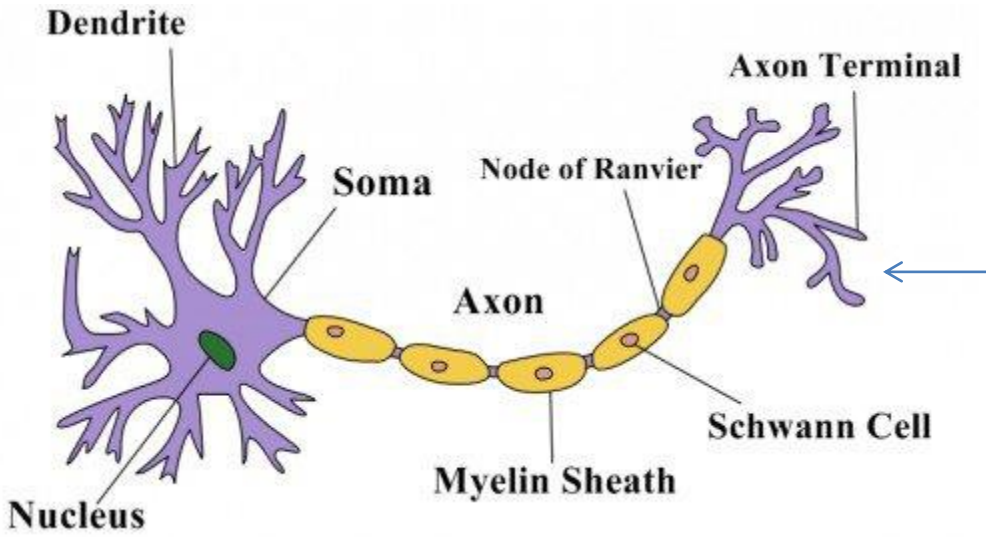
Neural Networks

Prof. Ankur Sinha
Indian Institute of Management Ahmedabad
Gujarat India

A typical Neuron



Releases neurotransmitters to other neurons

Information Flow

Applications

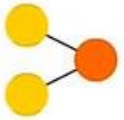
- Speech recognition
- Handwriting recognition
- Driverless Cars
- Products: Google translate, Alexa

A mostly complete chart of

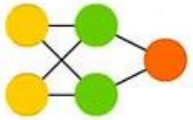
Neural Networks

- Backfed Input Cell
- Input Cell
- Noisy Input Cell
- Hidden Cell
- Probablistic Hidden Cell
- Spiking Hidden Cell
- Output Cell
- Match Input Output Cell
- Recurrent Cell
- Memory Cell
- Different Memory Cell
- Kernel
- Convolution or Pool

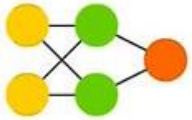
Perceptron (P)



Feed Forward (FF)



Radial Basis Network (RBF)



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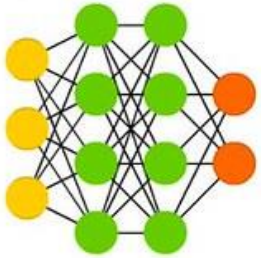
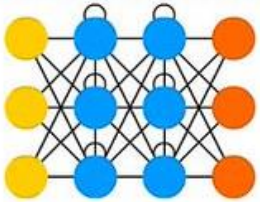
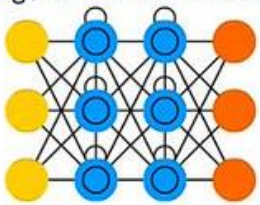


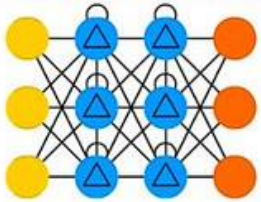
Recurrent Neural Network (RNN)



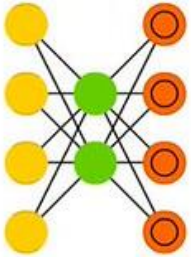
Long / Short Term Memory (LSTM)



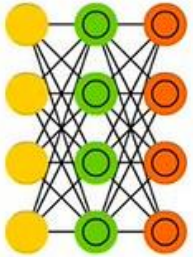
Gated Recurrent Unit (GRU)



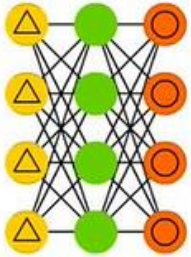
Auto Encoder (AE)



Variational AE (VAE)



Denoising AE (DAE)



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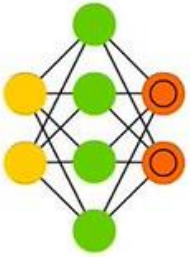

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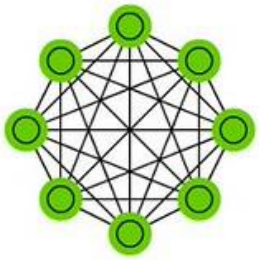

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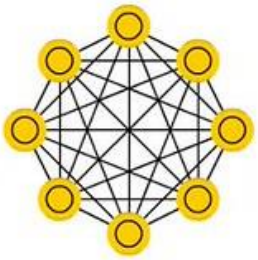
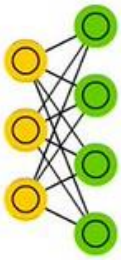


Boltzmann Machine (BM)

Restricted BM (RBM)



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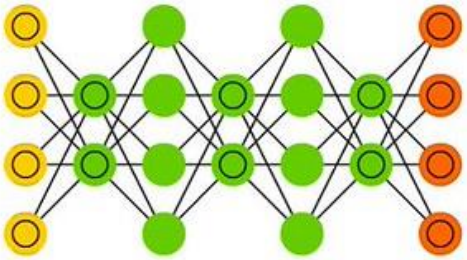

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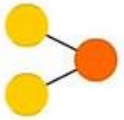

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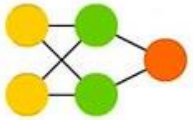

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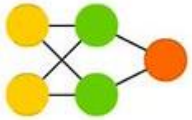

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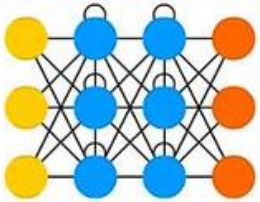

