Deep Learning

Learning from Examples

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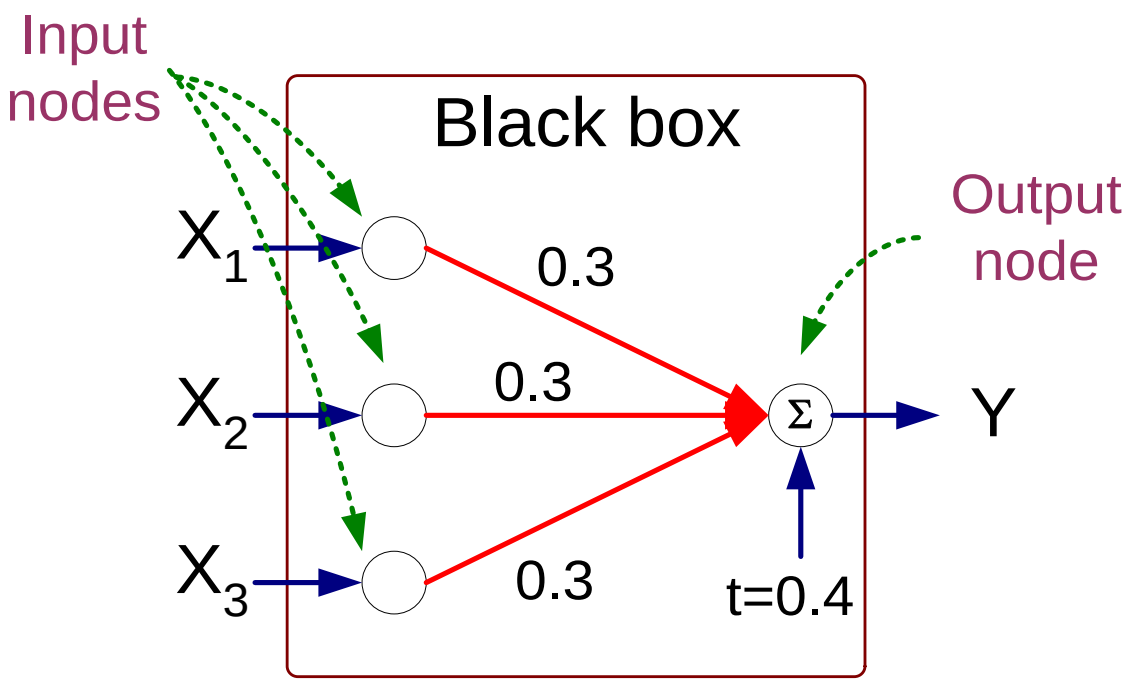
Deep Learning borrows ideas from how the **human brain** works. It simulates a network of **connected neurons** that process information in a **sophisticated** way. It is referred to as **Artificial Neural Networks (ANN)**.

The simplest form of an ANN is called a perceptron. It consists of a single neuron.

