DEEP LEARNING WITH PYTHON

Meta Brains

Introduction to Deep Learning

- Artificial Neural Networks (ANN)
- Propagation of information in ANNs
- Neural Network Architectures
- Activation Functions
- Gradient Descent Algorithm
- Summary Overview of Neural Networks
- Implementation of ANN in Python
- Convolutional Neural Networks (CNN)
- Implementation of CNN in Python

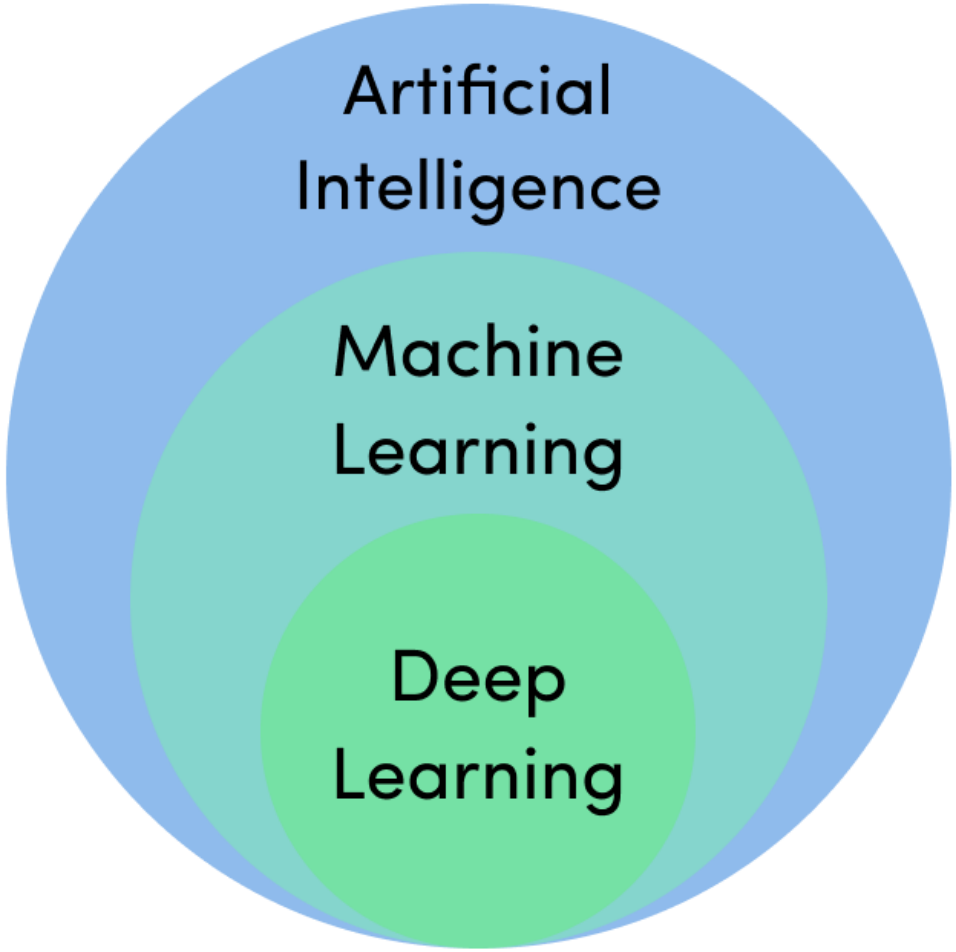
What is deep learning? 01

02 Why is Deep Learning Important?

Software and frameworks 03

Meta Brains

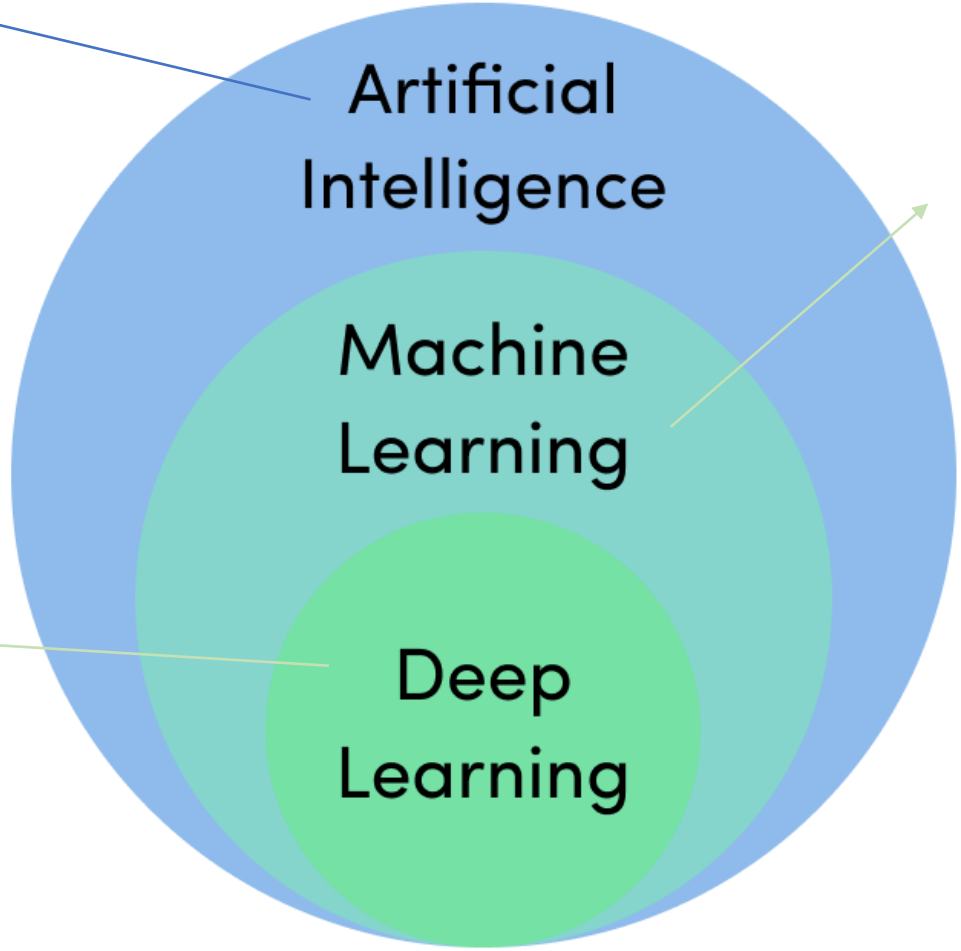
What is Deep Learning



Meta Brains

What is Deep Learning

AI: The computer performs tasks without explicitly programming them .



Programming: Data+ Rules = Answers

ML: Data + Answers = Rules

DL: Performing Machine learning tasks using deep neural network(DNN)

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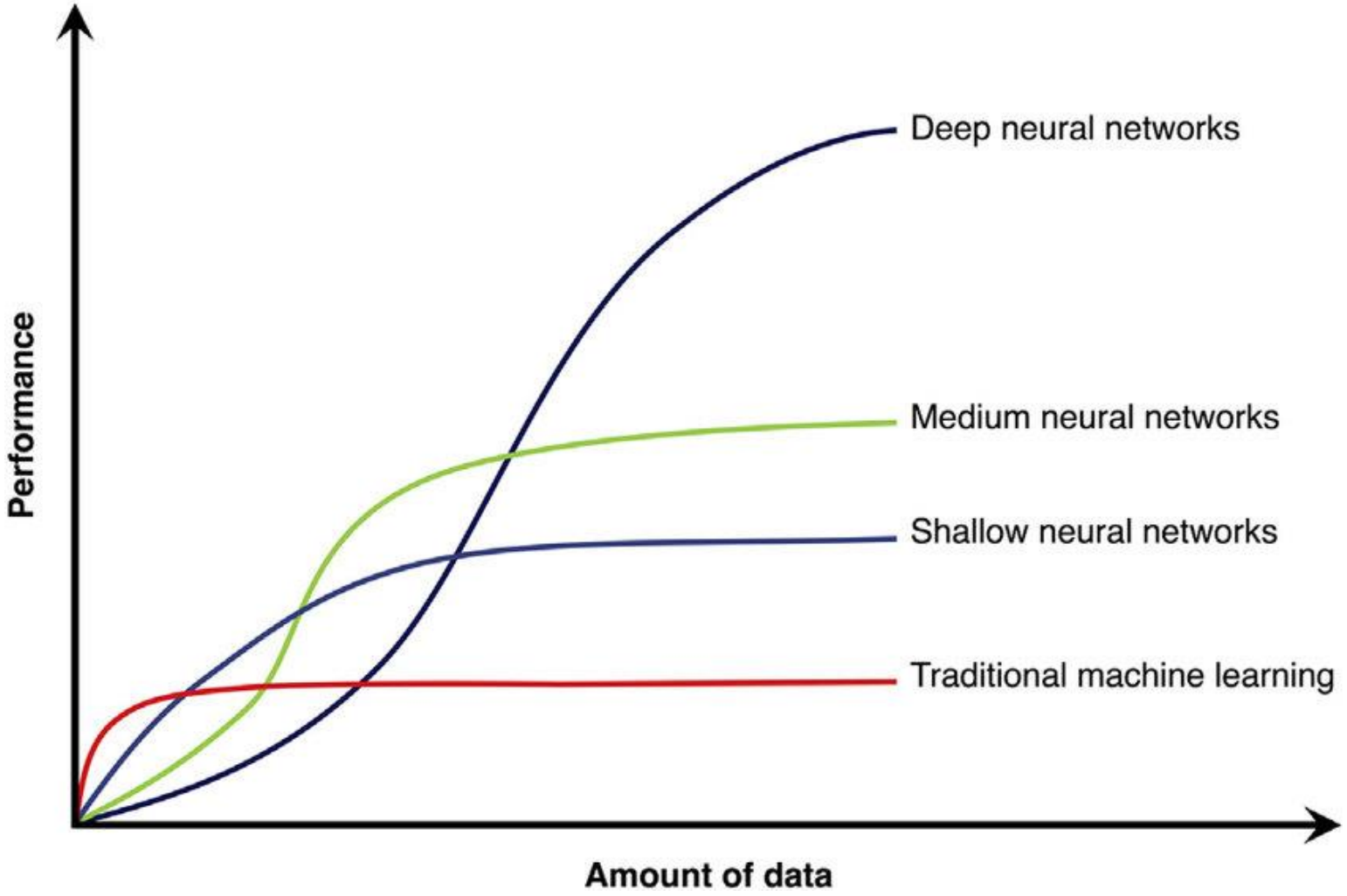
Why is Deep Learning Important?



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Software and Frameworks

julia

mxnet

DEEP LEARNING

theano

Microsoft CNTK

Caffe2

Chainer

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Introduction 01

02 Anatomy and function of neurons

An introduction to the neural network 03

04 Architecture of a neural network

Introduction

An artificial neuron network is a computational model that mimics the way nerve cells work in the human brain.

There are more complicated and high-end models in the DL approach. However, ANN is a vital element in all the models in DL.

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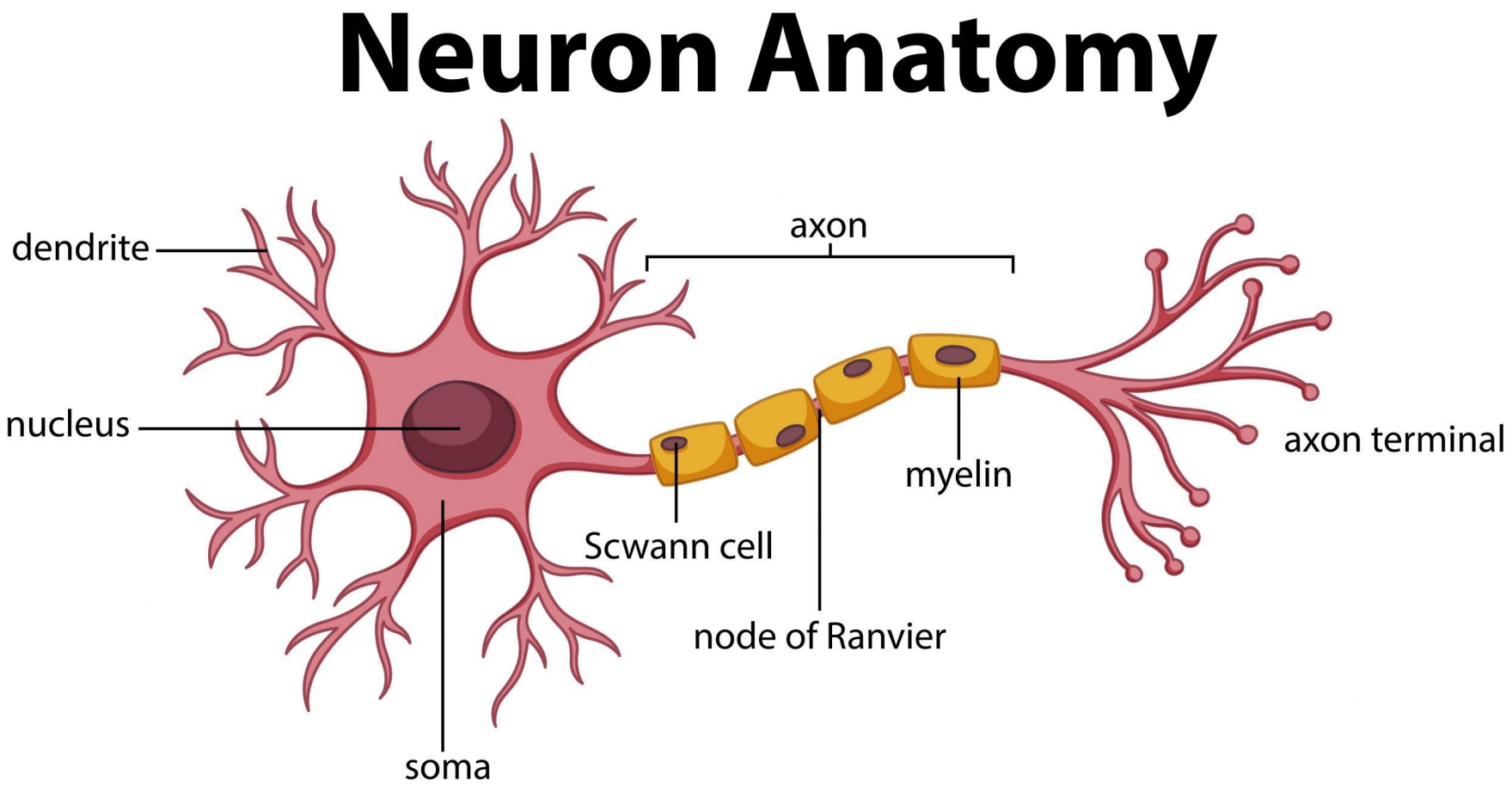
Anatomy and function of neurons



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An introduction to the neural network