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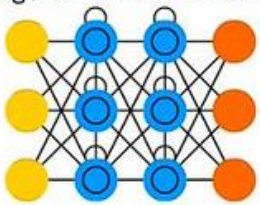

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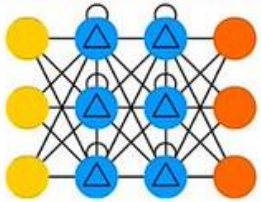

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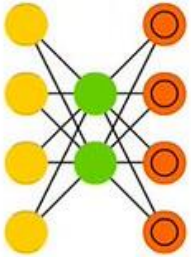

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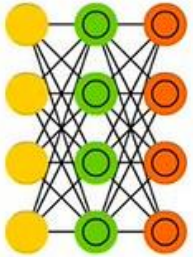

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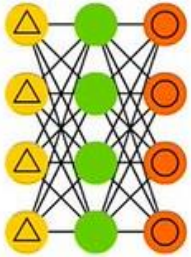

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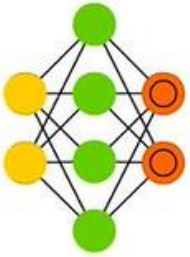

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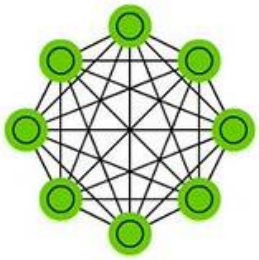

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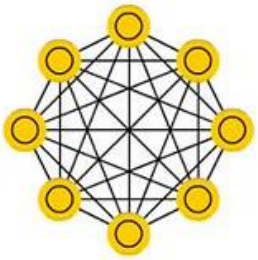

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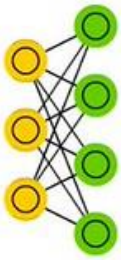

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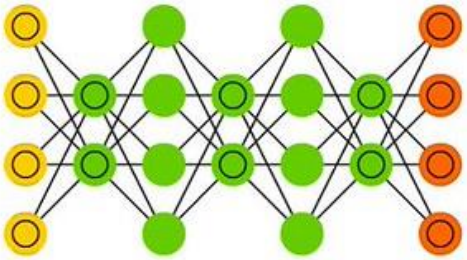
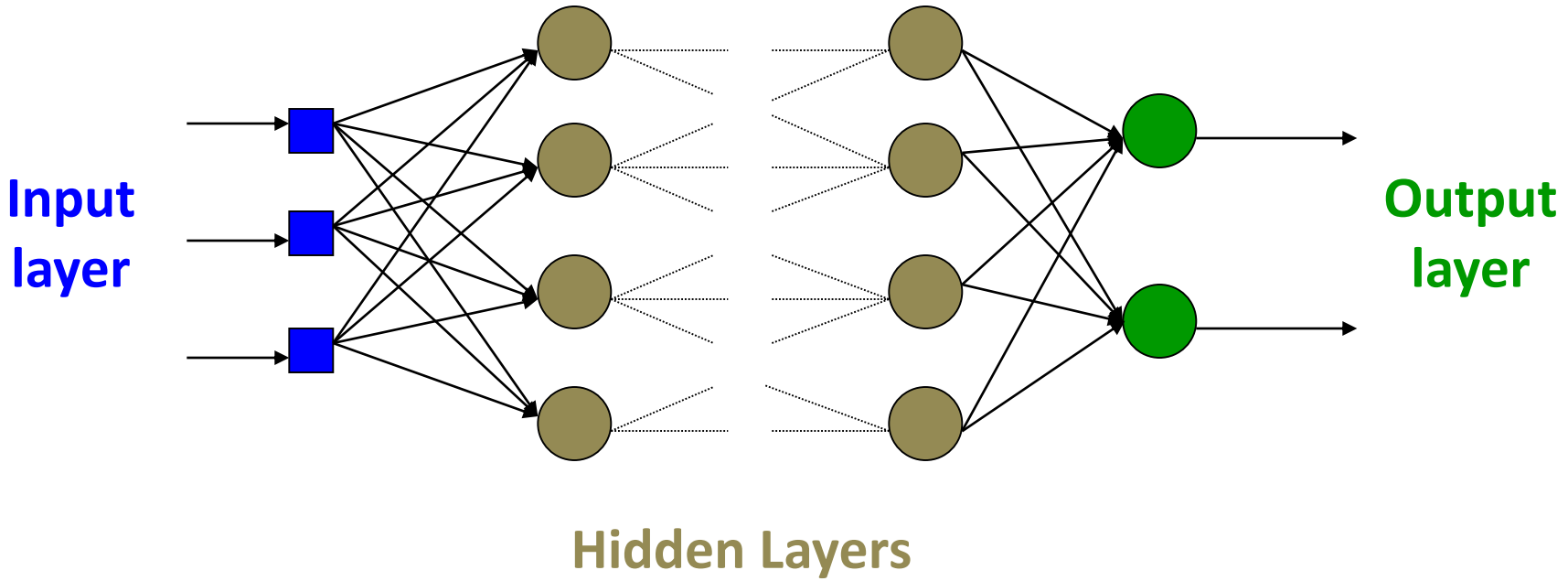
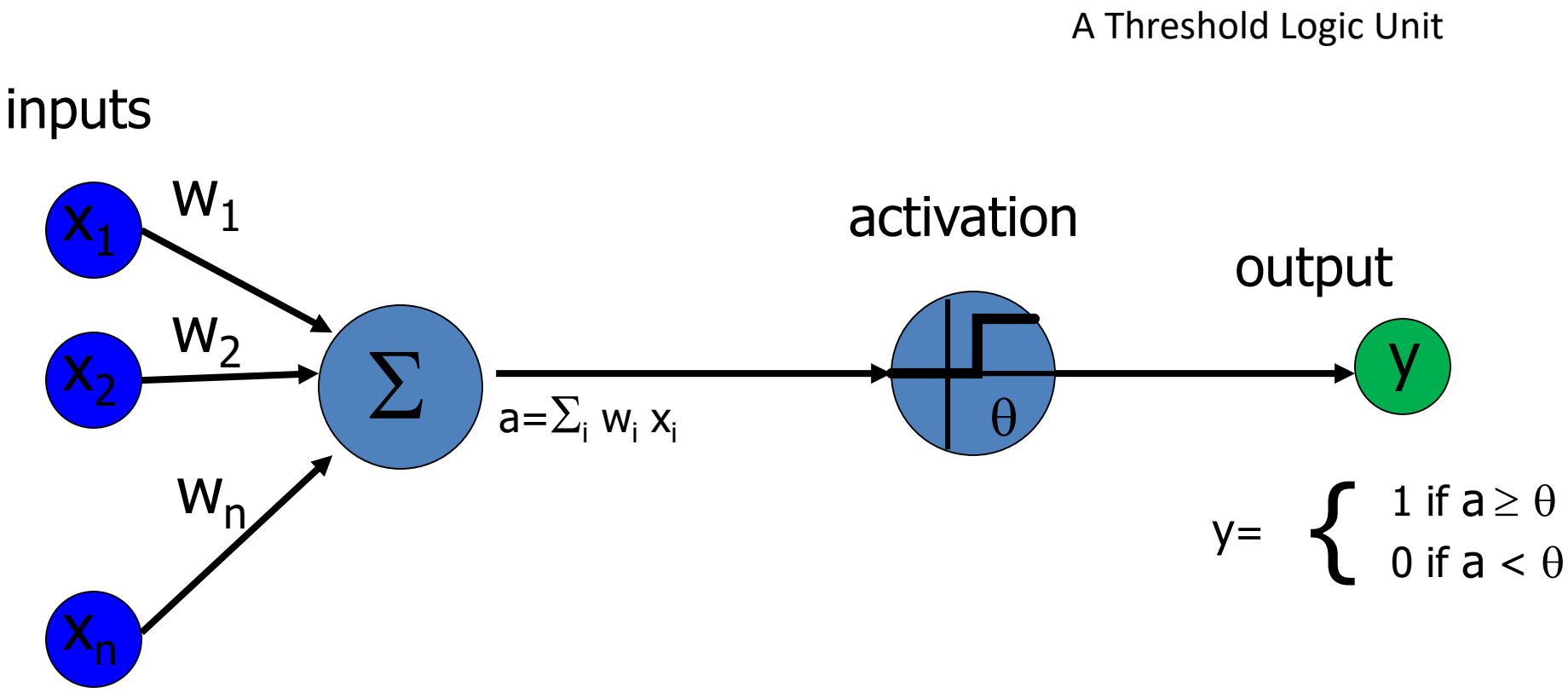