The Perceptron Network

Perceptron

X_1	X_2	X_3	Y
1	0	0	-1
1	0	1	1
1	1	0	1
1	1	1	1
0	0	1	-1
0	1	0	-1
0	1	1	1
0	0	0	-1



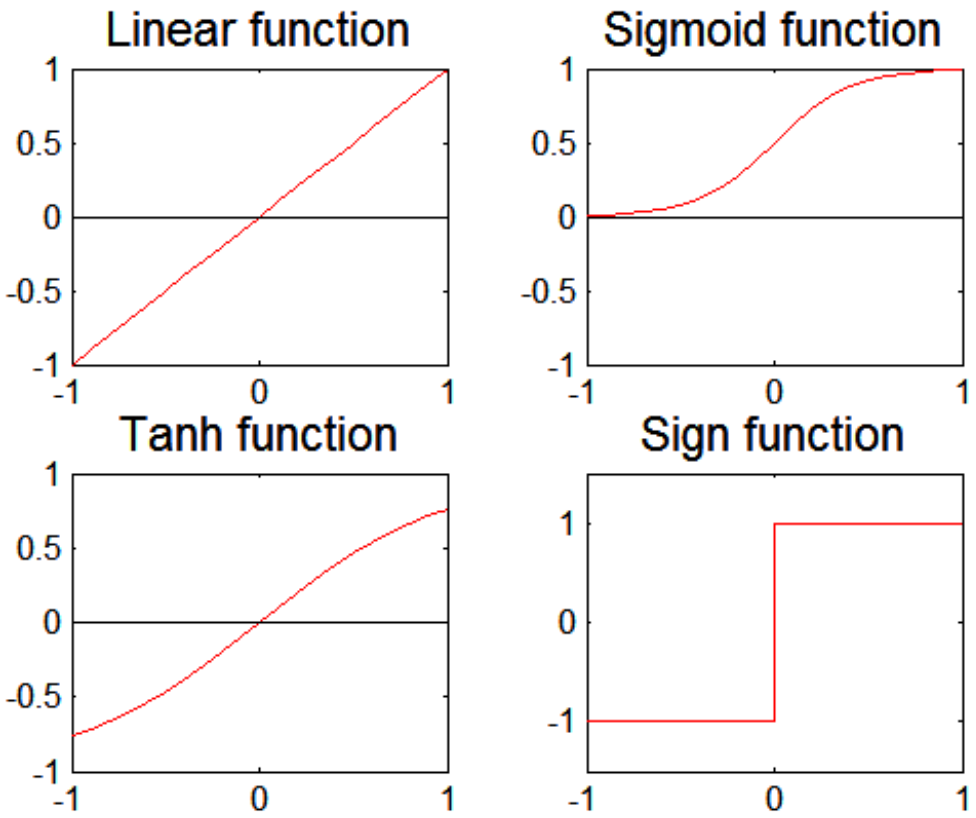
$$Y = sign(0.3X_1 + 0.3X_2 + 0.3X_3 - 0.4)$$

$$\text{where } sign(x) = \begin{cases} 1 & \text{if } x \geq 0 \\ -1 & \text{if } x < 0 \end{cases}$$

Source: Introduction to Data Mining, 2nd Edition

Various types of activation functions (f)

$$Y = f\left(\sum_i w_i X_i\right)$$



The perceptron creates a boundary classifier. It is a classifier that separates the points belonging to different classes.