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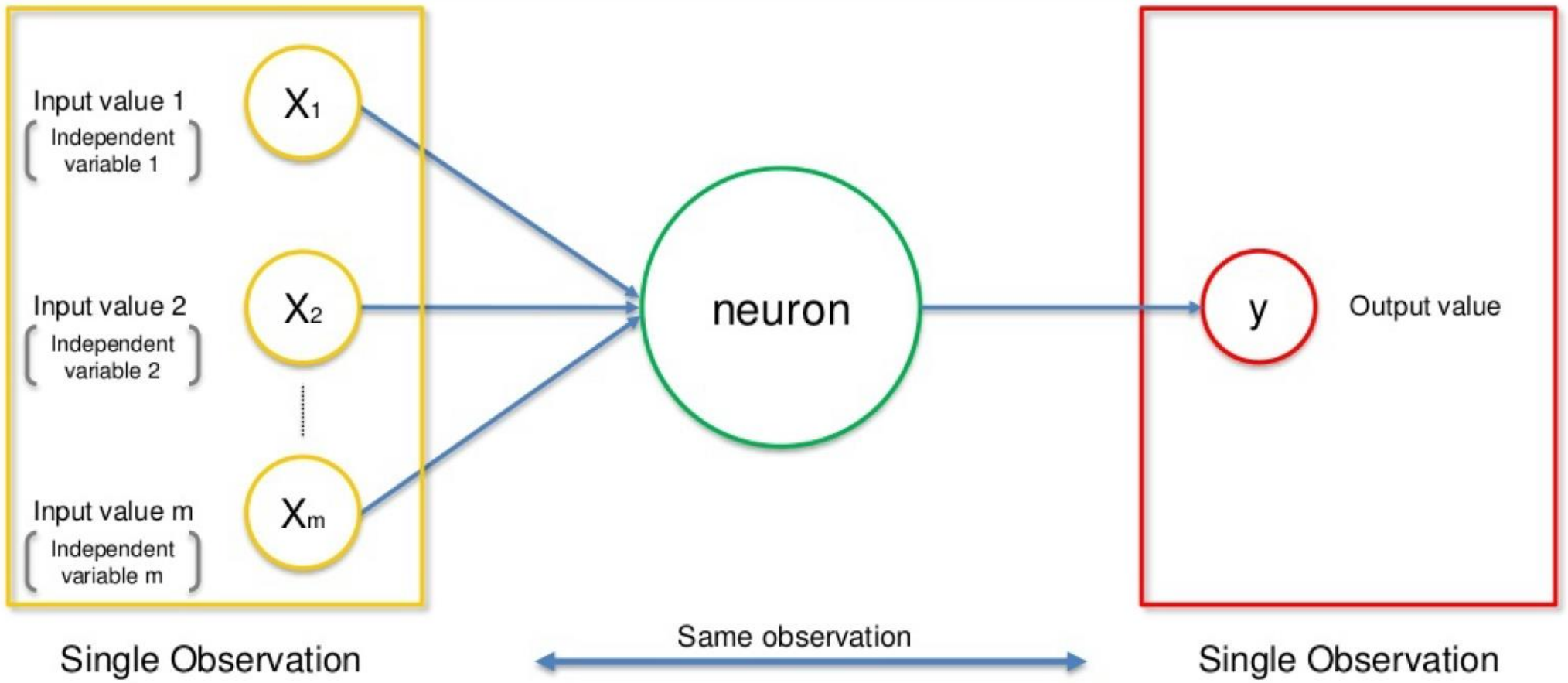
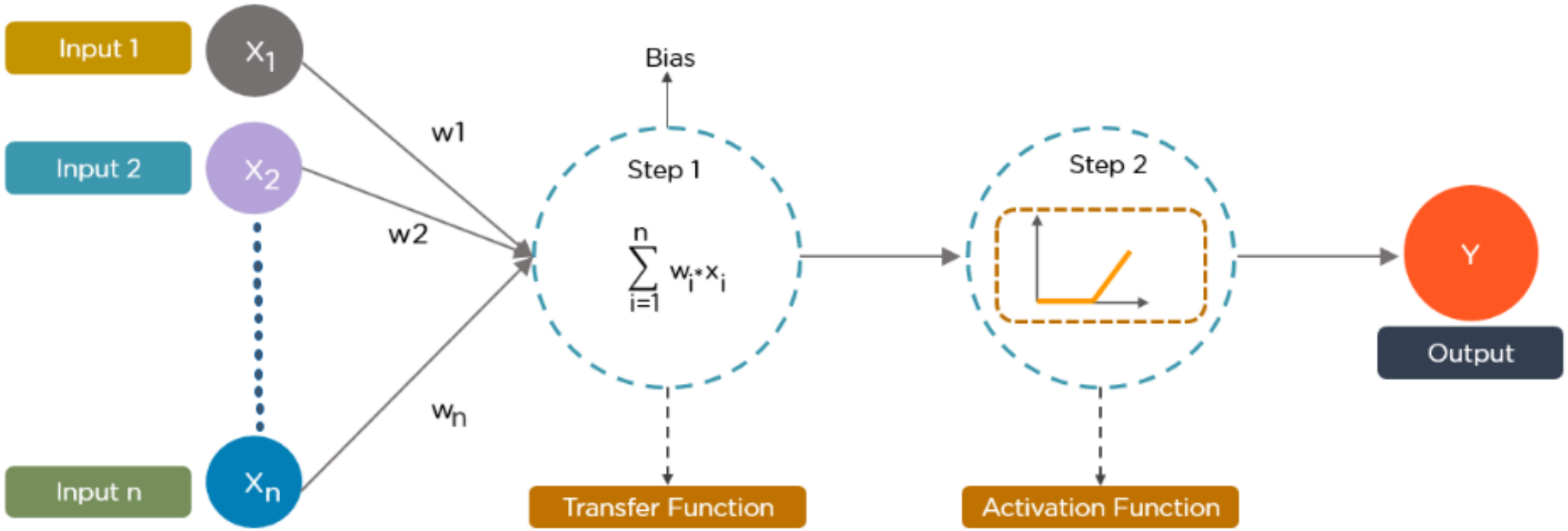
04 Architecture of a neural network

An introduction to the neural network (1/2)



An introduction to the neural network (2/2)



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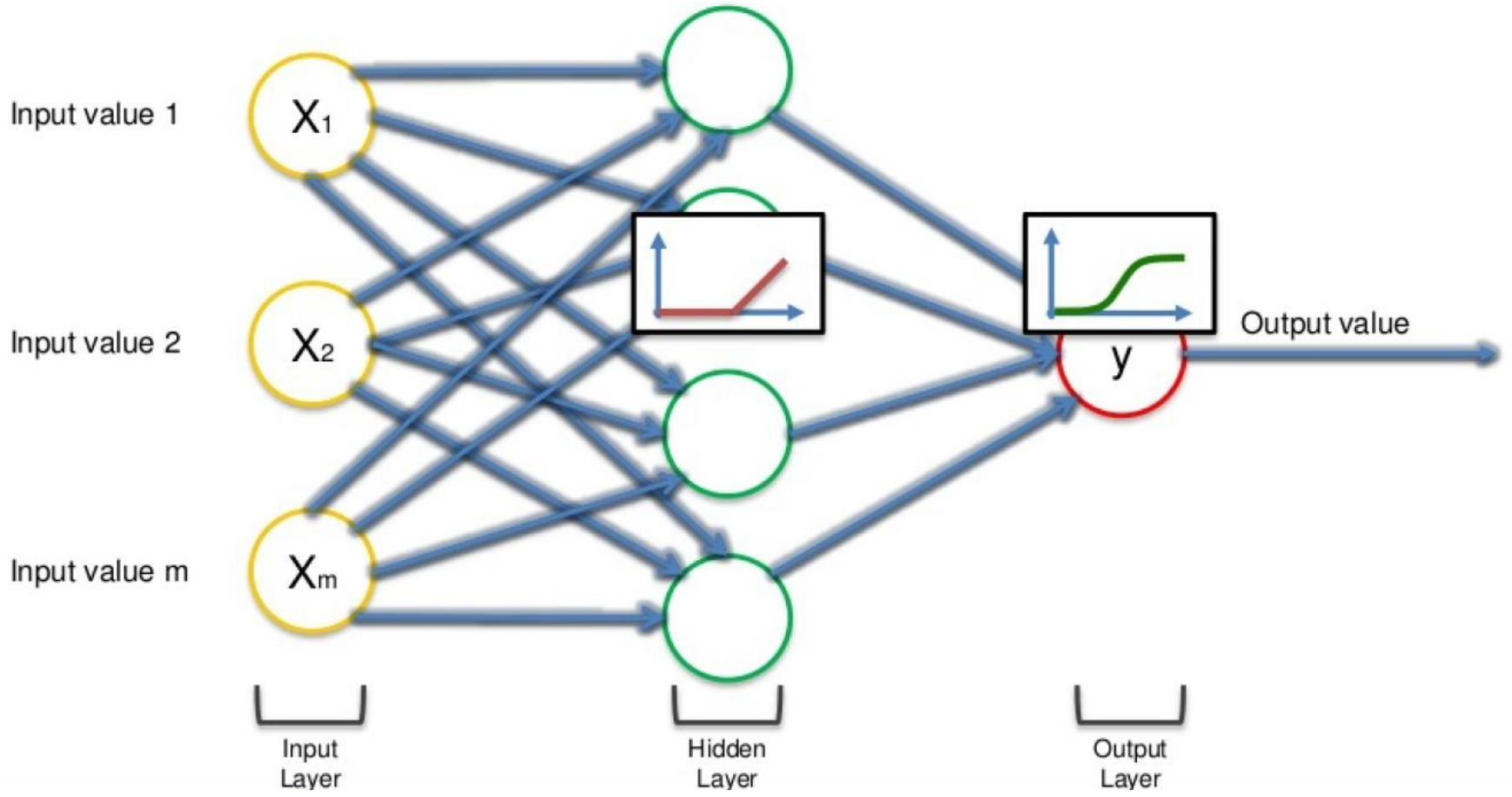
04 **Architecture of a neural network**

Architecture of a neural network



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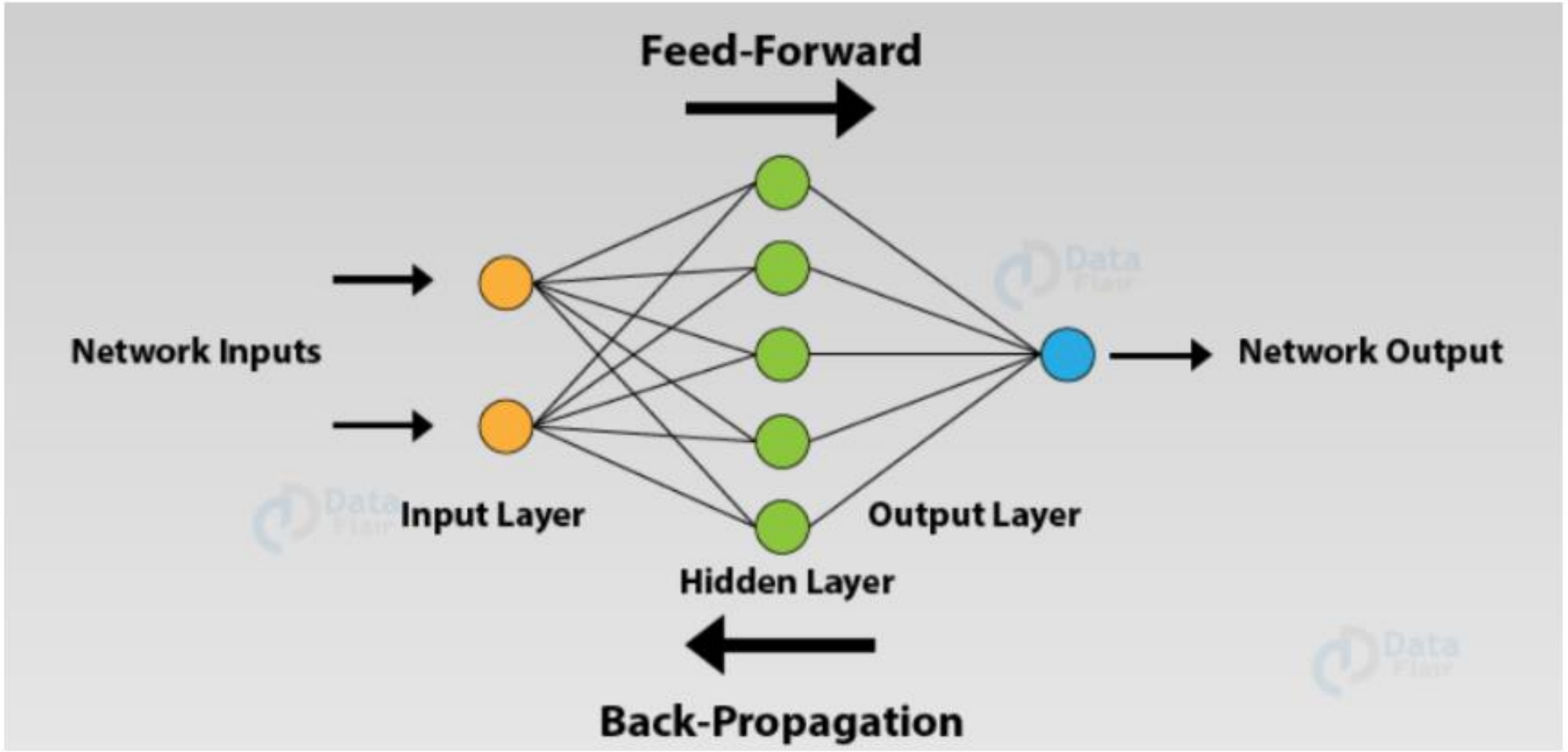
Feed-forward and Back Propagation Networks 01

02 Backpropagation In Neural Networks

Minimizing the cost function using backpropagation 03


Feed-Forward
Network Inputs
Network Output
Input Layer
Output Layer
Hidden Layer
Back-Propagation

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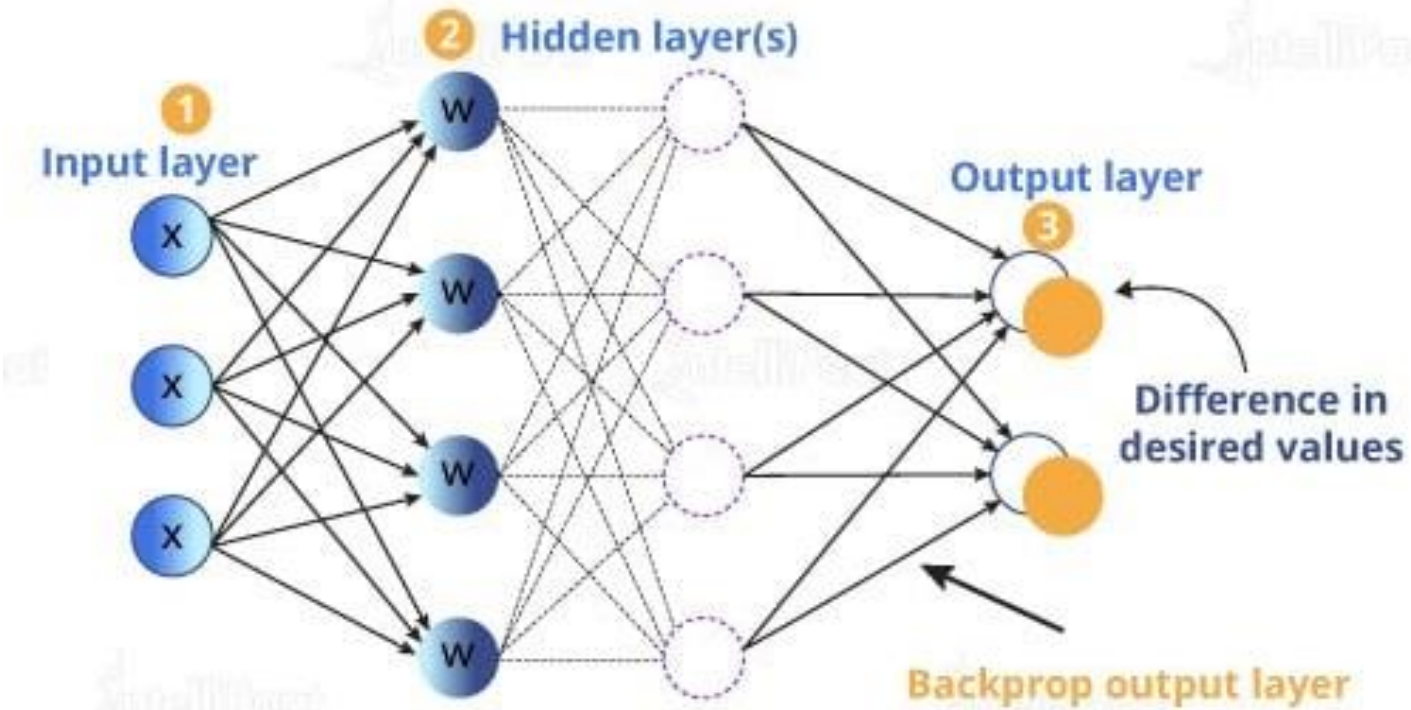
Back Propagation



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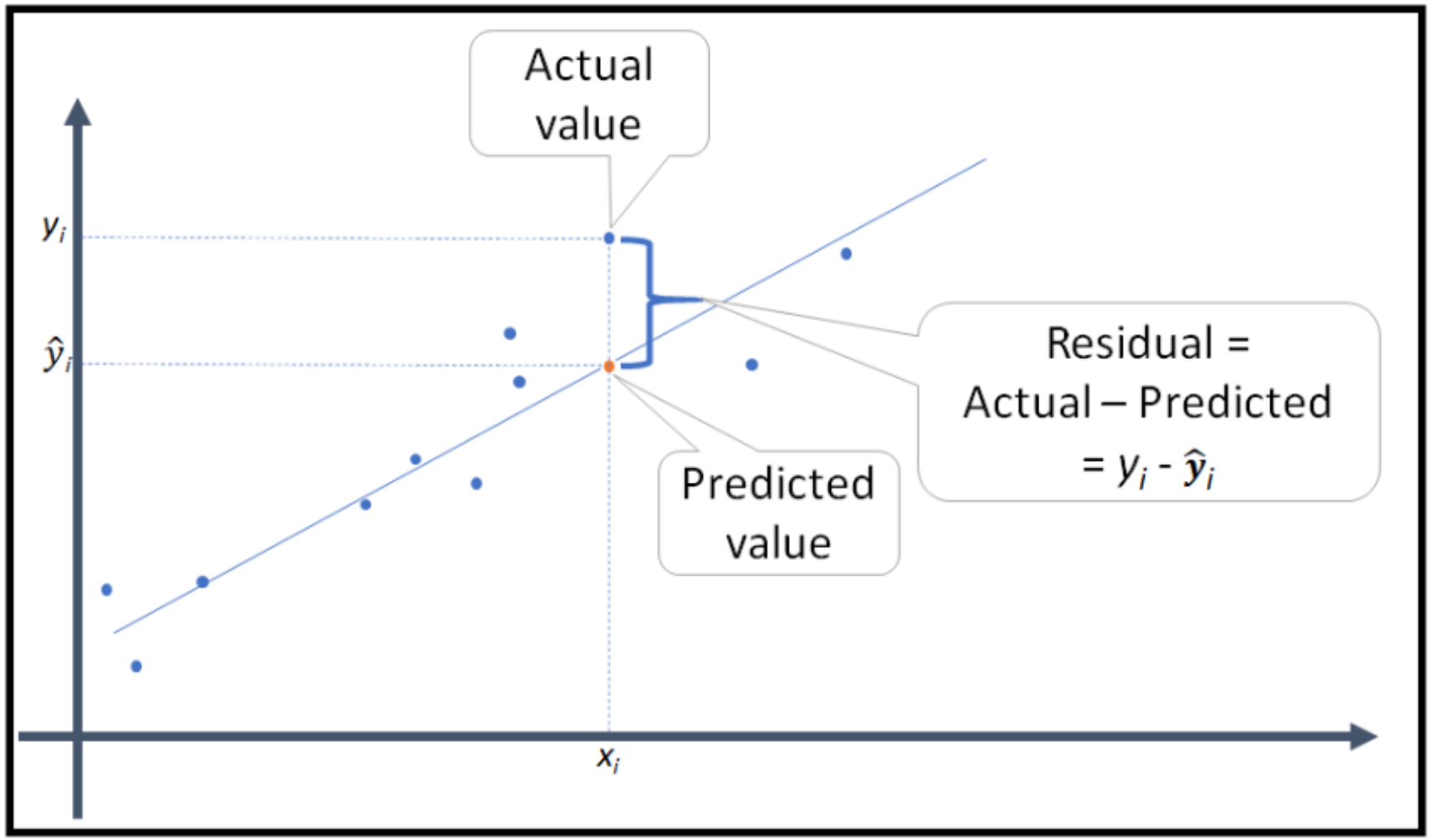
Actual value
y_i
$\hat{y}_i$
Residual = Actual – Predicted = y_i - $\hat{y}_i$
Predicted value
x_i