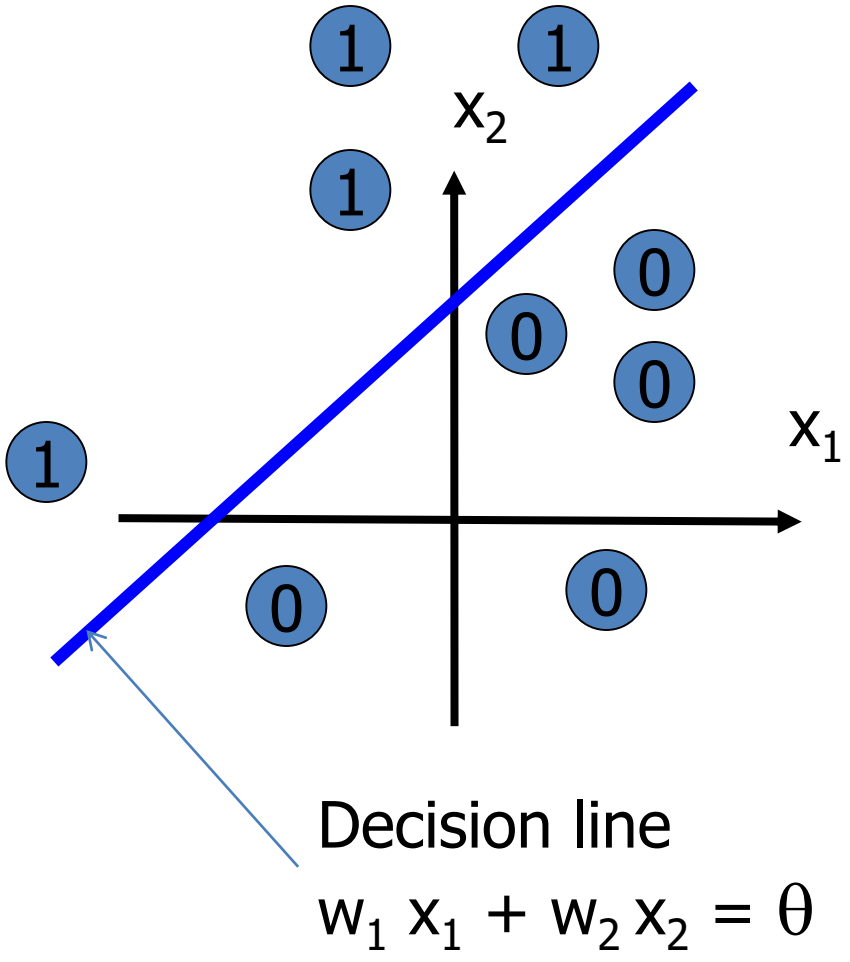
MLP Architecture



A Simple Architecture



Decision Surface of a TLU



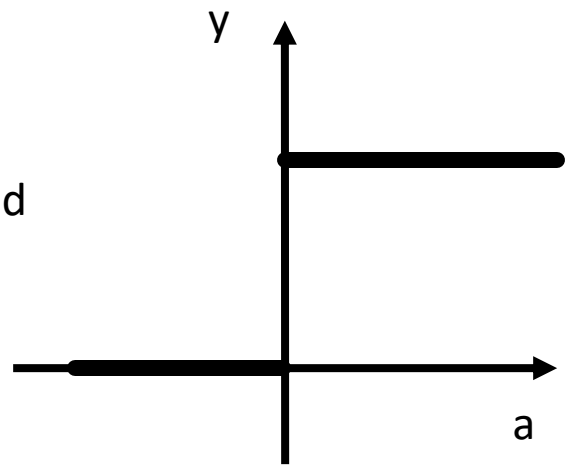
A TLU works as a linear classifier

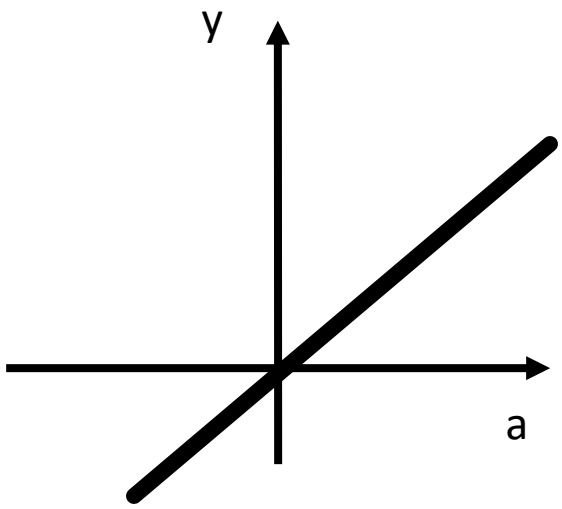
Similar to SVM?

How do you identify the weights and threshold?