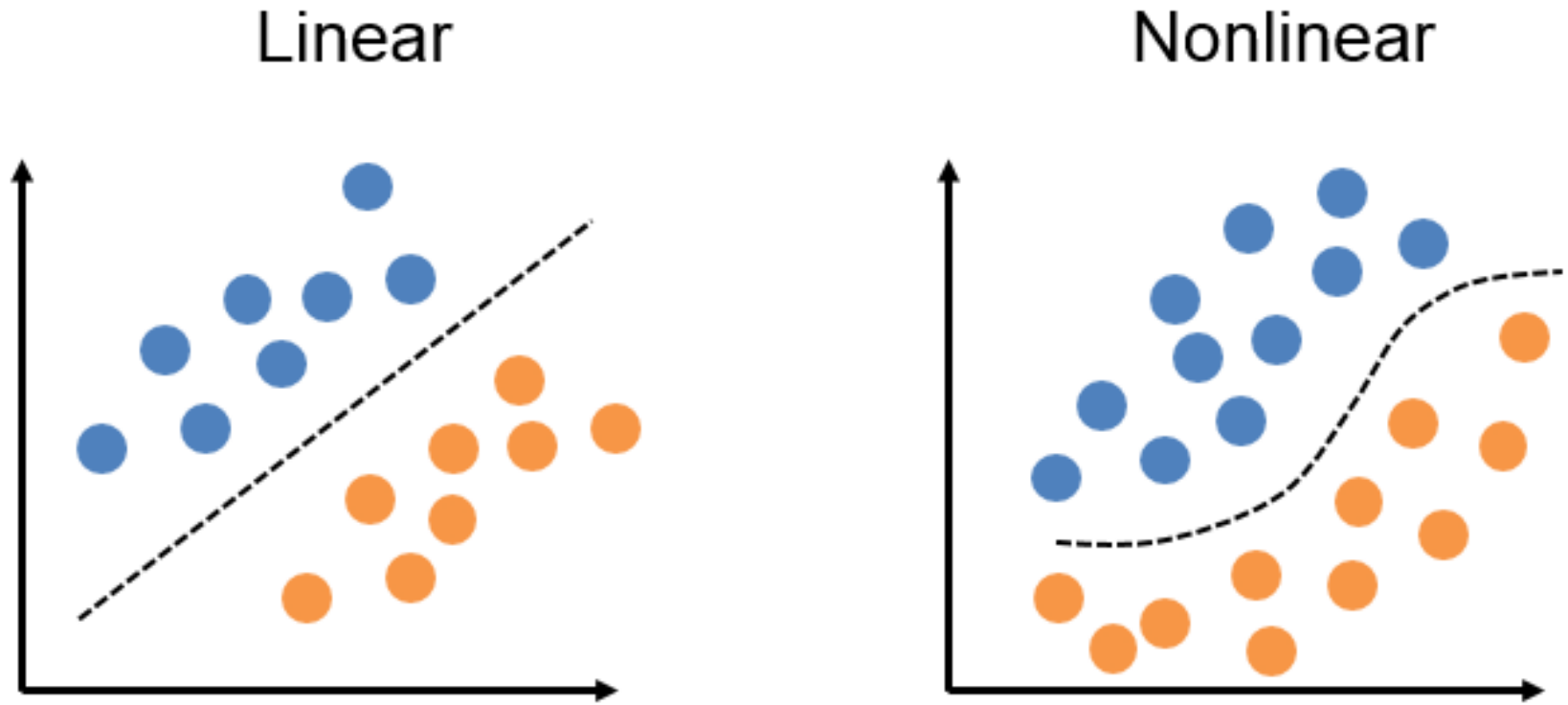


Image Source: https://jtsulliv.github.io/perceptron/

Linear vs Non-Linear Separable Data

- Since f(w,x) is a linear combination of input variables, decision boundary is linear

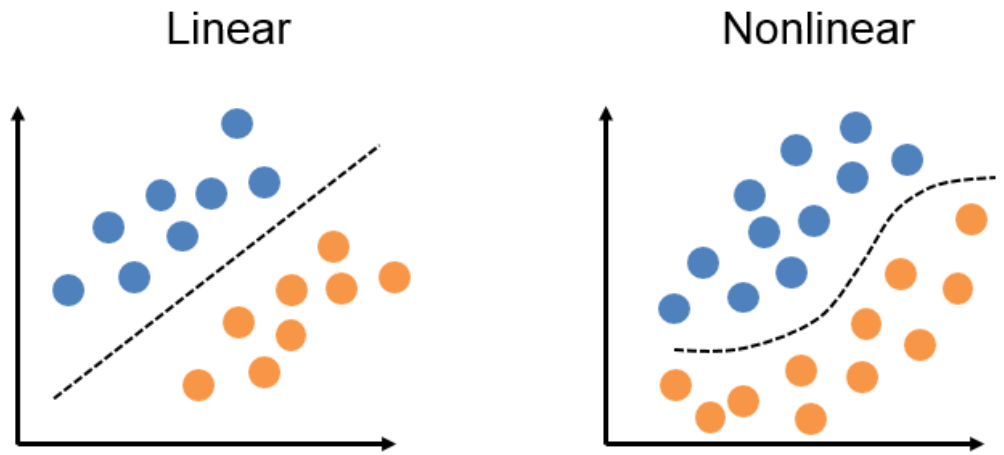


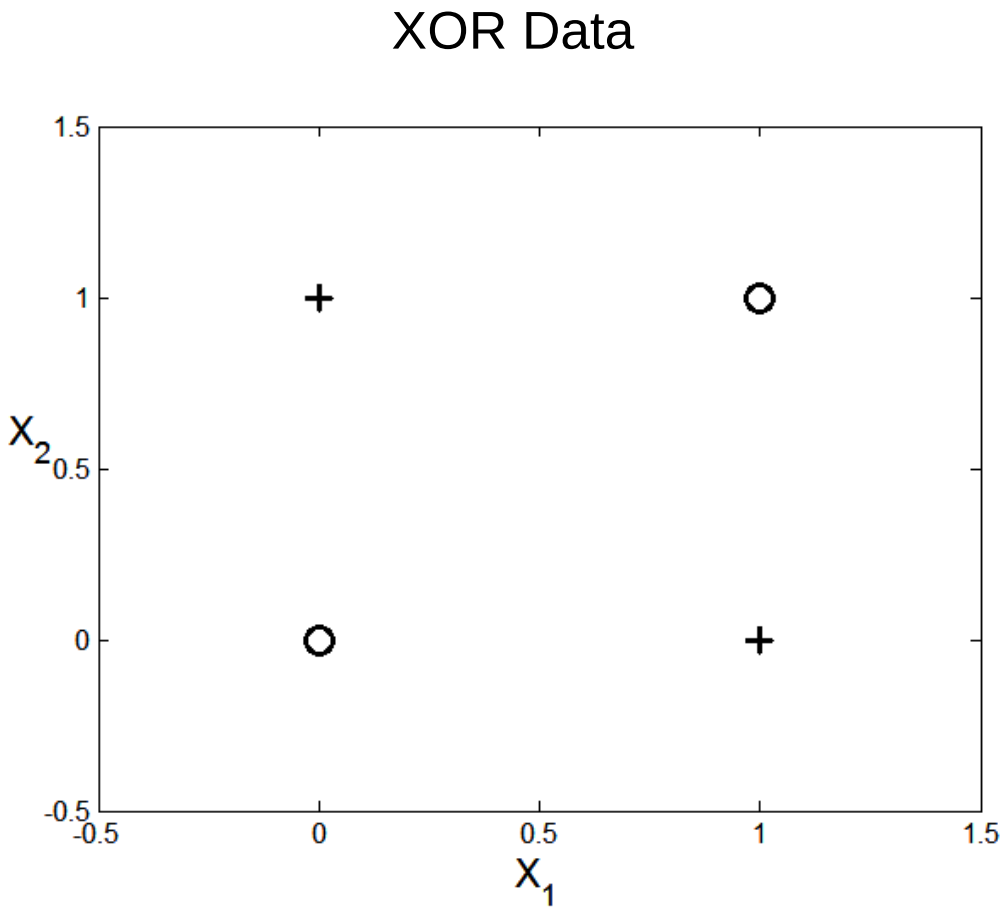
Image Source: https://jtsulliv.github.io/perceptron/