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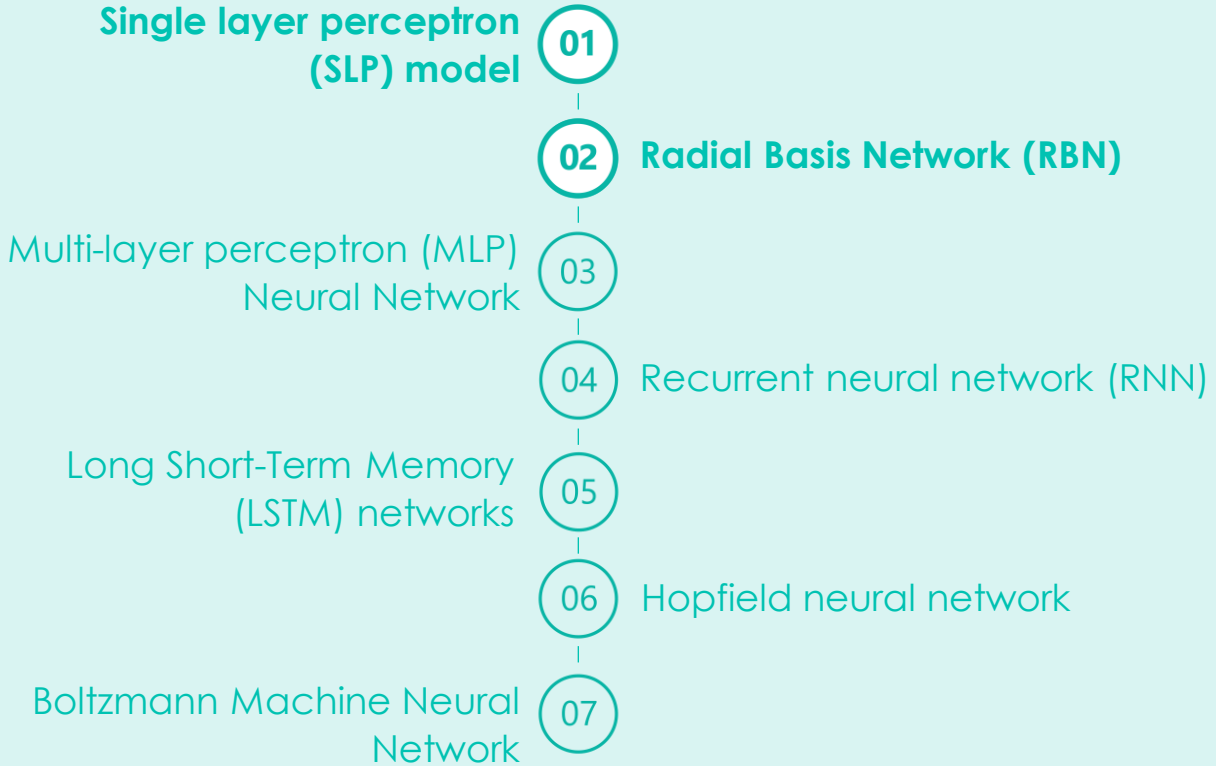
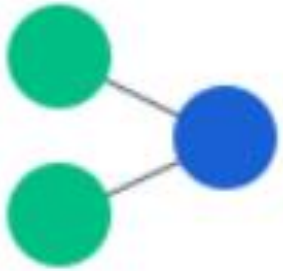


NN Architecture Types



Single Layer Perceptron

Radial Basis Network (RBN)

Input Unit

Hidden Unit

Backfed Input Unit

Output Unit

Feedback with Memory Unit

Probabilistic Hidden Unit

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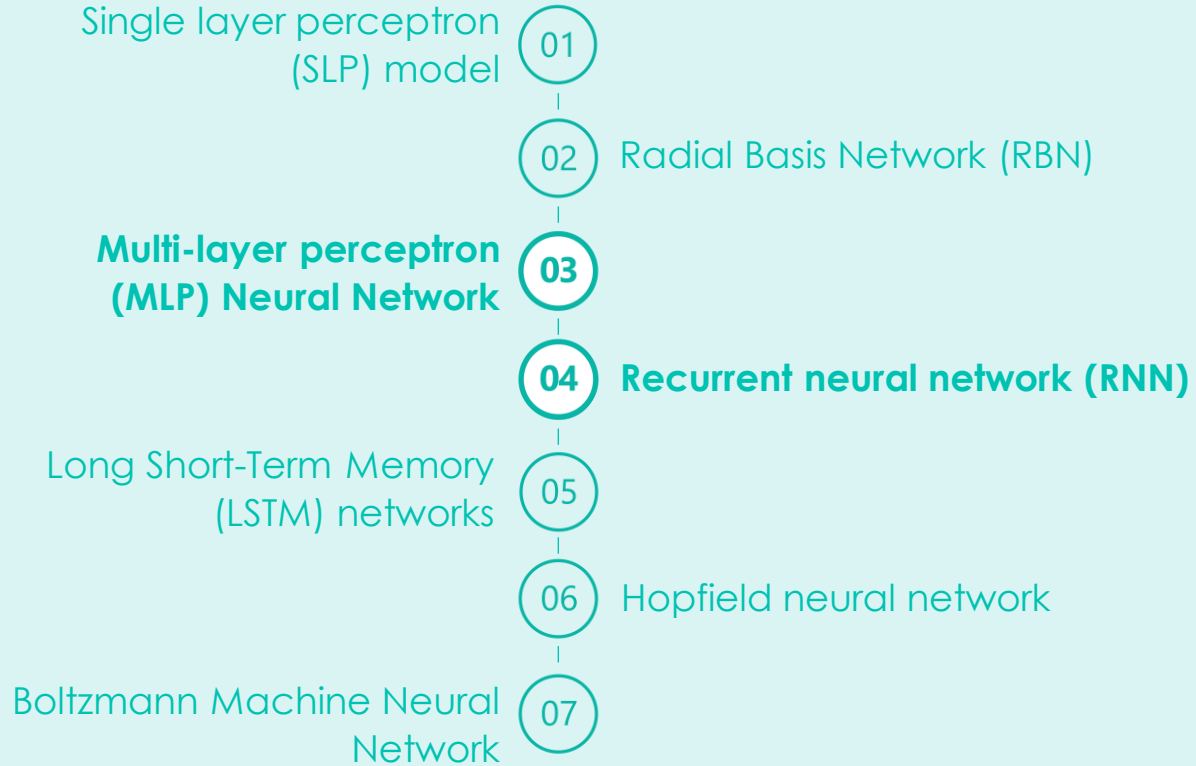
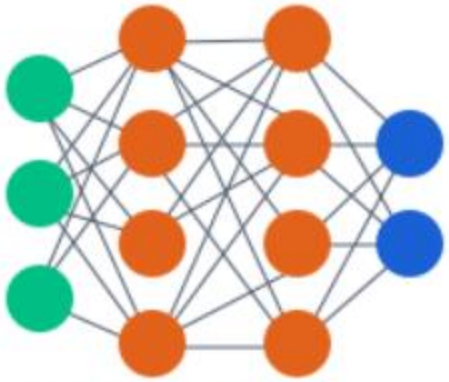
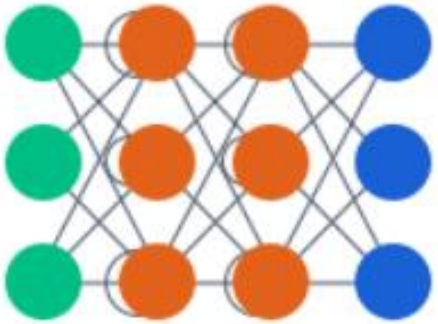


NN Architecture Types



Multi Layer Perceptron



Recurrent Neural Network

Input Unit

Hidden Unit

Backfed Input Unit

Output Unit

Feedback with Memory Unit

Probabilistic Hidden Unit

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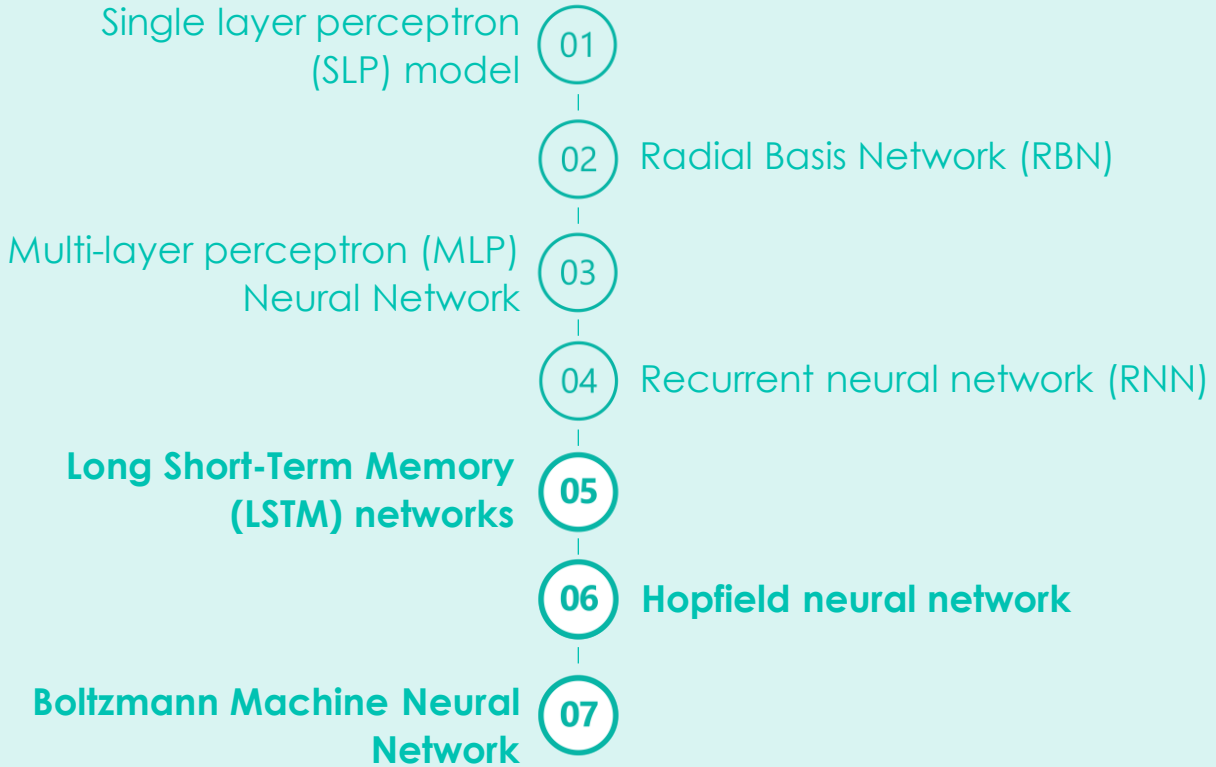
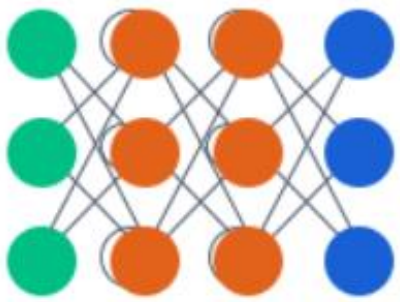


NN Architecture Types



LSTM Recurrent
Neural Network

Hopfield Network

Boltzmann Machine

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04 Hyperbolic tangent function

Softmax function 05

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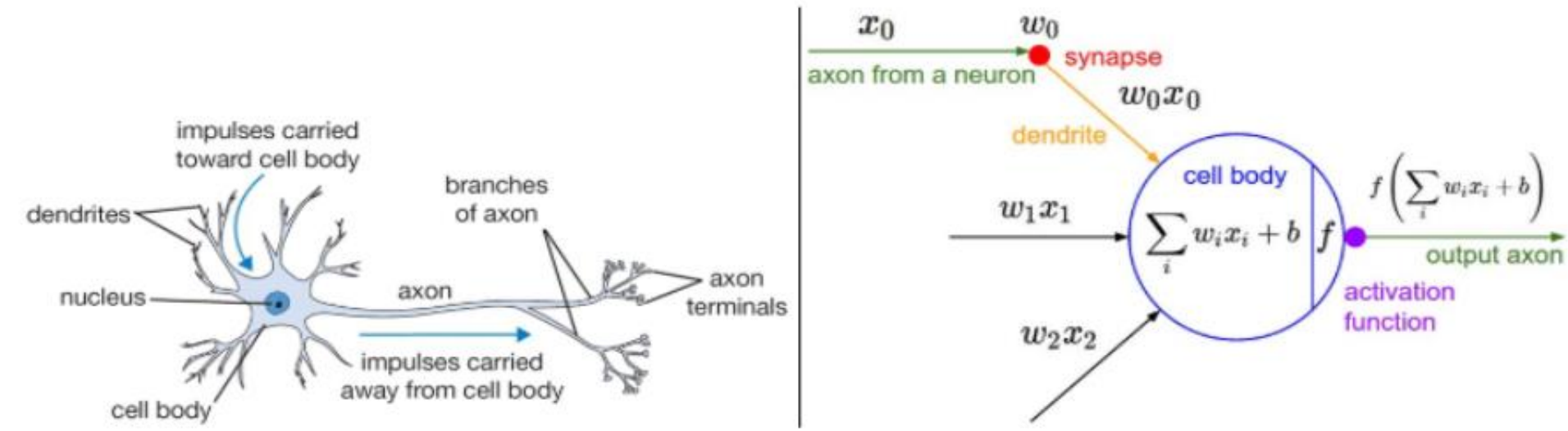
Leaky Rectified Linear Unit function 07

What is the Activation Function? – Superpower for ANN (1/2)

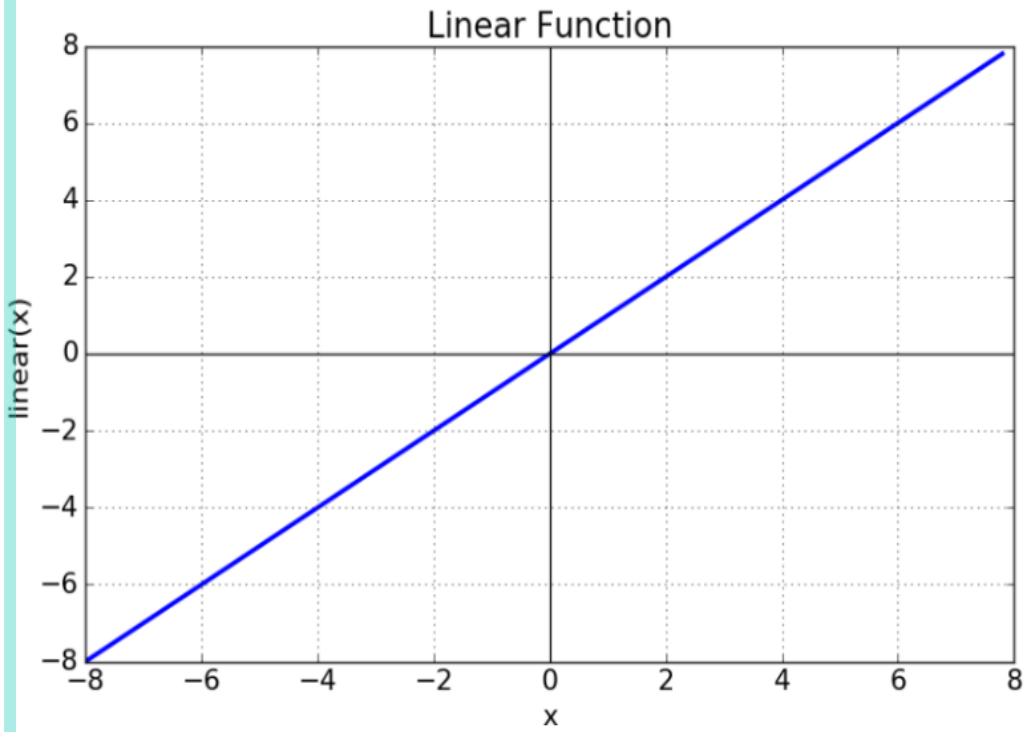
So what actually Activation Function (AF) do? AF is a function that is added into an ANN to help the network learn complex patterns in the data.