Types of Activation Functions

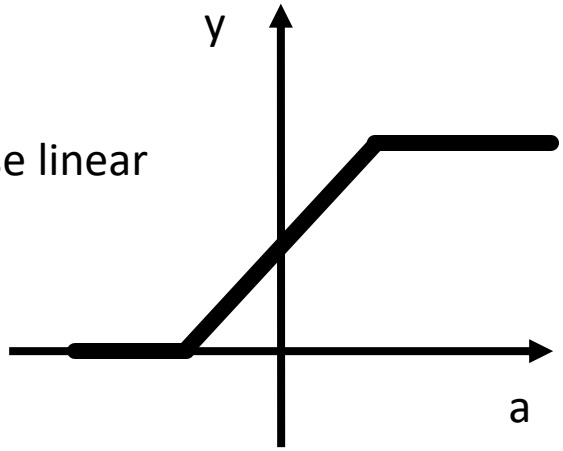
threshold

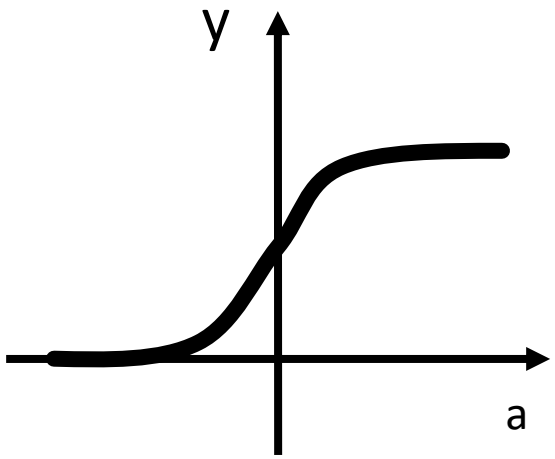




linear

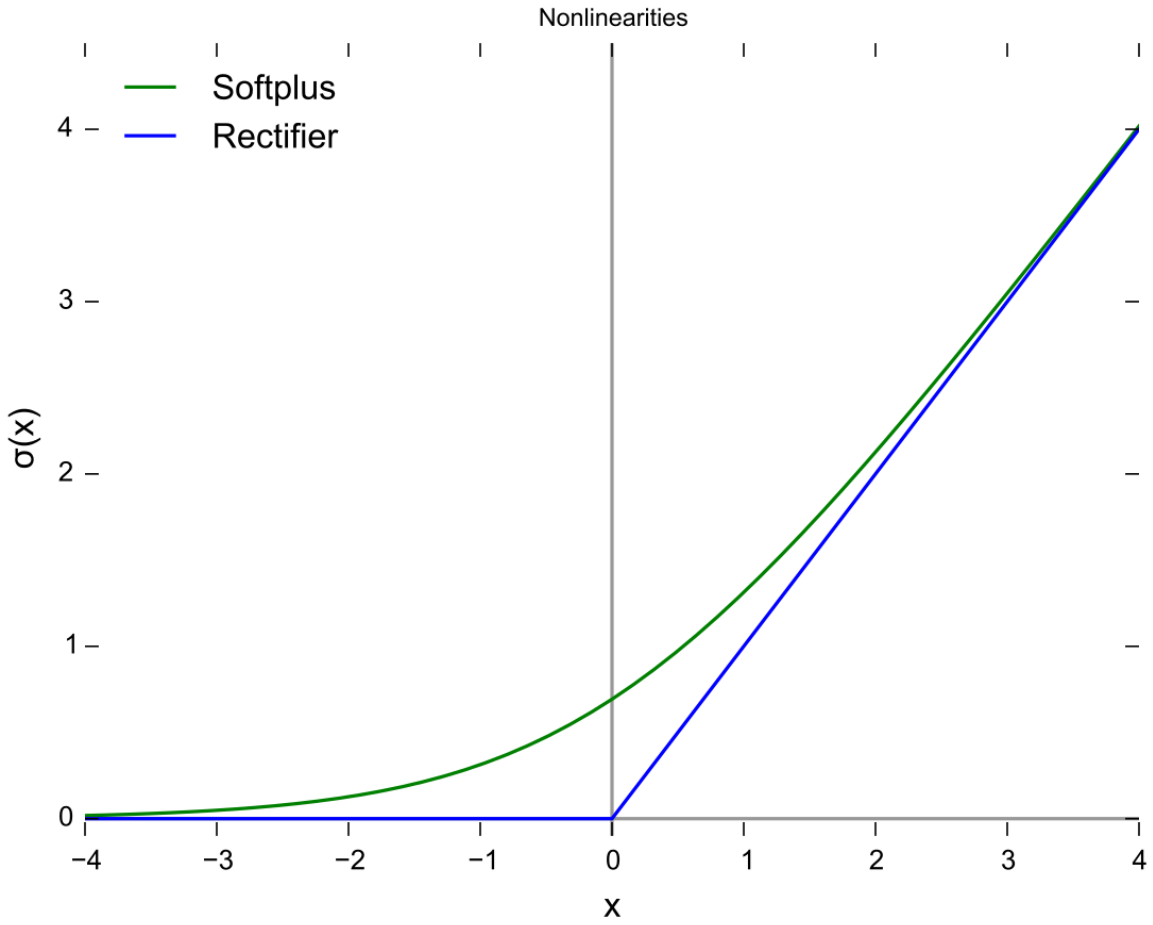
piece-wise linear





sigmoid

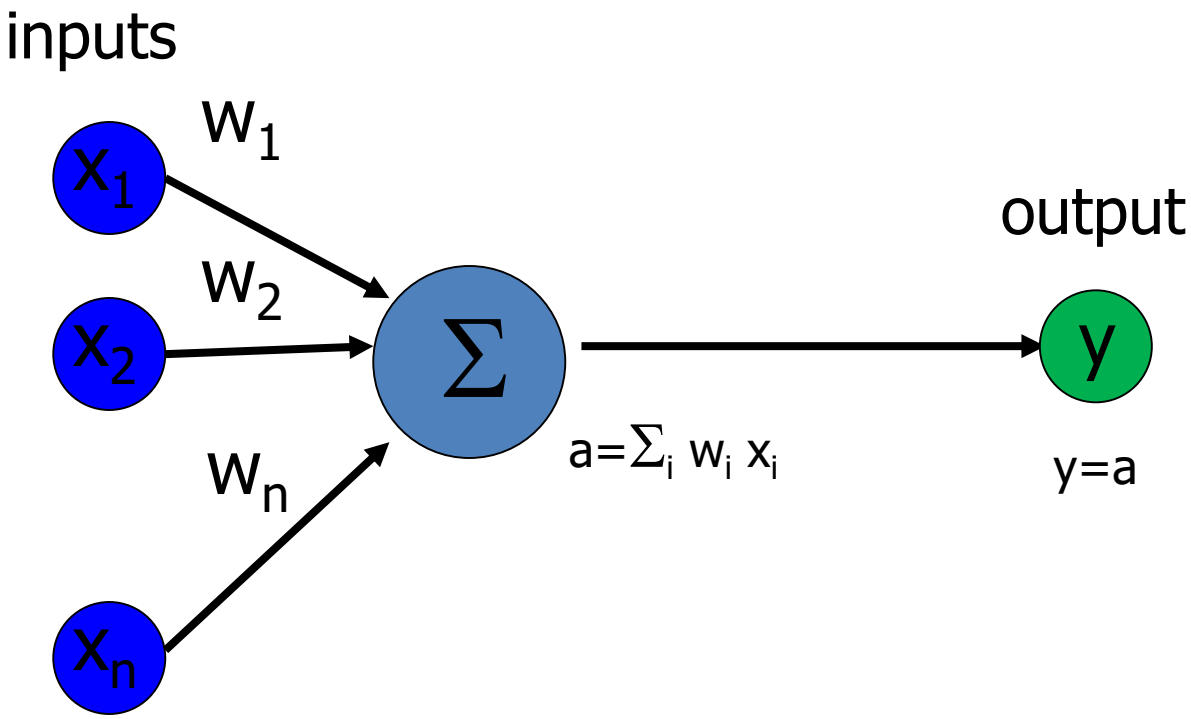
Types of Activation Functions



Training Neural Network

- A training set S of examples {**x**,t} is required
  - **x** is an input vector
  - t is the desired target vector
- Finding acceptable values of w and θ
  - Assume some values for w and θ
  - For the training example **x**, compute the network output y
  - Compare output y with targets t, a difference denotes error
  - Adjust w and θ so that the error can be reduced
  - Accept w and θ that leads to minimum error