- For nonlinearly separable problems, a linear perceptron network fails because no single hyperplane can separate the data perfectly.

Nonlinearly Separable Data

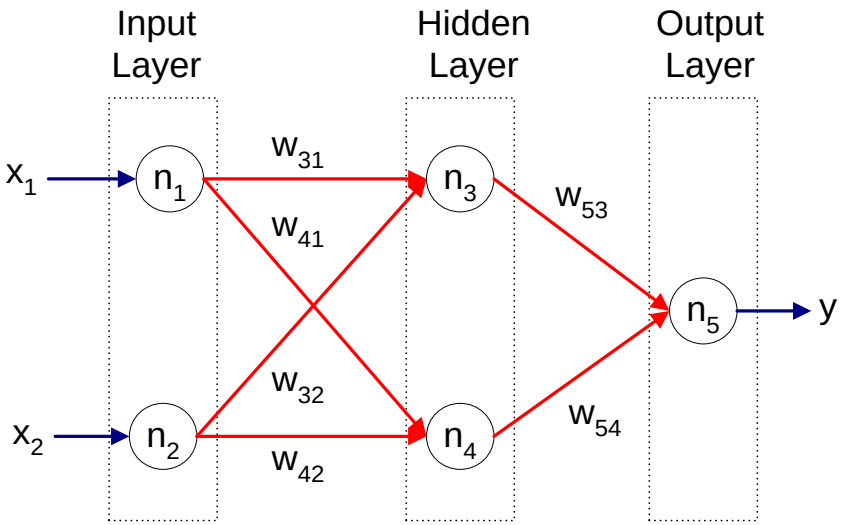
$$y = x_1 \oplus x_2$$

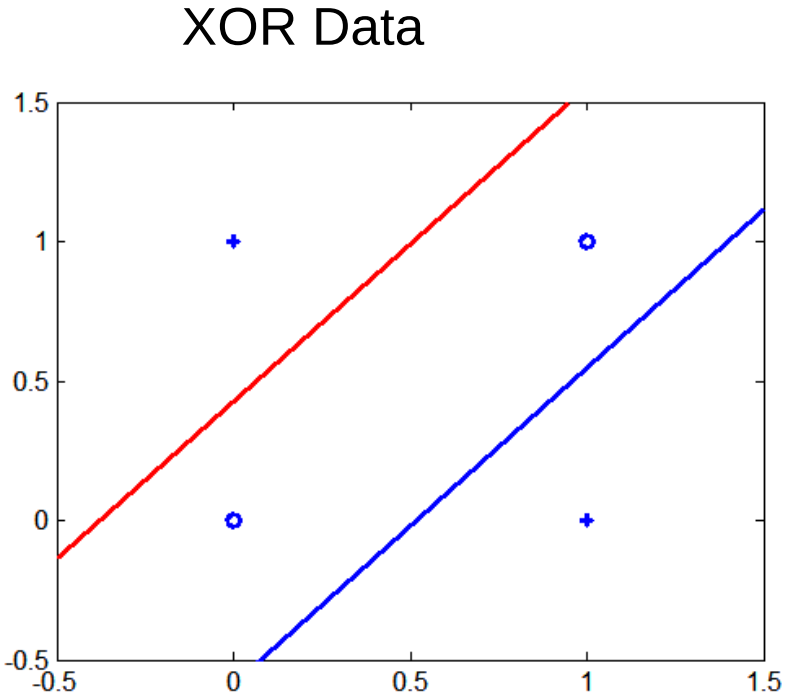
x_1	x_2	y
0	0	-1
1	0	1
0	1	1
1	1	-1



Multi-layer Neural Network

- Multi-layer neural network can solve any type of classification task involving nonlinear decision surfaces