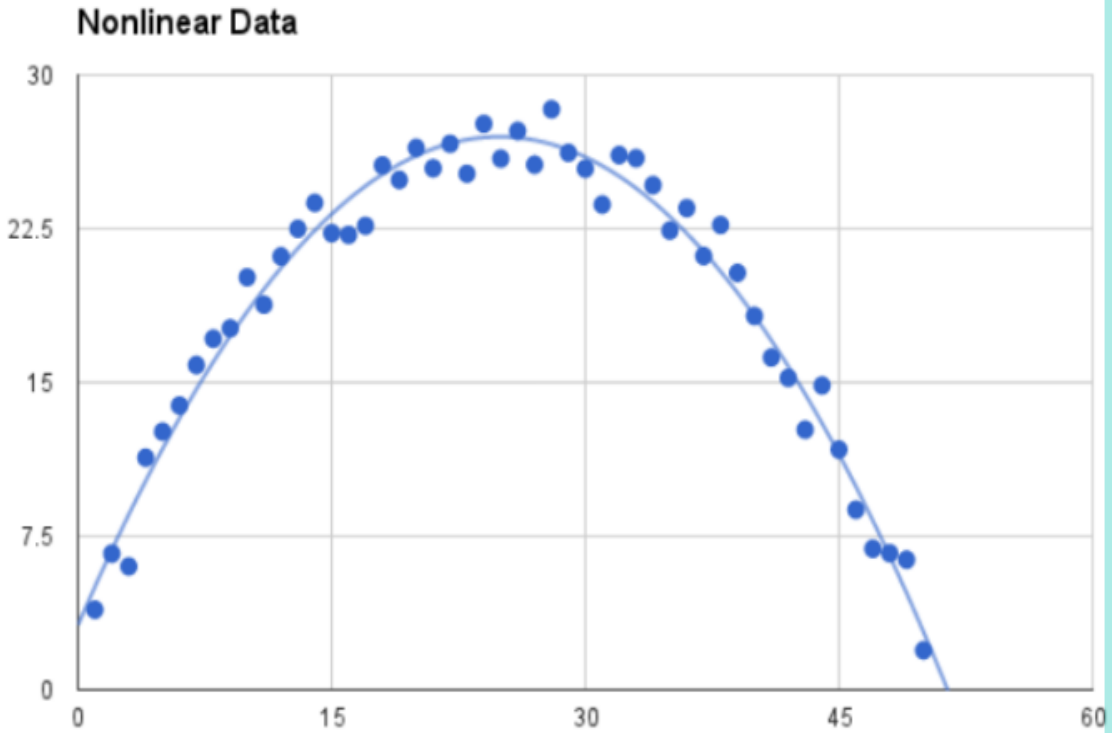


A cartoon drawing of a biological neuron (left) and its mathematical model (right).

Meta Brains

What is the Activation Function? – Superpower for ANN (2/2)





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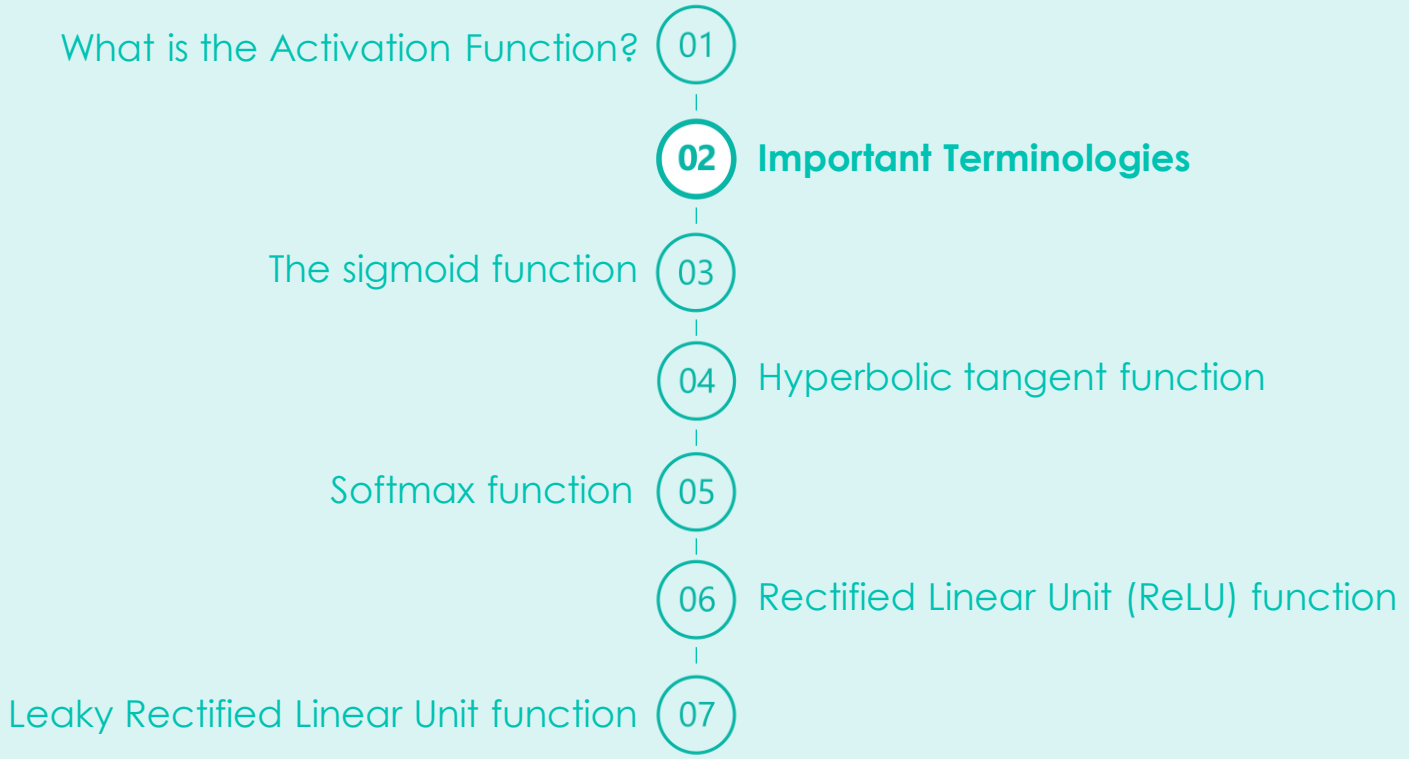

Important Terminologies

1. **Differential function:** Change in Y-axis w.r.t change in X-axis (slope!)

2. **Monotonic function:** A function which is increasing on its entire domain or decreasing on its entire domain.

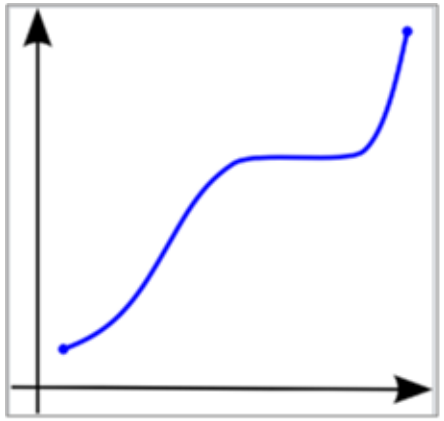

Figure 1 - A monotonically increasing function

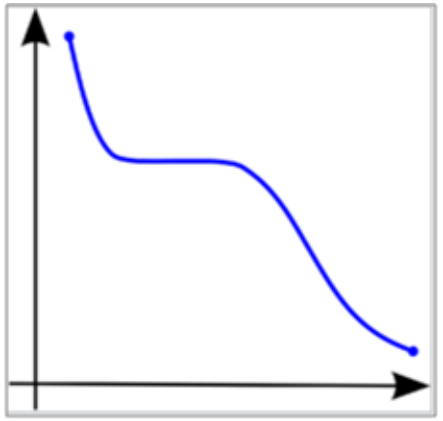

Figure 2 - A monotonically decreasing function

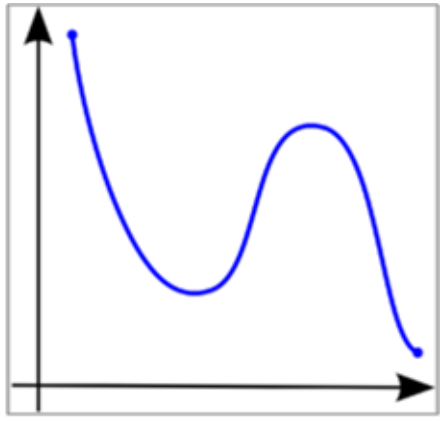

Figure 3 - A function that is not monotonic

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04 Hyperbolic tangent function

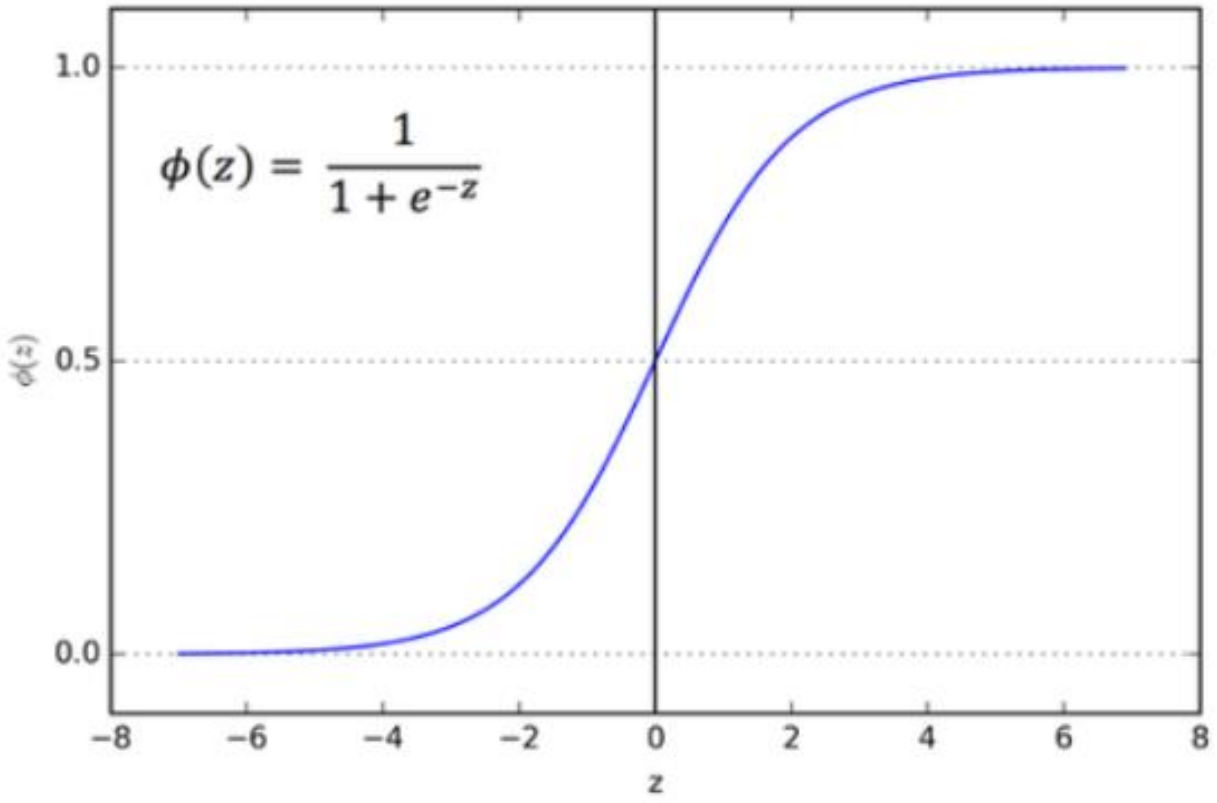
05 Softmax function

06 Rectified Linear Unit (ReLU) function

07 Leaky Rectified Linear Unit function

Non-Linear Activation Functions (1/5)

1. Sigmoid function



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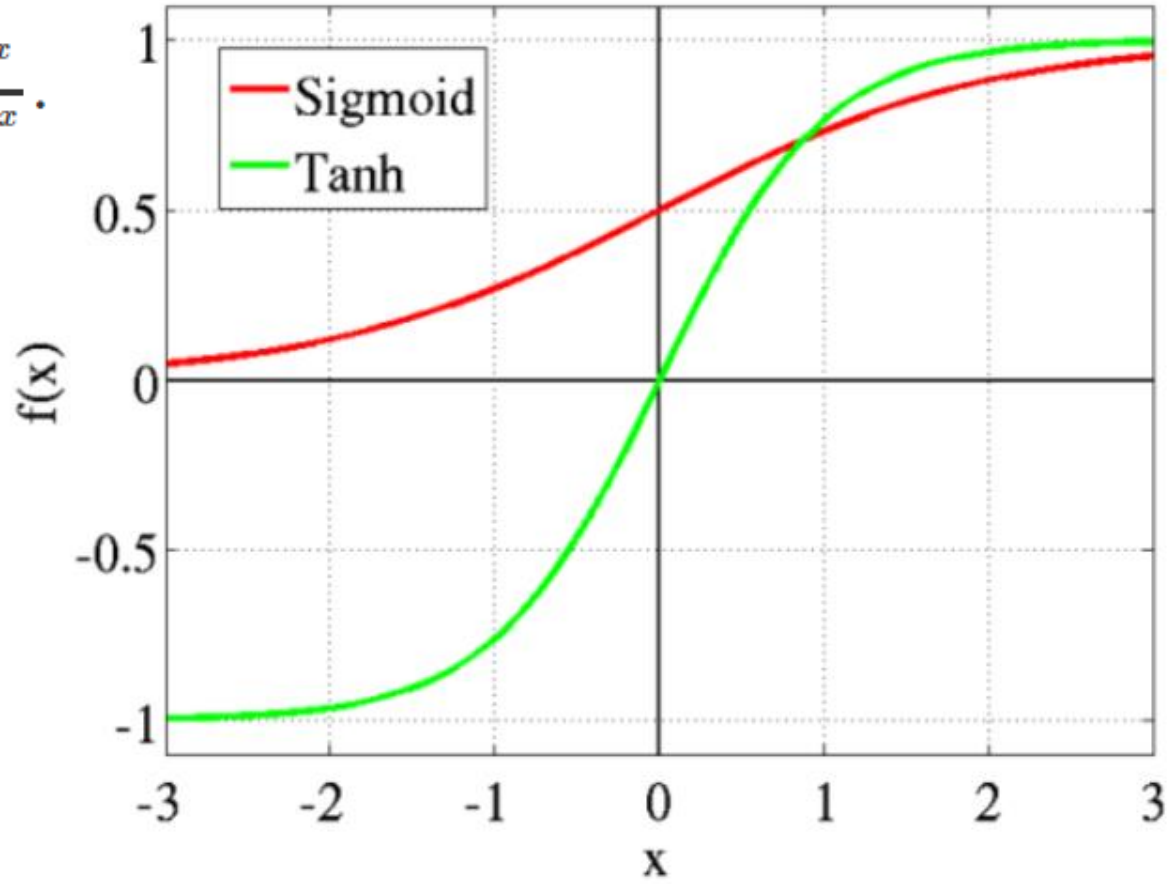
Non-Linear Activation Functions (2/5)