A Linear Unit

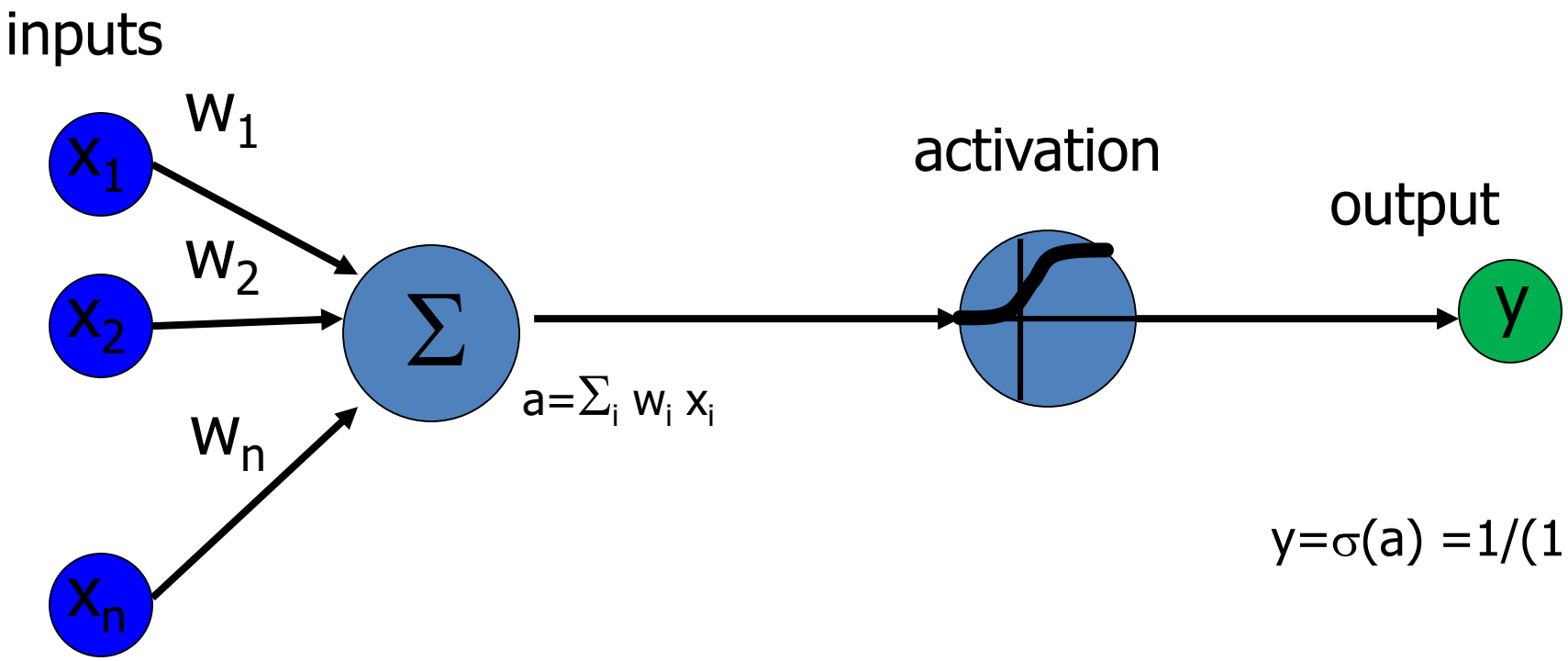


Tries to give the best linear relationship between input and output

Similar to regression?

Neuron with Sigmoid Function

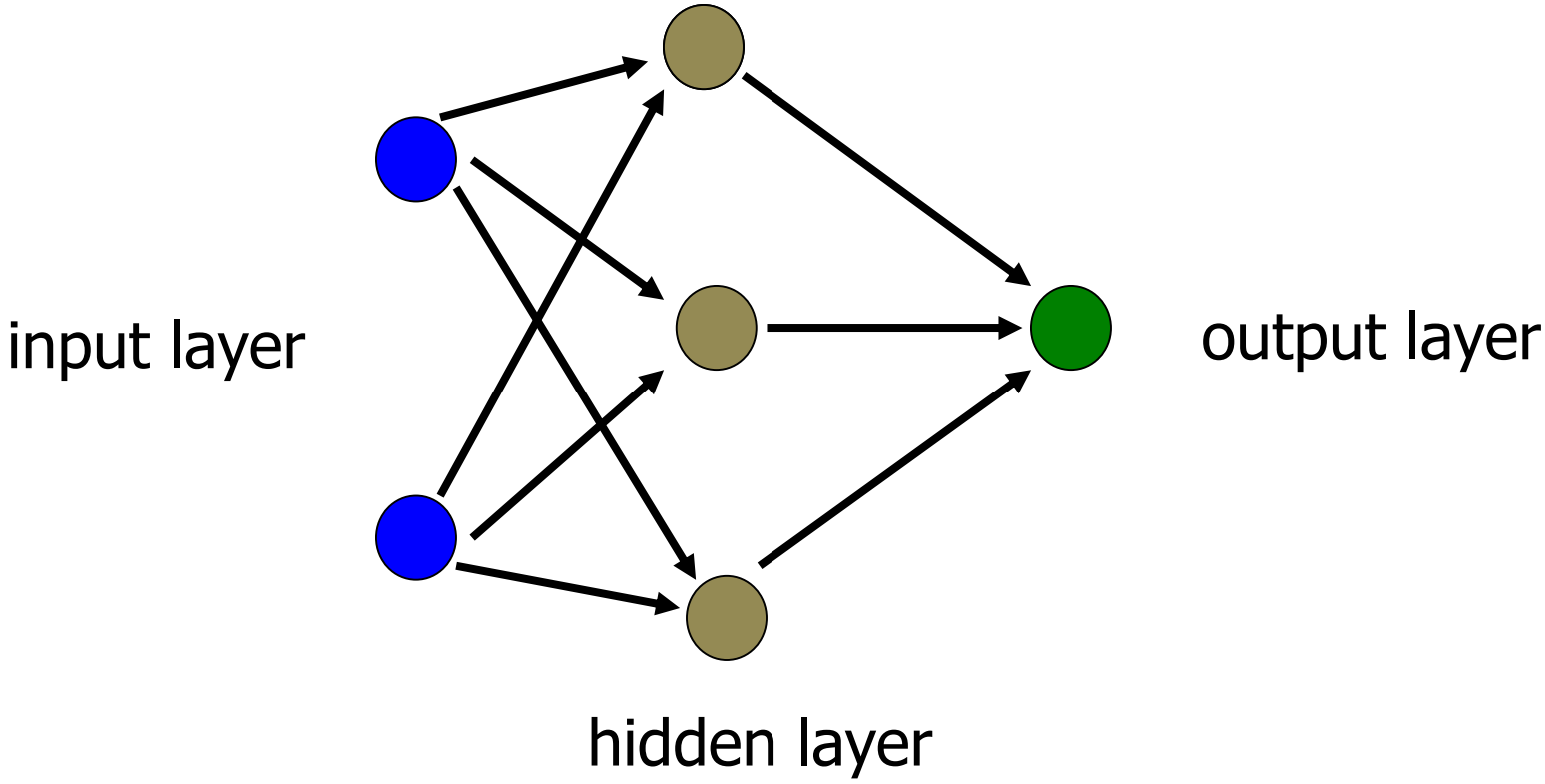
A Threshold Logic Unit



$y=\sigma(a) = 1/(1+e^{-a})$

Gradient descent rules are used to learn the parameters of the NN

Multiple Layers



Backpropagation approach is used to train the neural network

More about NN Parameters

- The weights of the neural network are determined by training data
- As more training data is obtained the weights should be updated

