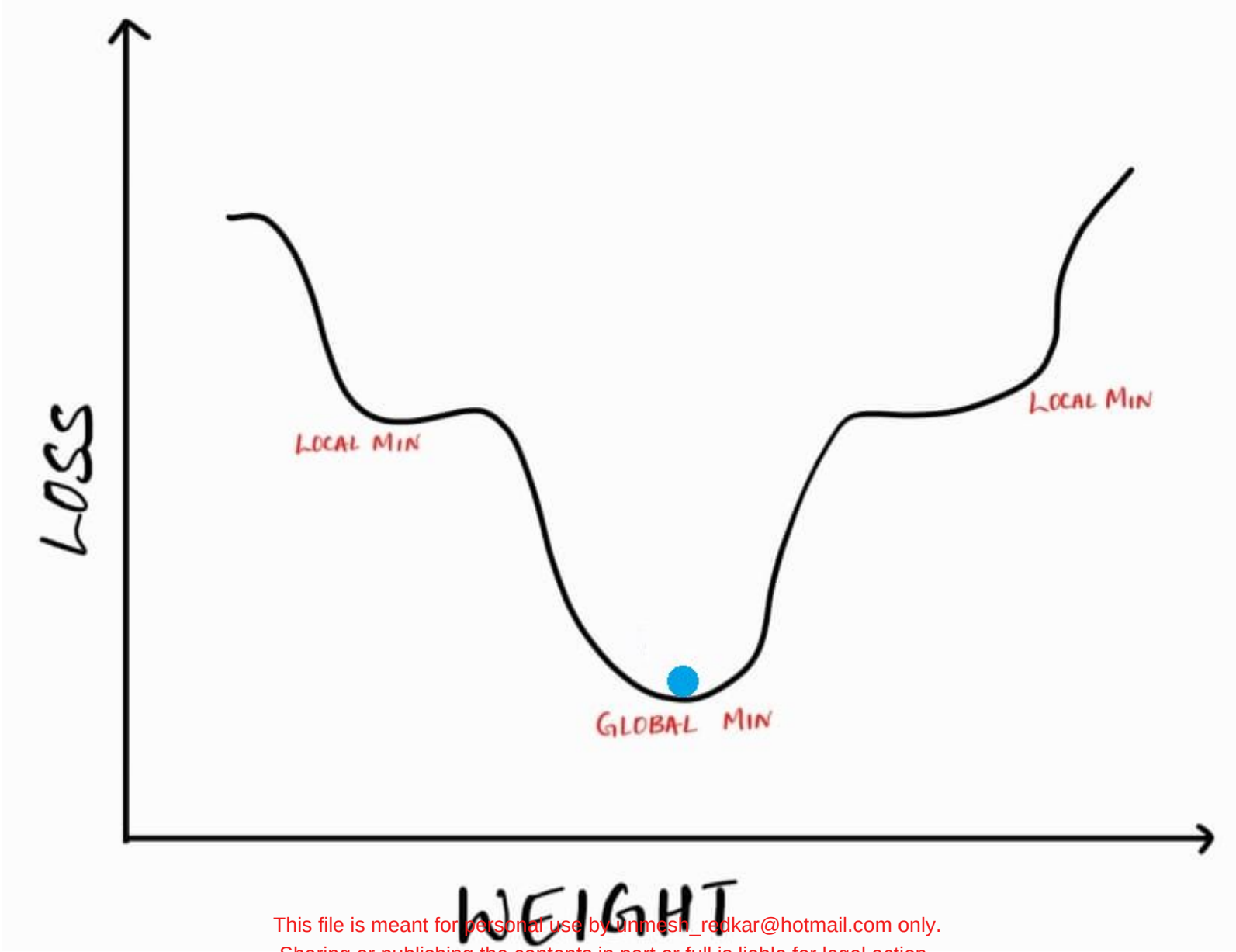
High Loss

Training a Neural Network – Loss

- To train a neural network we show it LOTS of images of characters that are already labeled
- Then calculate the loss for each character
- Average all these losses
- We want to find the weights and biases that makes this average loss as small as possible!



Training a Neural Network – Loss



Training a Neural Network

- Training a neural network to find the weights and biases that lead to the minimum average loss is the hardest part!
- If you have taken calculus, minimizing is related to calculating derivatives
- We need to find the derivative of the average loss with respect to each weight and bias
  - This is DIFFICULT!
- The algorithm we use to calculate these derivatives is called backpropogation
- Once we calculate the derivatives, we use them to find the best weights and biases!

Thank you