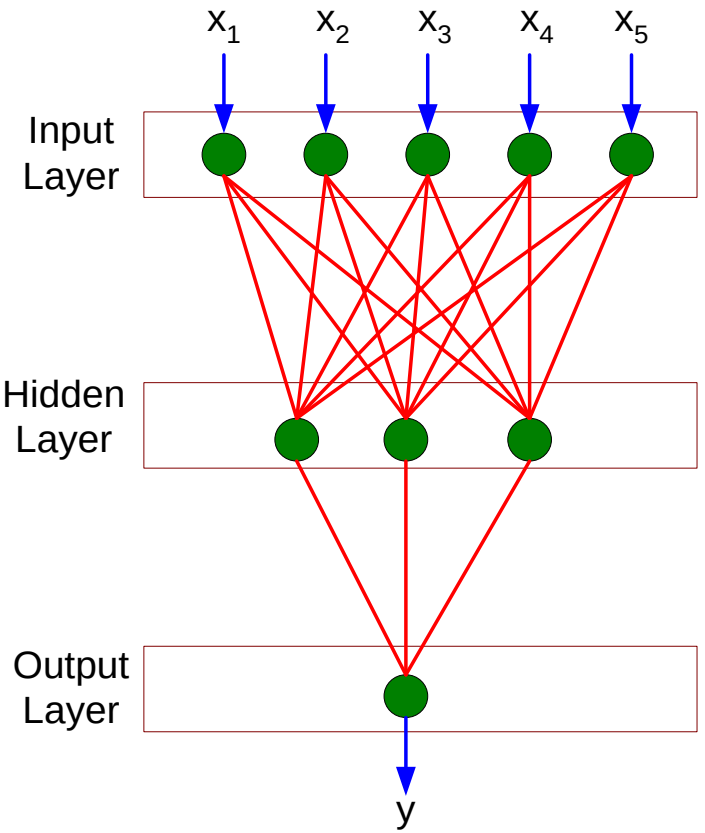




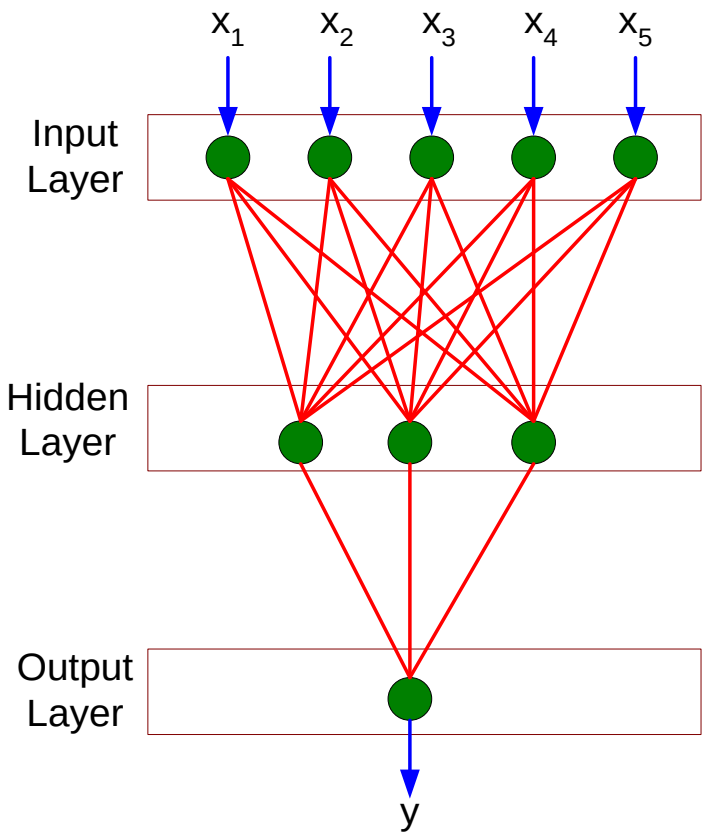
The Multi-Layer Network

Multilayer Neural Network

- Hidden layers
  - intermediary layers between input & output layers
- More general activation functions (sigmoid, tanh, etc.)