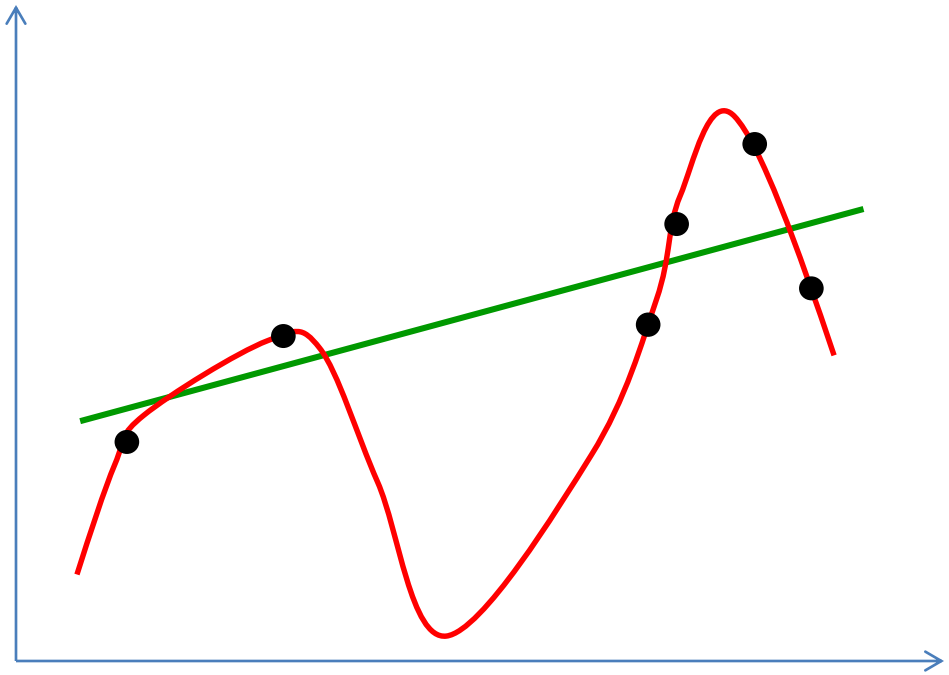
Neural Networks are Universal

- Any boolean function can be learnt by a neural network with single hidden layer
  - It might require a large number of hidden units

- Any mathematical function that is continuous and bounded can be approximated to an arbitrarily small accuracy using a neural network with one hidden layer
  - A large number of hidden units might be required if the error of approximation is very small

Be Careful!

- Neural network can easily lead to overfitting
- Try to minimize the generalization error than the training error



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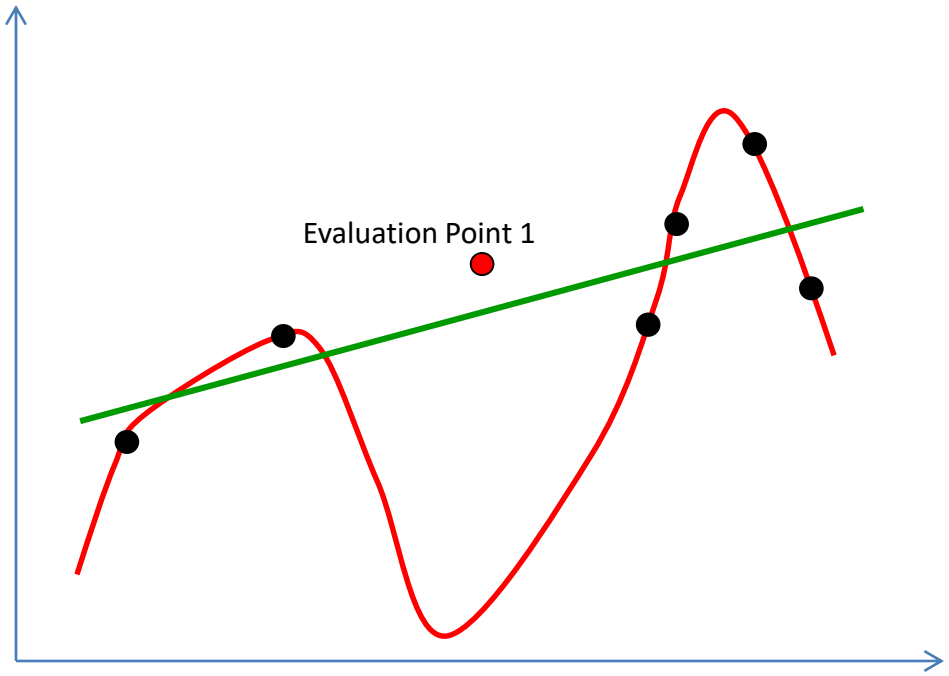

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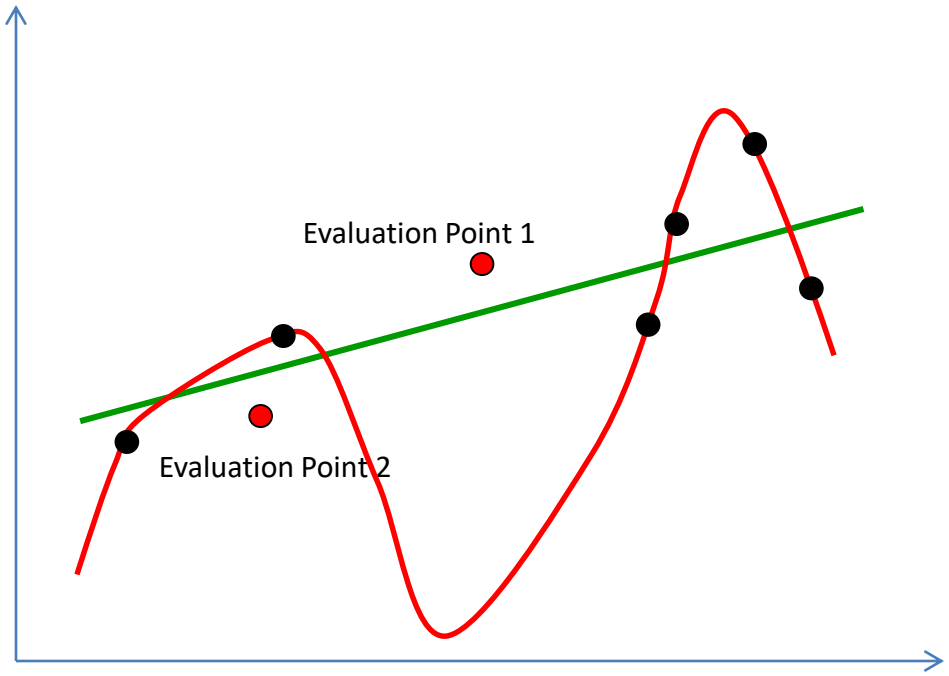
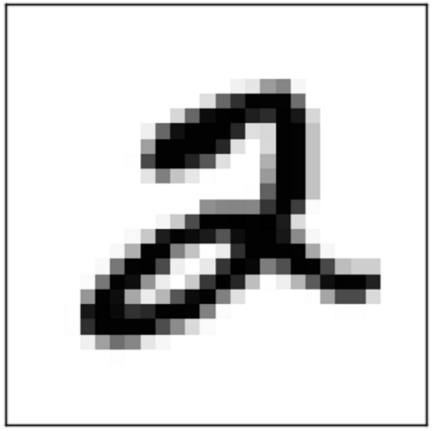


MNIST Database



The MNIST database contains 60,000 training images and 10,000 testing images.