2. Hyperbolic Tangent function (Tanh)

$$tanh(x) = \frac{e^{x} - e^{-x}}{e^{x} + e^{-x}}.$$



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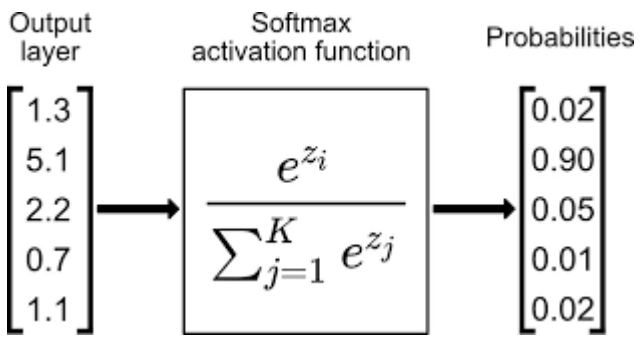
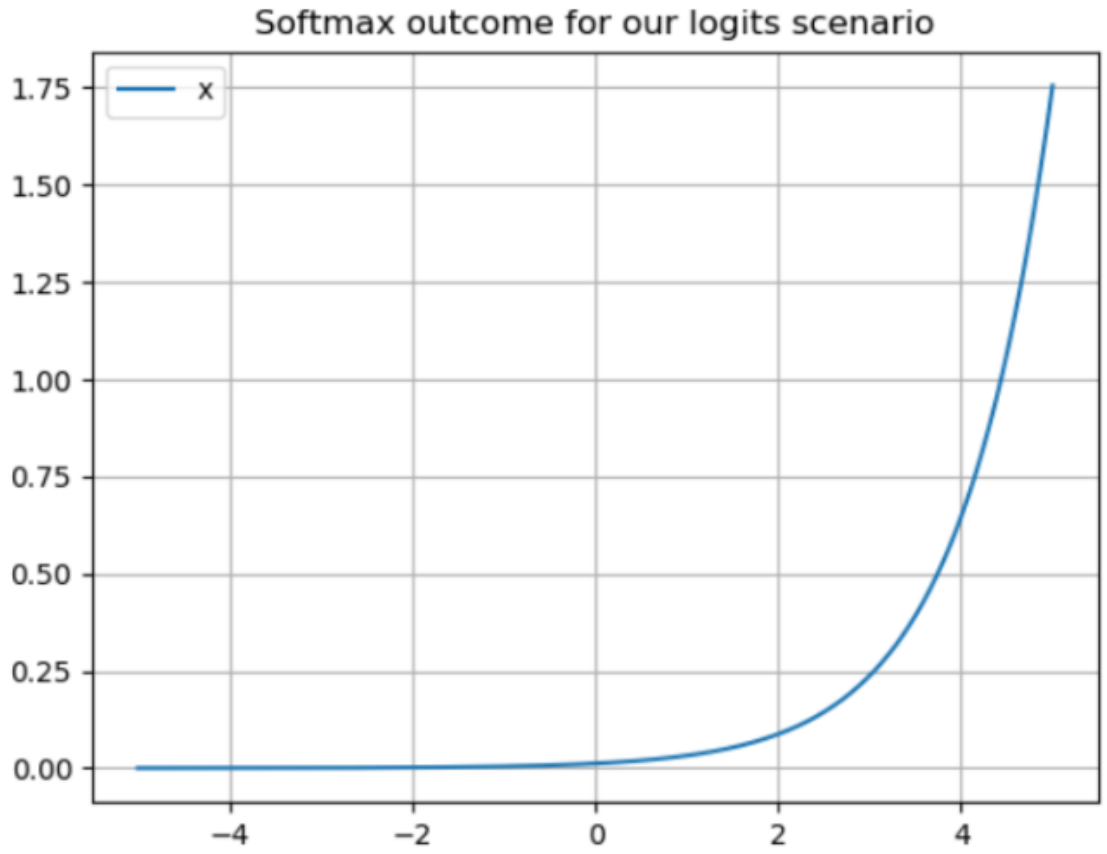
Non-Linear Activation Functions (3/5)

3. Softmax function





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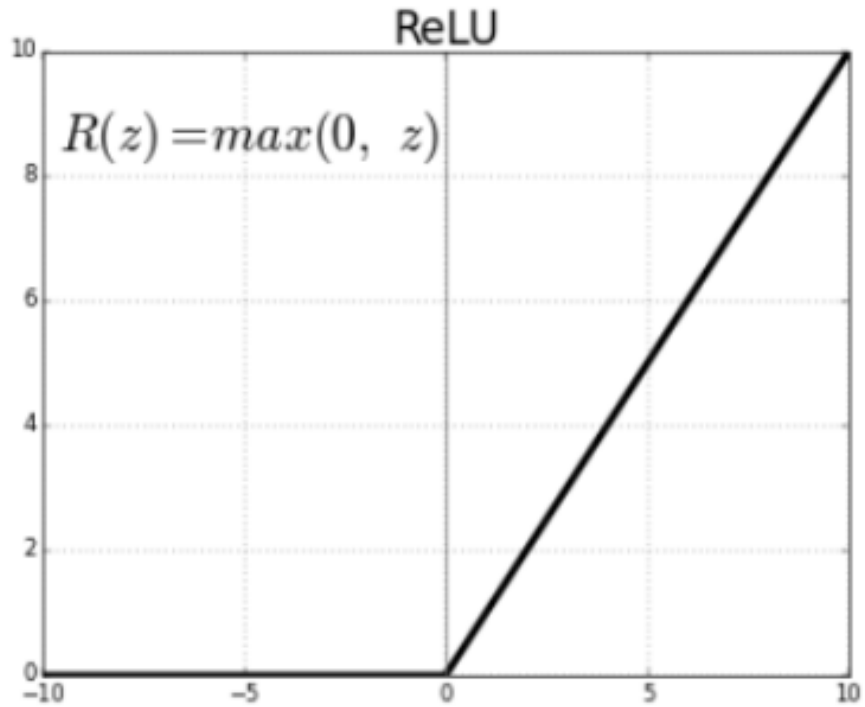
Non-Linear Activation Functions (4/5)

4. Rectified Linear Unit (ReLU) function



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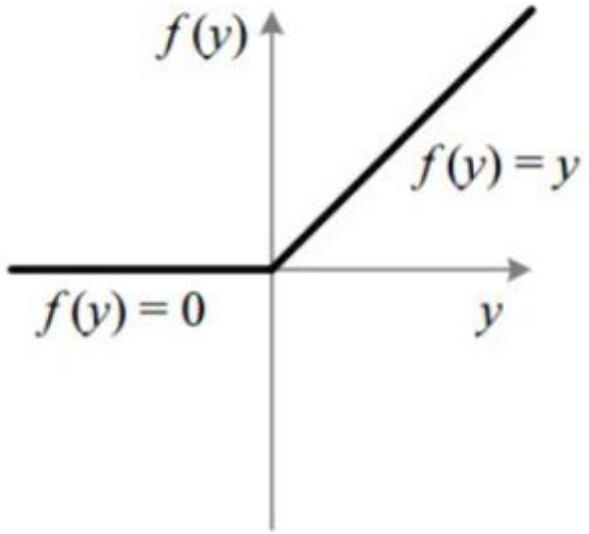
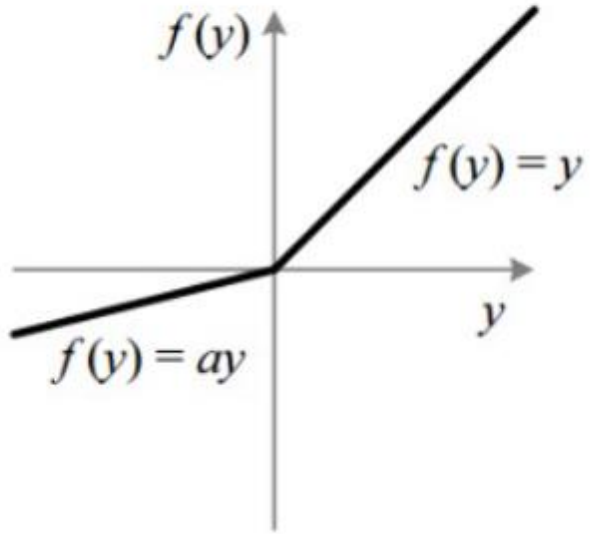
Non-Linear Activation Functions (5/5)

5. Leaky ReLU





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What is Gradient Decent? 01

02 What is Stochastic Gradient Decent?

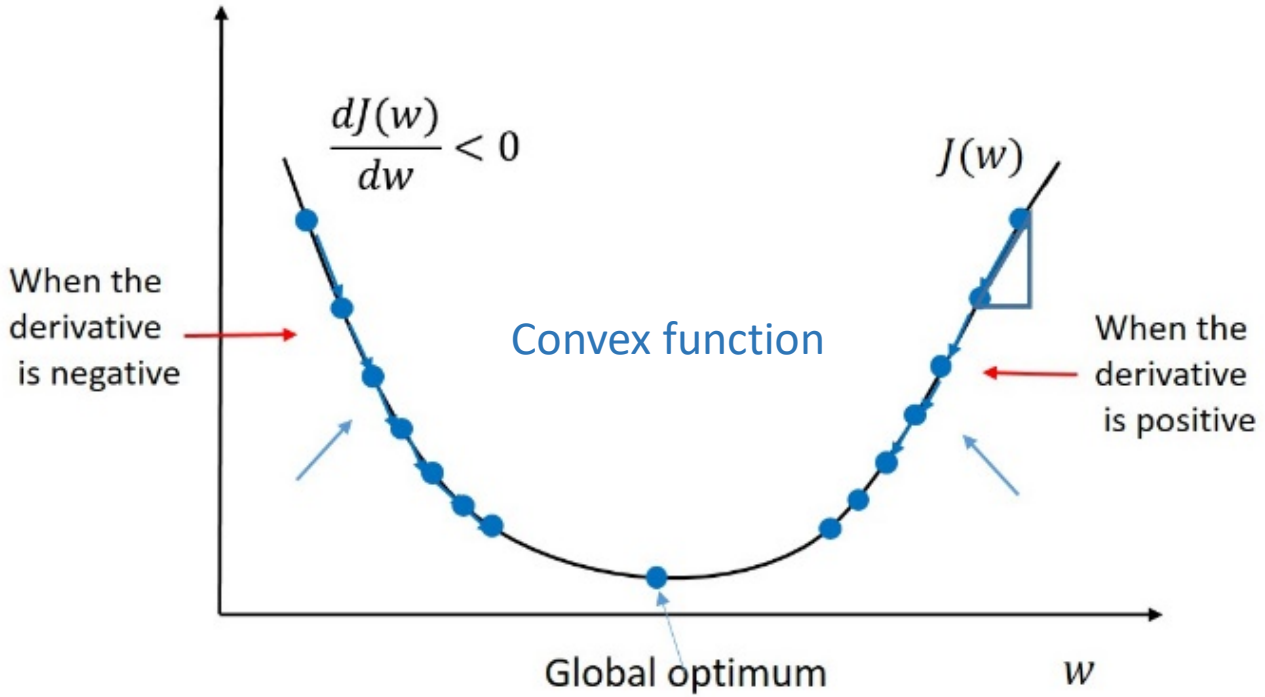
Gradient Decent vs Stochastic Gradient Decent 03

Gradient Decent

Gradient: measures how much the output of a function changes if you change the inputs a little bit. In mathematics it is similar to slope.

$$\mathbf{b} = \mathbf{a} - \gamma \nabla \mathbf{f}(\mathbf{a})$$

b: next position
a: current position
ϒ(gamma) : waiting factor
Δf(a) : direction



Gradient Descent = Descending into Minimum of COST function

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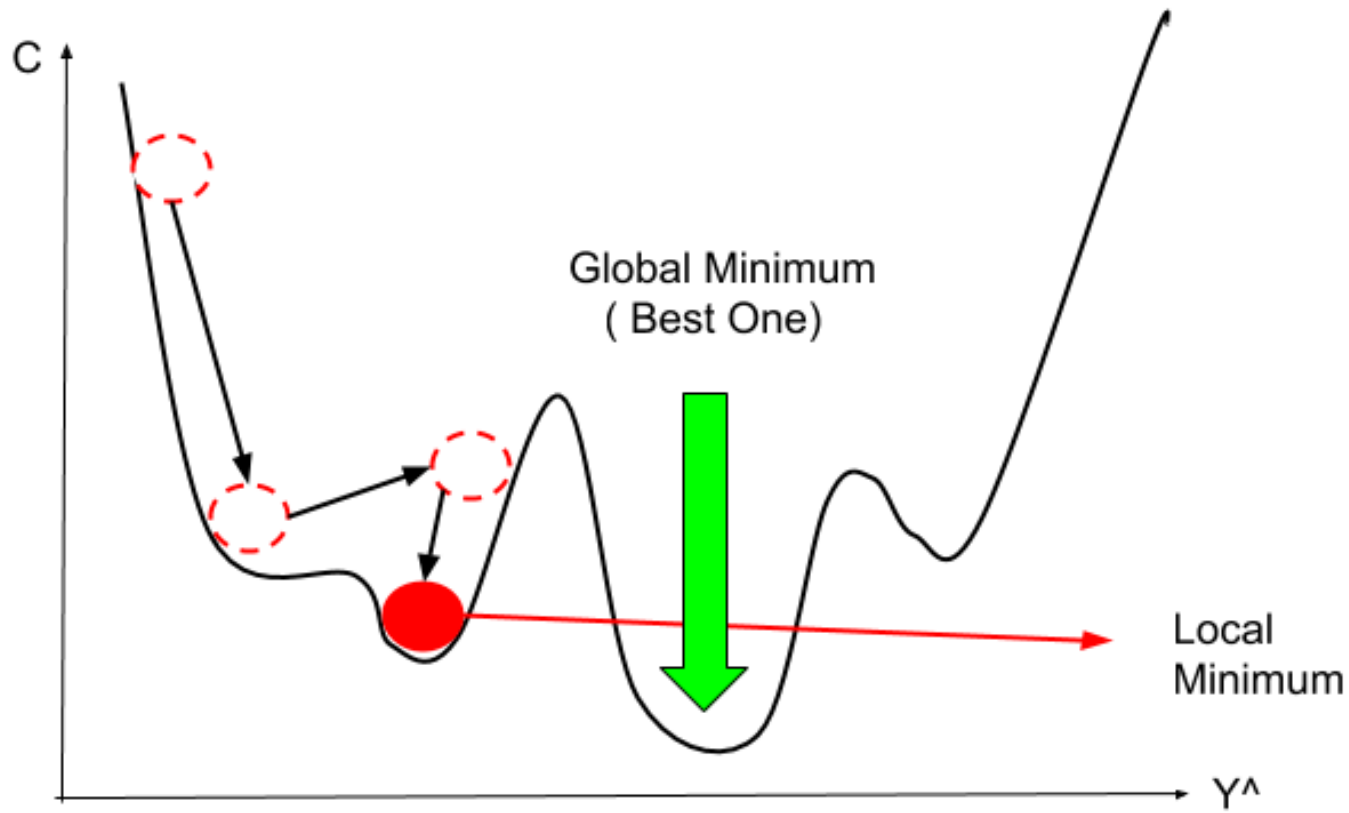
02 **What is Stochastic Gradient Decent?**

Gradient Decent vs Stochastic Gradient Decent 03

Stochastic Decent



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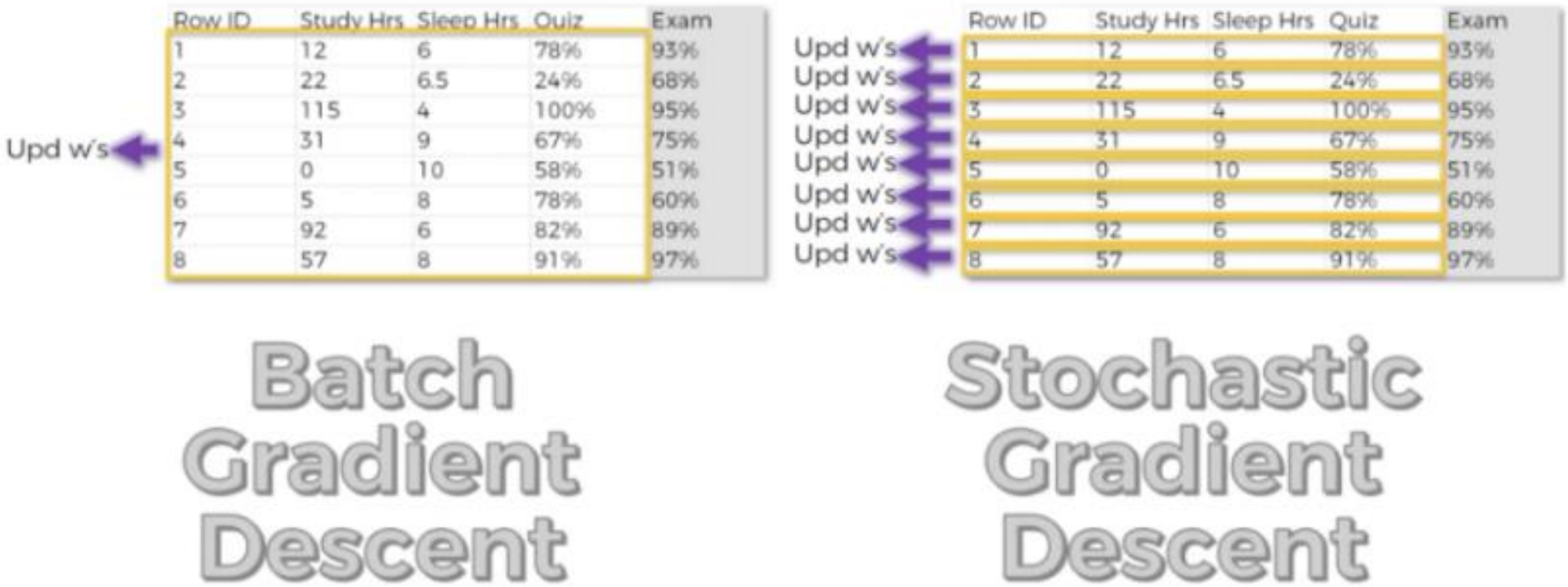
01 What is Gradient Decent?