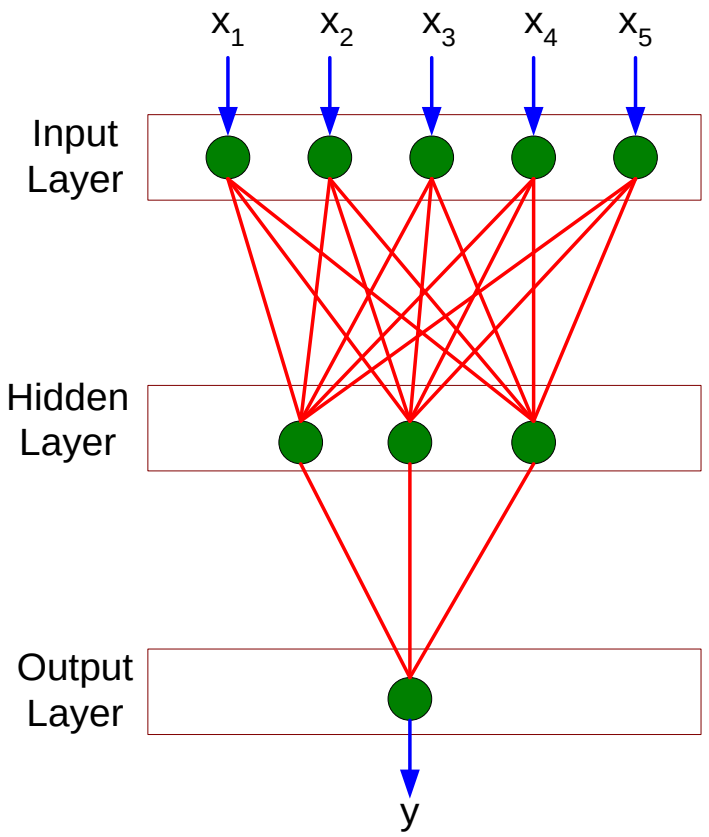


A Multi-layer NN contains multiple nodes that combine the input in different ways to produce the output.

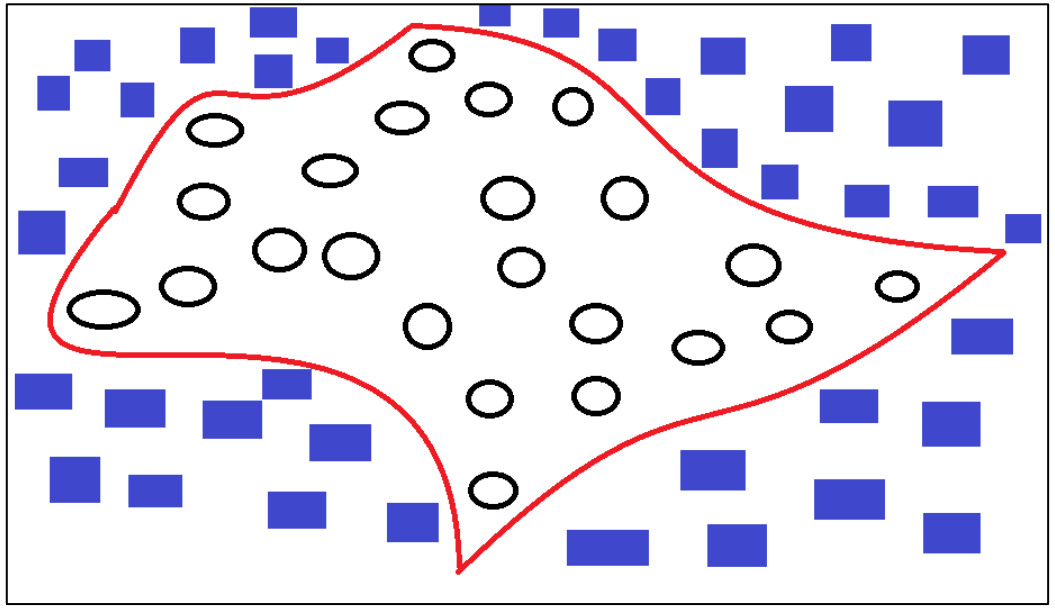


The output is a sophisticated function in the input.

$$y = f(x)$$



It can generate arbitrarily-shaped boundaries.



Deep Learning occurs when the network has **many hidden layers**.

It is used for **learning from examples.**