MNIST: Modified National Institute of Standards and Technology database

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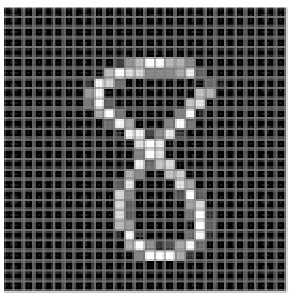

28 x 28
784 pixels

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0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0	0	0	0	0	121	255	98	3	0	0	0	0	0	8	194	225	12	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	169	253	120	3	0	0	0	0	128	247	51	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	3	111	244	169	19	0	14	131	249	117	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	59	241	235	72	142	229	66	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	25	218	254	231	36	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	133	253	221	33	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	19	237	111	196	217	19	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	174	138	0	23	193	204	18	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	96	224	0	0	0	25	218	169	3	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	215	138	0	0	0	0	86	253	99	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	215	97	0	0	0	0	3	162	214	11	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	215	97	0	0	0	0	0	118	253	68	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	185	157	0	0	0	0	0	40	254	98	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	50	244	61	0	0	0	0	112	244	58	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	174	251	142	59	83	167	244	111	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	6	133	253	253	253	169	61	3	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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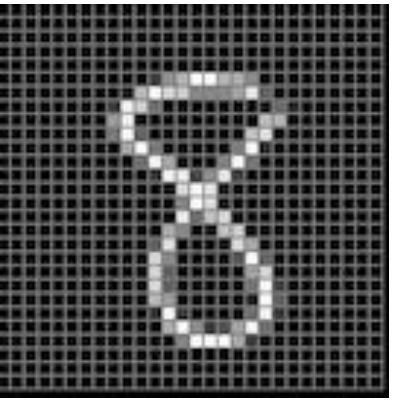
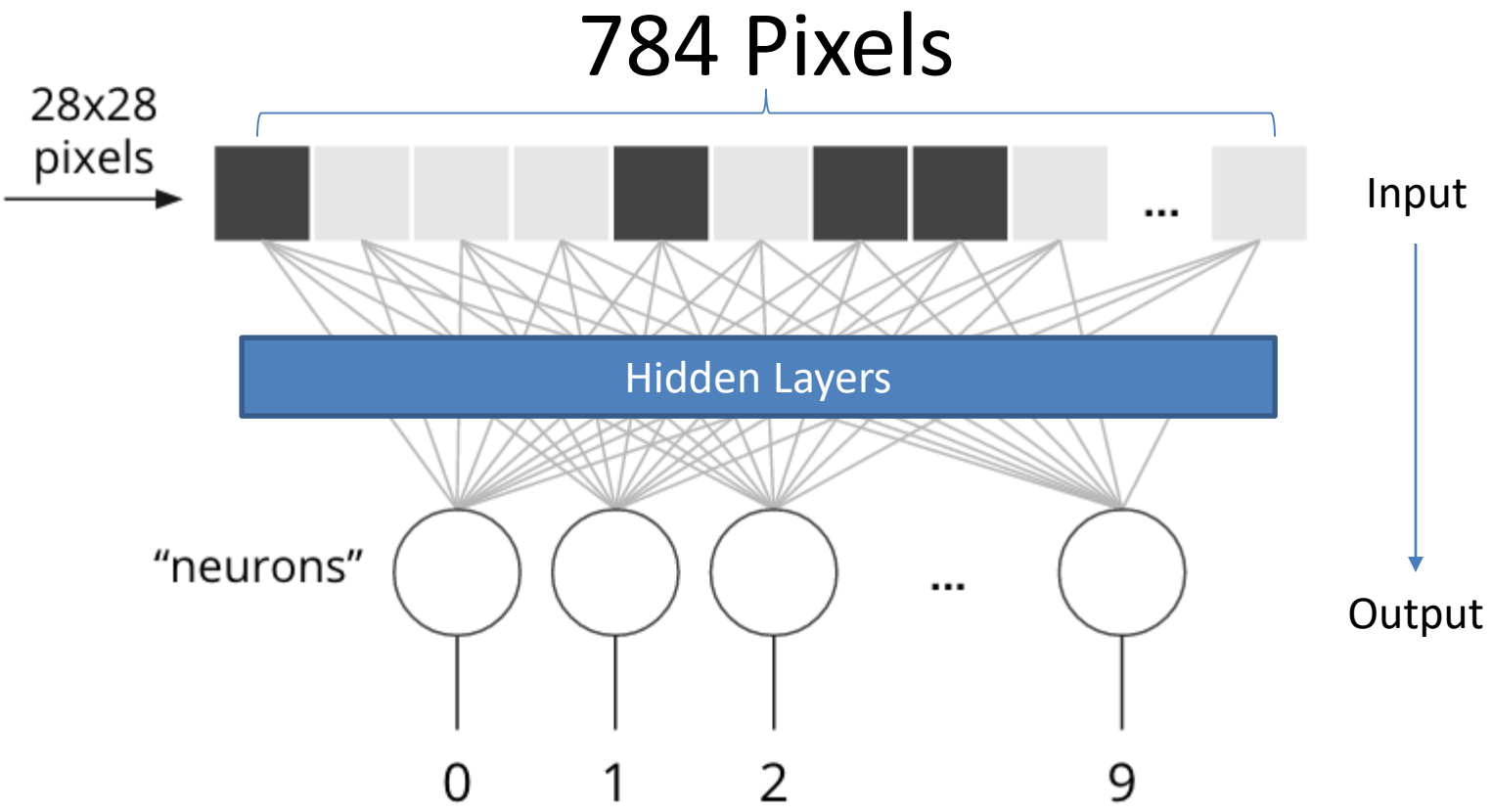
MNIST Database





Each of the output nodes fires a 0 or 1
(or the probability)