02 What is Stochastic Gradient Decent?

03 **Gradient Decent vs Stochastic Gradient Decent**

Stochastic Decent (2/2)

For more clarification between GD and SGD, see the below picture



*** Mini Batch Gradient Descent = Gradient Descent + Stochastic Gradient Descent**

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How artificial neural networks work? 01

02 Advantages of Neural Networks

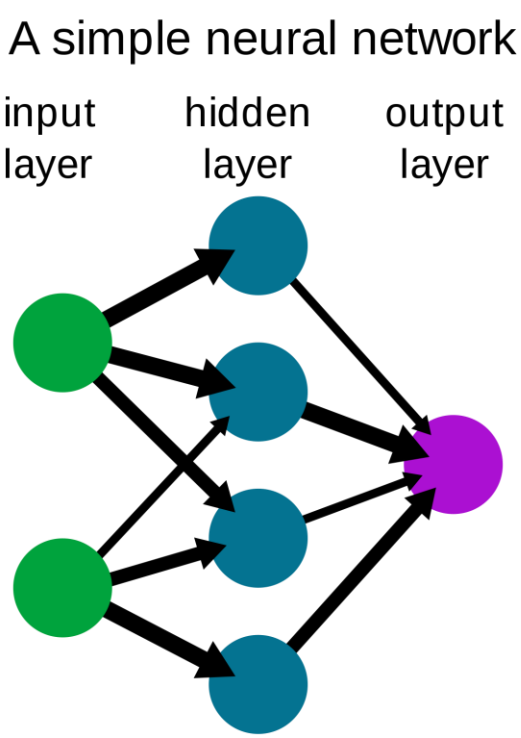
Disadvantages of Neural Networks 03

04 Applications of Neural Networks

How network works? – Overall Summary! (1/4)

- It is consisted of a number of simple but highly interconnected elements or nodes, called ‘neurons’. Those neurons are organized in layers which process information using dynamic state responses to external inputs.

- The First layer is the input layer. The Last layer is the output layer by default.



Meta Brains

How network works? – Overall Summary! (2/4)

- Assume that we need to calculate the price of the house and we don't have a hidden layer. So, the price will be simply the summation of the product of inputs and their weight respectively. This is an approach of Machine learning model.

- So, what makes DL approach something better than the Machine Learning model is the addition of a hidden layer, it gives some flexibility and power, to increase accuracy.

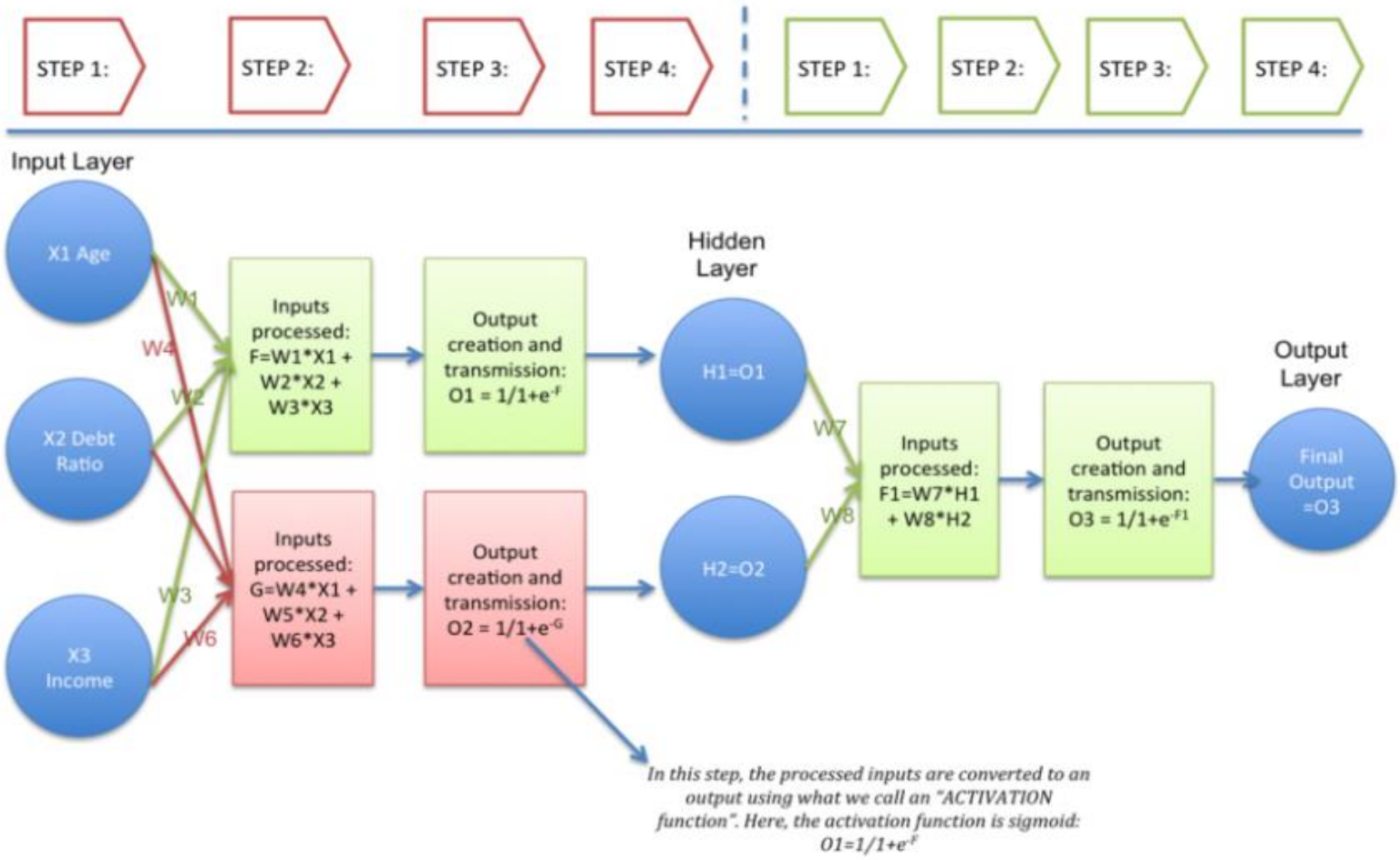
Meta Brains

How network works? – Overall Summary! (3/4)

- Let us consider estimating the cost of the house for the same example with ANN. All inputs neurons are connected to all the neurons in the hidden layer, which means it won't have the same weightage from the input layer, which means depending on the priorities the weightage values changes. Each neuron in the hidden layer has some priorities and weightage for application-related like how our brain works.

- If we keep on increasing the hidden layers for some importance or weightage or for solving complex calculations, the accuracy gets increased, it's like fine-tuning the network to get the optimal output.

How network works? – Overall Summary! (4/4)



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How artificial neural networks work? 01

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04 Applications of Neural Networks

Advantages of ANNs

1. Ability to work with incomplete knowledge
2. Fault tolerance
3. Parallel processing capability

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Disadvantages of Neural Networks **03**

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Disadvantages of ANNs

1. Hardware dependence

2. Determination of proper network structure

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01 How artificial neural networks work?

02 Advantages of Neural Networks

03 Disadvantages of Neural Networks

04 **Applications of Neural Networks**

Applications

1. Handwritten Recognition
2. Image compression
3. Stock exchange prediction

Quiz Time

1.What is back propagation

a) It is another name given to the curvy function in perceptron
b) It is the transmission of error back through the network to adjust the input
c) It is the transmission of error back through the network to allow weights to be adjusted so that the network can learn
d) Node of the mentioned

Quiz Time

1.What is back propagation

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08 One-hot encoding using scikit-learn

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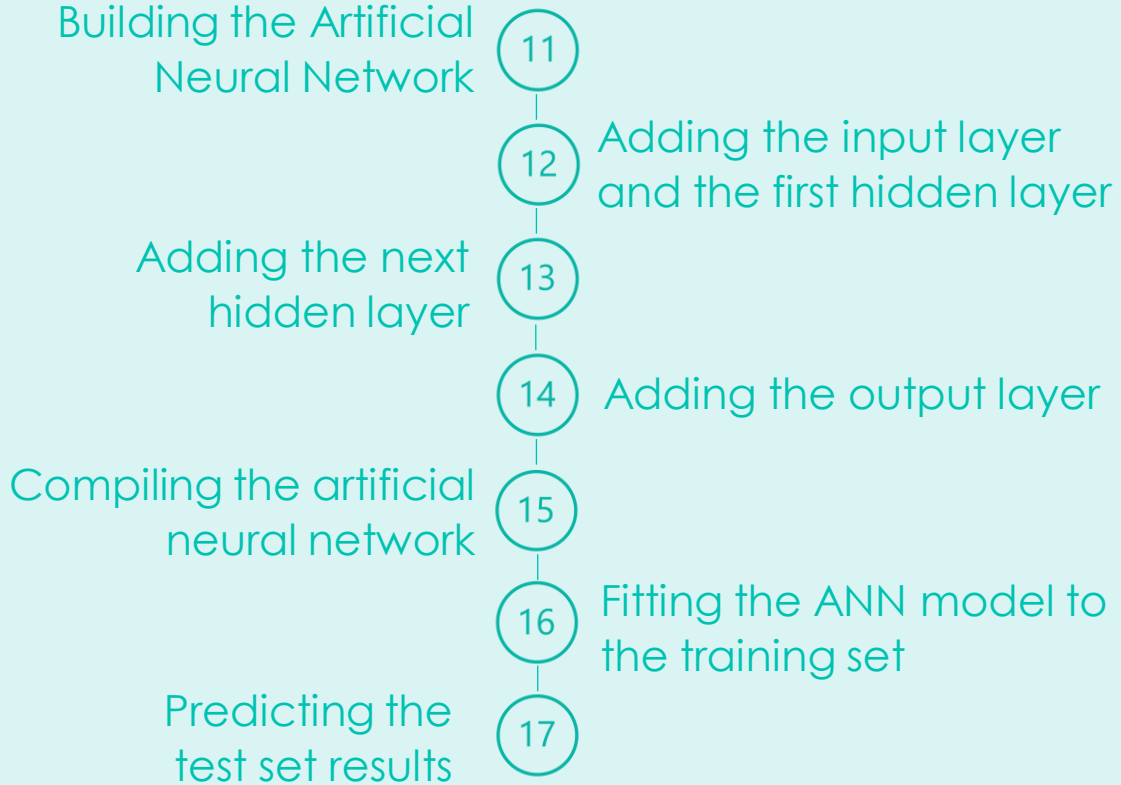

ANN Implementation in Python

For implementation, I am going to use **Churn Modelling Dataset**. You can download the dataset from **Kaggle**.

Artificial Neural Network can be used for **both classification and regression**. And here we are going to use **ANN for classification.**

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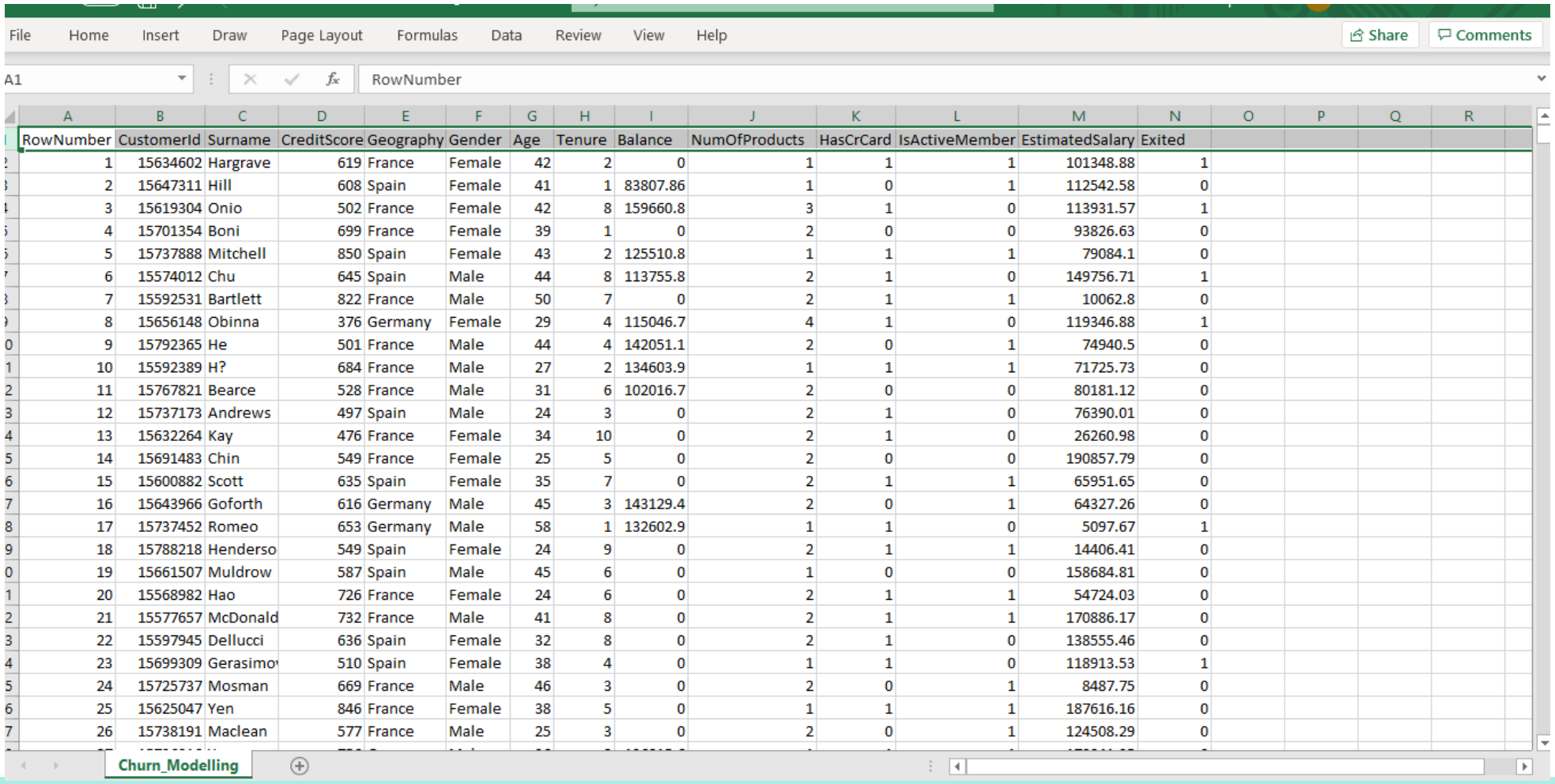
ANN Implementation in python

This dataset has following features-



File Home Insert Draw Page Layout Formulas Data Review View Help Share Comments

A1 RowNumber

RowNumber	CustomerId	Surname	CreditScore	Geography	Gender	Age	Tenure	Balance	NumOfProducts	HasCrCard	IsActiveMember	EstimatedSalary	Exited
1	15634602	Hargrave	619	France	Female	42	2	0	1	1	1	101348.88	1
2	15647311	Hill	608	Spain	Female	41	1	83807.86	1	0	1	112542.58	0
3	15619304	Onio	502	France	Female	42	8	159660.8	3	1	0	113931.57	1
4	15701354	Boni	699	France	Female	39	1	0	2	0	0	93826.63	0
5	15737888	Mitchell	850	Spain	Female	43	2	125510.8	1	1	1	79084.1	0
6	15574012	Chu	645	Spain	Male	44	8	113755.8	2	1	0	149756.71	1
7	15592531	Bartlett	822	France	Male	50	7	0	2	1	1	10062.8	0
8	15656148	Obinna	376	Germany	Female	29	4	115046.7	4	1	0	119346.88	1
9	15792365	He	501	France	Male	44	4	142051.1	2	0	1	74940.5	0
10	15592389	H?	684	France	Male	27	2	134603.9	1	1	1	71725.73	0
11	15767821	Bearce	528	France	Male	31	6	102016.7	2	0	0	80181.12	0
12	15737173	Andrews	497	Spain	Male	24	3	0	2	1	0	76390.01	0
13	15632264	Kay	476	France	Female	34	10	0	2	1	0	26260.98	0
14	15691483	Chin	549	France	Female	25	5	0	2	0	0	190857.79	0
15	15600882	Scott	635	Spain	Female	35	7	0	2	1	1	65951.65	0
16	15643966	Goforth	616	Germany	Male	45	3	143129.4	2	0	1	64327.26	0
17	15737452	Romeo	653	Germany	Male	58	1	132602.9	1	1	0	5097.67	1
18	15788218	Henderso	549	Spain	Female	24	9	0	2	1	1	14406.41	0
19	15661507	Muldrow	587	Spain	Male	45	6	0	1	0	0	158684.81	0
20	15568982	Hao	726	France	Female	24	6	0	2	1	1	54724.03	0
21	15577657	McDonald	732	France	Male	41	8	0	2	1	1	170886.17	0
22	15597945	Dellucci	636	Spain	Female	32	8	0	2	1	0	138555.46	0
23	15699309	Gerasimo	510	Spain	Female	38	4	0	1	1	0	118913.53	1
24	15725737	Mosman	669	France	Male	46	3	0	2	0	1	8487.75	0
25	15625047	Yen	846	France	Female	38	5	0	1	1	1	187616.16	0
26	15738191	Maclean	577	France	Male	25	3	0	2	0	1	124508.29	0

Churn_Modelling

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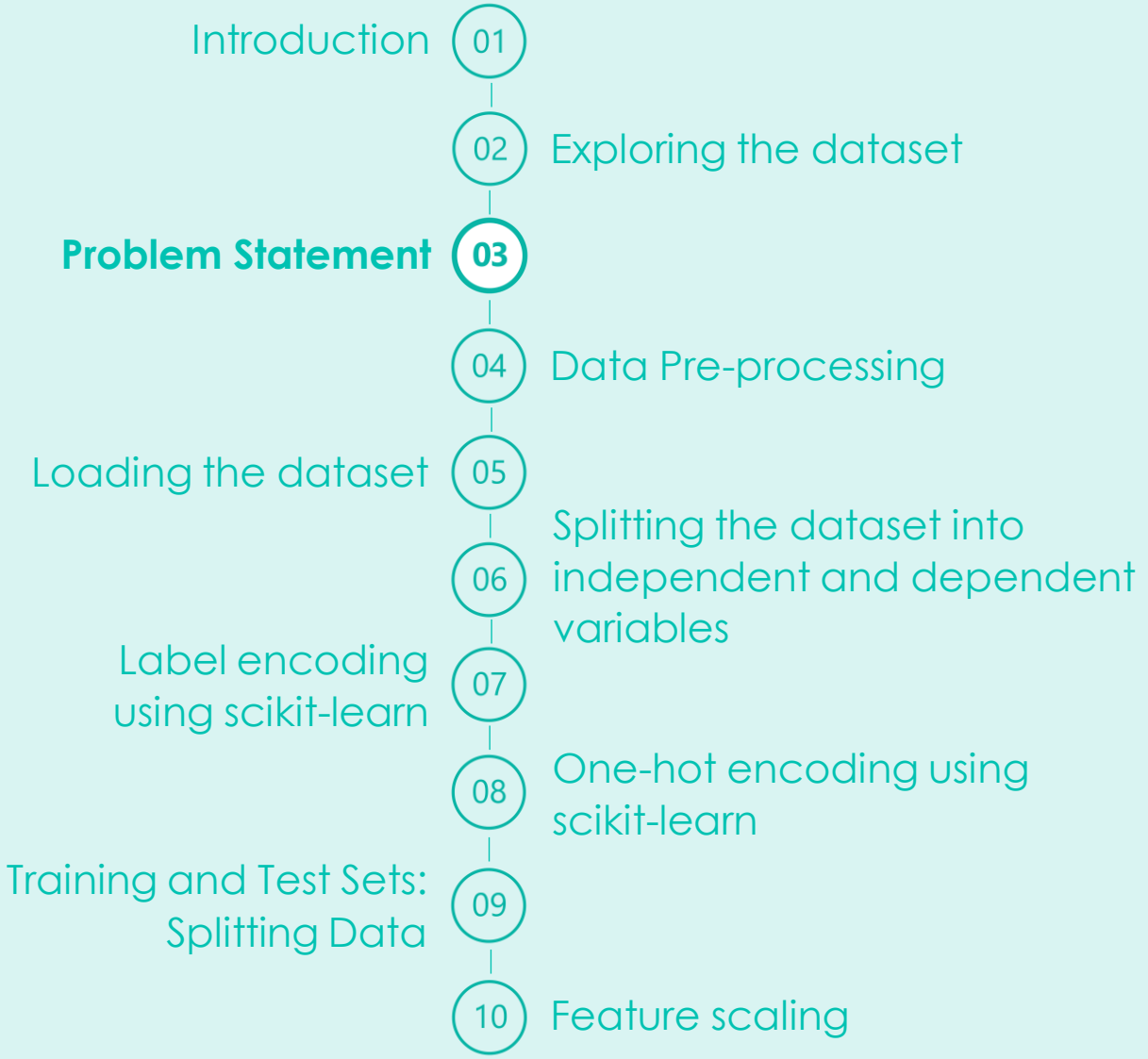

ANN Implementation in python

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Data Preprocessing

In data preprocessing the first step is-
Import the Libraries-

```
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
```

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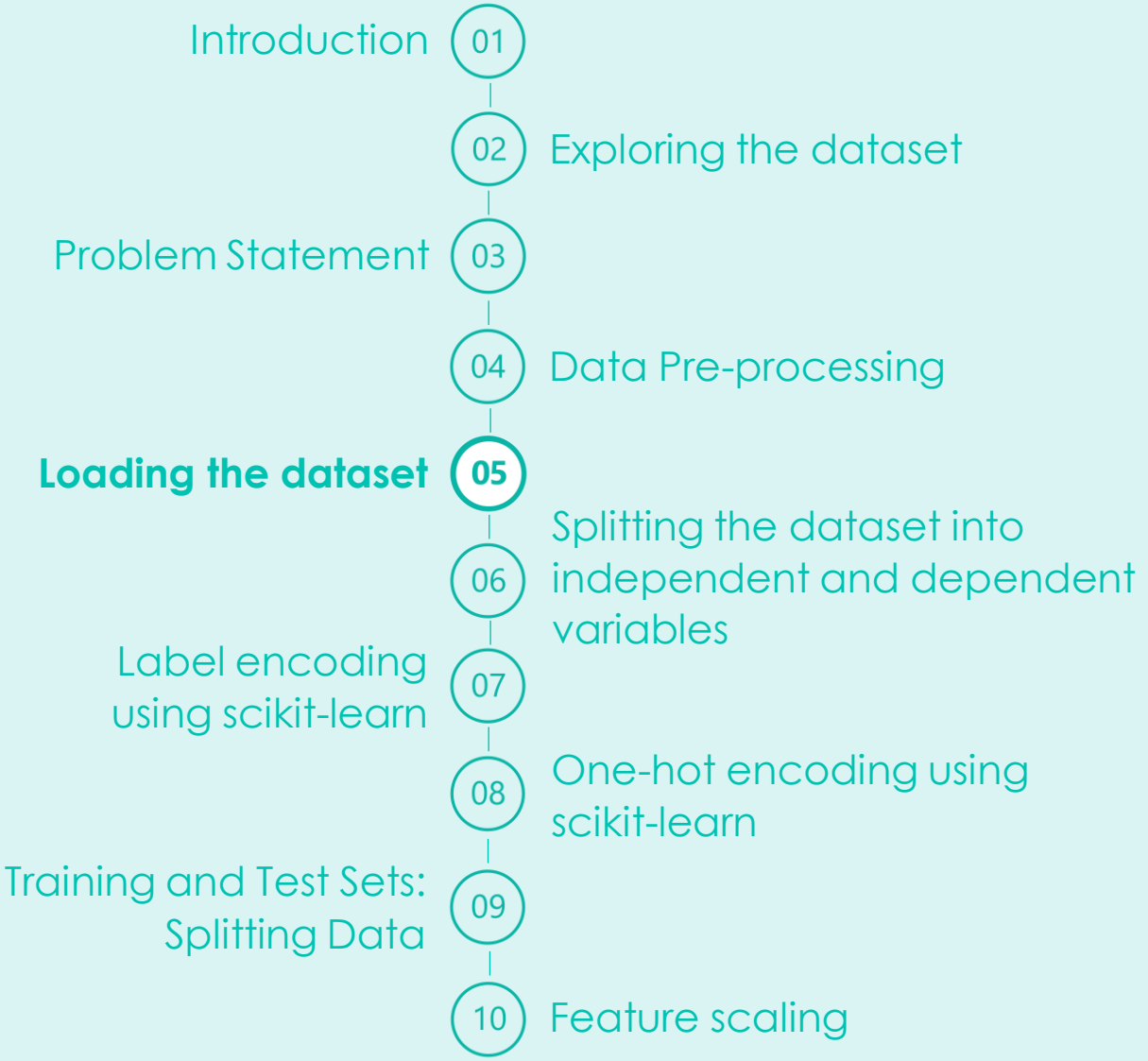

Data Preprocessing

Load the dataset-

```
dataset = pd.read_csv('Churn_Modelling.csv')
```

So, when you load the dataset after running this line of code, you will get your data something like this-

dataset - DataFrame

Index	owNumbe	CustomerId	Surname	CreditScore	Geography	Gender	Age	Tenure	Balance	mOfProdu	HasCrCard	ctiveMeml	imatedSal	Exited
0	1	15634602	Hargrave	619	France	Female	42	2	0	1	1	1	101349	1
1	2	15647311	Hill	608	Spain	Female	41	1	83807.9	1	0	1	112543	0
2	3	15619304	Onio	502	France	Female	42	8	159661	3	1	0	113932	1
3	4	15701354	Boni	699	France	Female	39	1	0	2	0	0	93826.6	0
4	5	15737888	Mitchell	850	Spain	Female	43	2	125511	1	1	1	79084.1	0
5	6	15574012	Chu	645	Spain	Male	44	8	113756	2	1	0	149757	1
6	7	15592531	Bartlett	822	France	Male	50	7	0	2	1	1	10062.8	0
7	8	15656148	Obinna	376	Germany	Female	29	4	115047	4	1	0	119347	1
8	9	15792365	He	501	France	Male	44	4	142051	2	0	1	74940.5	0
9	10	15592389	H?	684	France	Male	27	2	134604	1	1	1	71725.7	0
10	11	15767821	Bearce	528	France	Male	31	6	102017	2	0	0	80181.1	0
11	12	15737173	Andrews	497	Spain	Male	24	3	0	2	1	0	76390	0
12	13	15632264	Kay	476	France	Female	34	10	0	2	1	0	26261	0
13	14	15691483	Chin	549	France	Female	25	5	0	2	0	0	190858	0
14	15	15600882	Scott	635	Spain	Female	35	7	0	2	1	1	65951.6	0
15	16	15643966	Goforth	616	Germany	Male	45	3	143129	2	0	1	64327.3	0
16	17	15737452	Romeo	653	Germany	Male	58	1	132603	1	1	0	5097.67	1
17	18	15788218	Henderson	549	Spain	Female	24	9	0	2	1	1	14406.4	0
18	19	15661507	Muldrow	587	Spain	Male	45	6	0	1	0	0	158685	0
19	20	15568982	Hao	726	France	Female	24	6	0	2	1	1	54724	0
20	21	15577657	McDonald	732	France	Male	41	8	0	2	1	1	170886	0

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Data Preprocessing

Split Dataset into X and Y-

```
X = dataset.iloc[:, 3:13].values
y = dataset.iloc[:, 13].values
```

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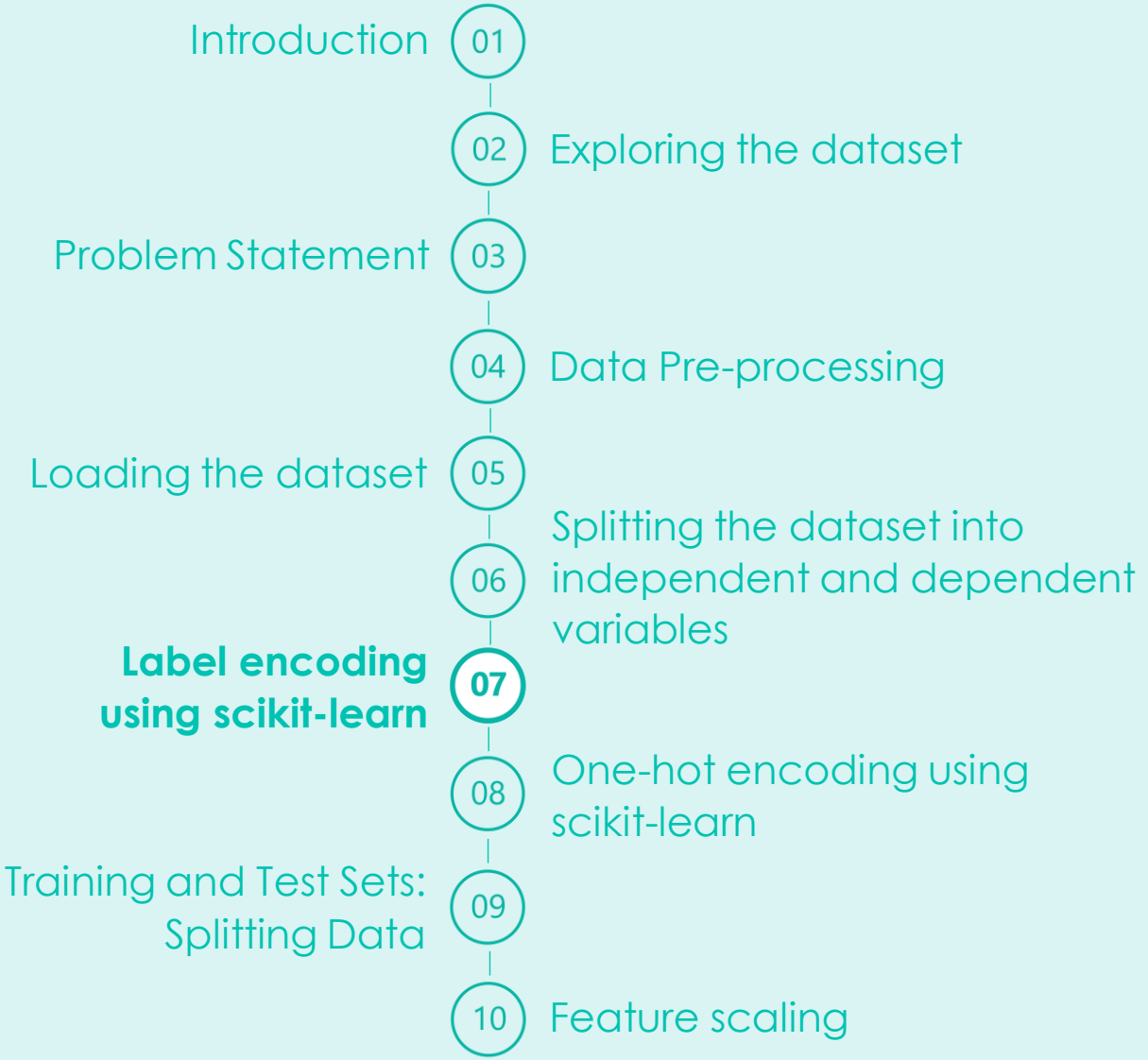


Data Preprocessing

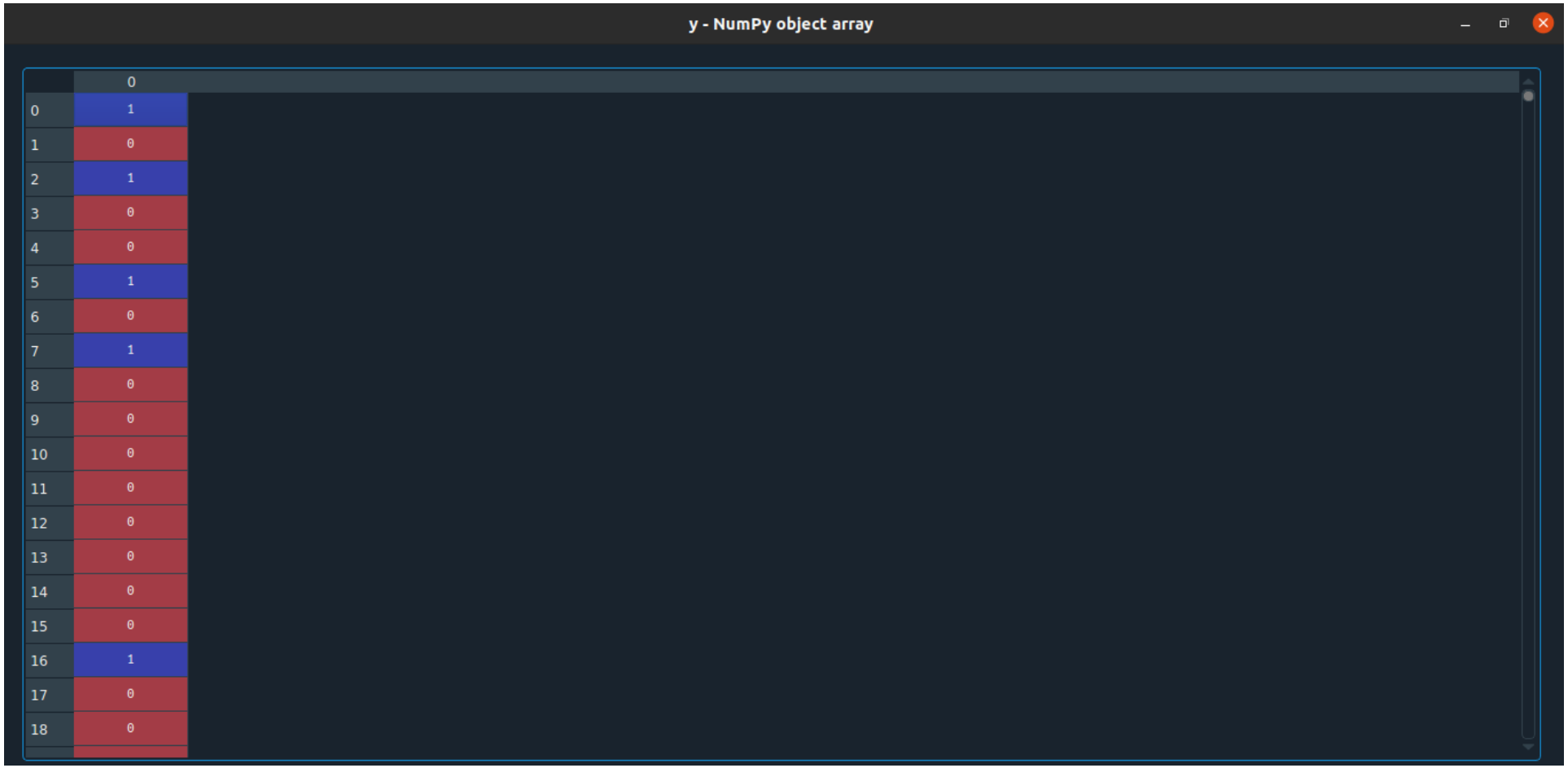
Independent Variable (X)-

X - NumPy object array (read only)

	0	1	2	3	4	5	6	7	8	9
0	619	France	Female	42	2	0.0	1	1	1	101348.88
1	608	Spain	Female	41	1	83807.86	1	0	1	112542.58
2	502	France	Female	42	8	159660.8	3	1	0	113931.57
3	699	France	Female	39	1	0.0	2	0	0	93826.63
4	850	Spain	Female	43	2	125510.82	1	1	1	79084.1
5	645	Spain	Male	44	8	113755.78	2	1	0	149756.71
6	822	France	Male	50	7	0.0	2	1	1	10062.8
7	376	Germany	Female	29	4	115046.74	4	1	0	119346.88
8	501	France	Male	44	4	142051.07	2	0	1	74940.5
9	684	France	Male	27	2	134603.88	1	1	1	71725.73
10	528	France	Male	31	6	102016.72	2	0	0	80181.12
11	497	Spain	Male	24	3	0.0	2	1	0	76390.01
12	476	France	Female	34	10	0.0	2	1	0	26260.98
13	549	France	Female	25	5	0.0	2	0	0	190857.79
14	635	Spain	Female	35	7	0.0	2	1	1	65951.65
15	616	Germany	Male	45	3	143129.41	2	0	1	64327.26
16	653	Germany	Male	58	1	132602.88	1	1	0	5097.67
17	549	Spain	Female	24	9	0.0	2	1	1	14406.41
18	587	Spain	Male	45	6	0.0	1	0	0	158684.81

Data Preprocessing

Dependent Variable (Y)-



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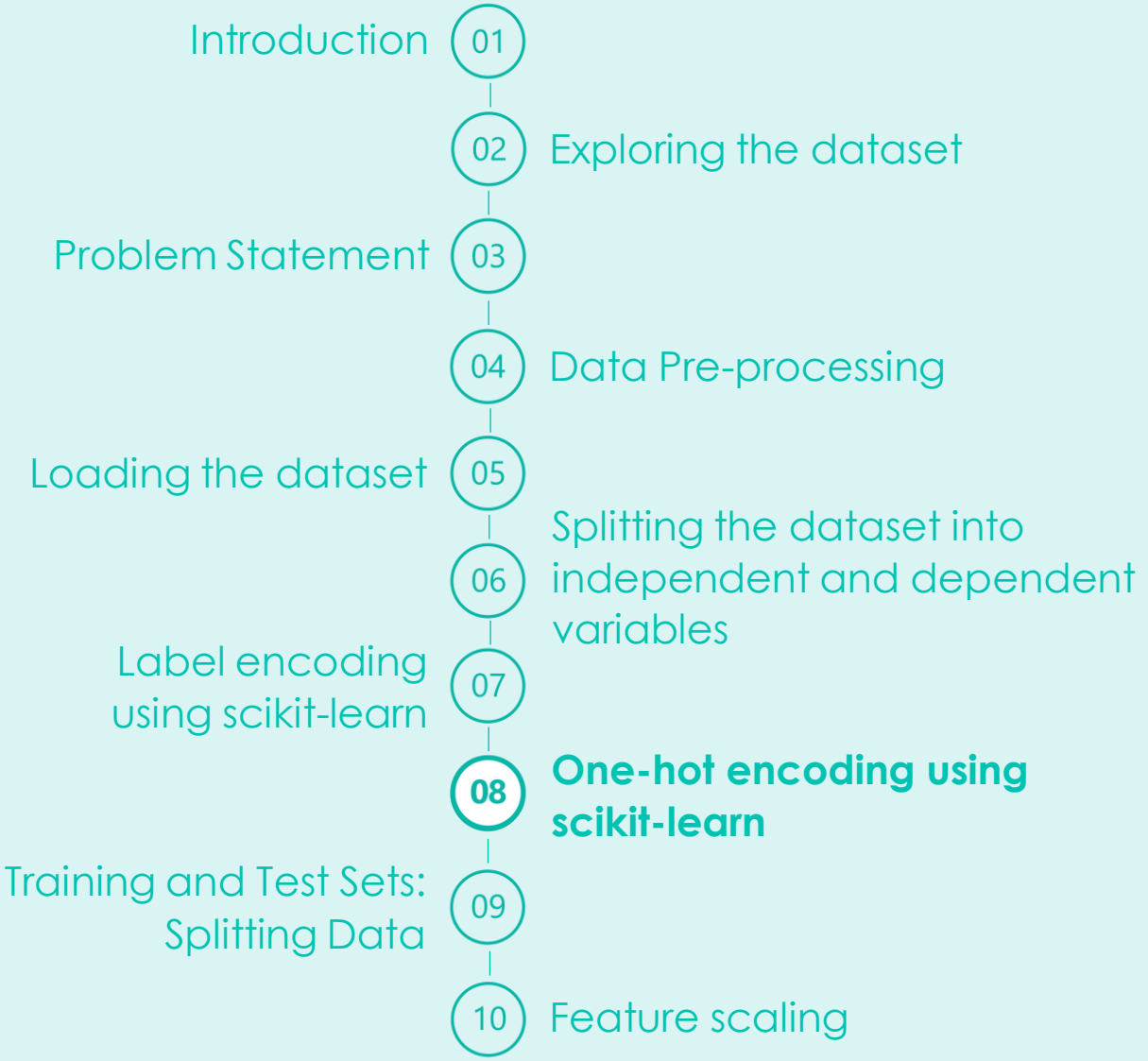


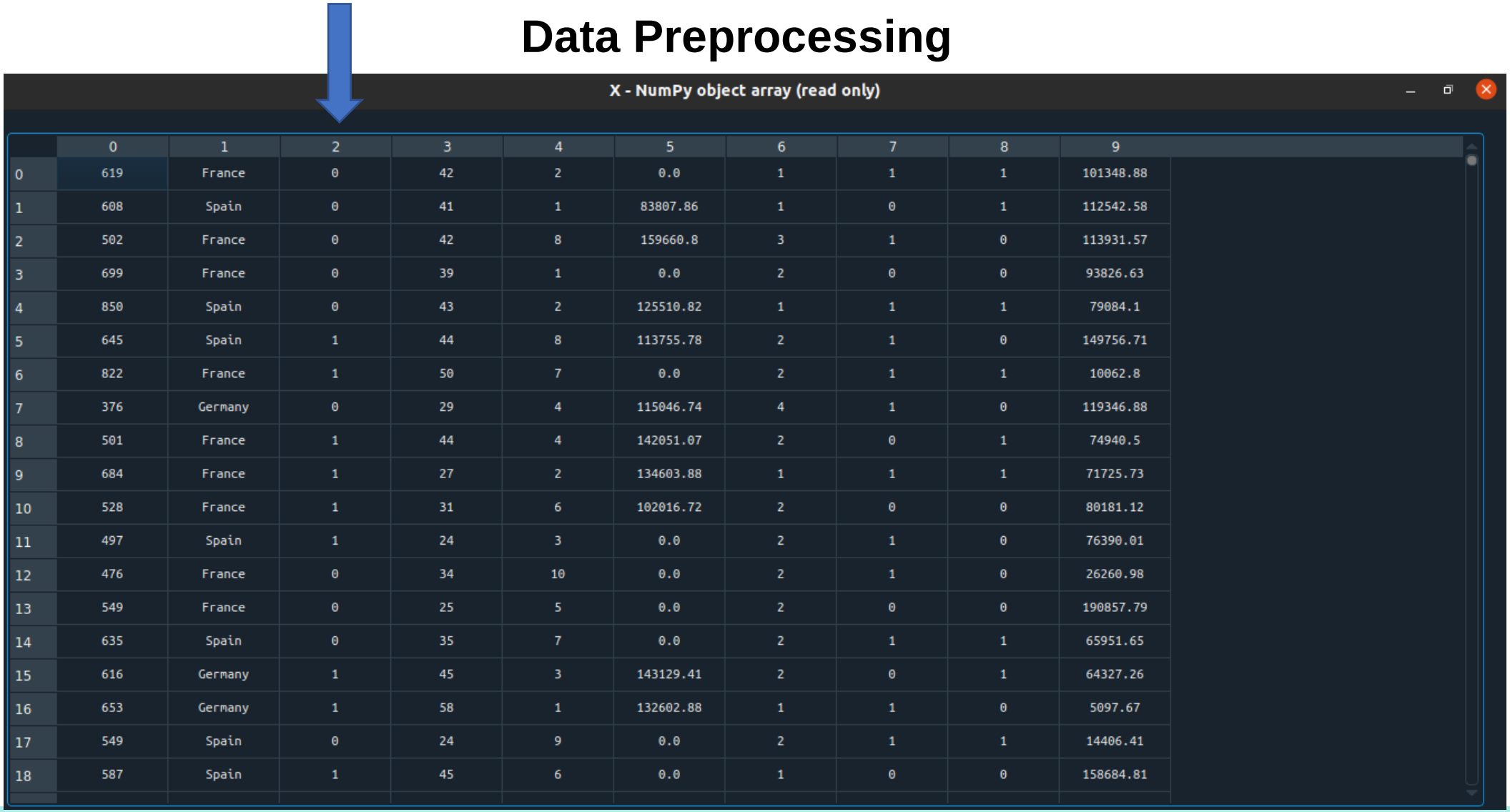
Data Preprocessing

Encode Categorical Data-

So first let's perform label encoding for gender variable-

```
from sklearn.preprocessing import LabelEncoder, OneHotEncoder
labelencoder_X_2 = LabelEncoder()
X[:, 2] = labelencoder_X_2.fit_transform(X[:, 2])
```

Data Preprocessing



	0	1	2	3	4	5	6	7	8	9
0	619	France	0	42	2	0.0	1	1	1	101348.88
1	608	Spain	0	41	1	83807.86	1	0	1	112542.58
2	502	France	0	42	8	159660.8	3	1	0	113931.57
3	699	France	0	39	1	0.0	2	0	0	93826.63
4	850	Spain	0	43	2	125510.82	1	1	1	79084.1
5	645	Spain	1	44	8	113755.78	2	1	0	149756.71
6	822	France	1	50	7	0.0	2	1	1	10062.8
7	376	Germany	0	29	4	115046.74	4	1	0	119346.88
8	501	France	1	44	4	142051.07	2	0	1	74940.5
9	684	France	1	27	2	134603.88	1	1	1	71725.73
10	528	France	1	31	6	102016.72	2	0	0	80181.12
11	497	Spain	1	24	3	0.0	2	1	0	76390.01
12	476	France	0	34	10	0.0	2	1	0	26260.98
13	549	France	0	25	5	0.0	2	0	0	190857.79
14	635	Spain	0	35	7	0.0	2	1	1	65951.65
15	616	Germany	1	45	3	143129.41	2	0	1	64327.26
16	653	Germany	1	58	1	132602.88	1	1	0	5097.67
17	549	Spain	0	24	9	0.0	2	1	1	14406.41
18	587	Spain	1	45	6	0.0	1	0	0	158684.81

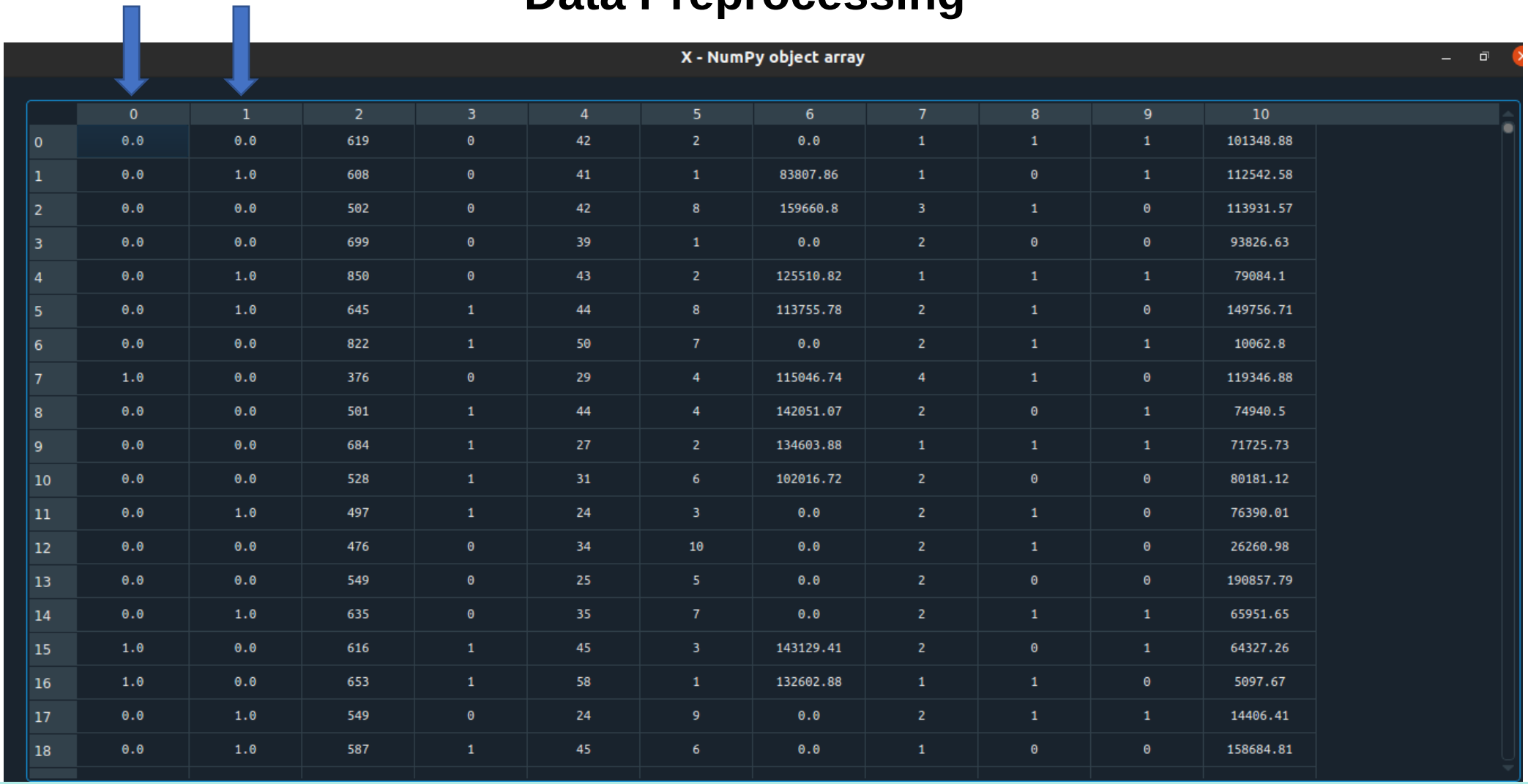
Meta Brains

Data Preprocessing

next is to perform one hot encoding for geography variable-

```
from sklearn.compose import ColumnTransformer
ct = ColumnTransformer([('ohe', OneHotEncoder(), [1])], remainder='passthrough'
X = np.array(ct.fit_transform(X), dtype = np.str) #.toarray()
X = X[:, 1:]
```

Data Preprocessing



	0	1	2	3	4	5	6	7	8	9	10
0	0.0	0.0	619	0	42	2	0.0	1	1	1	101348.88
1	0.0	1.0	608	0	41	1	83807.86	1	0	1	112542.58
2	0.0	0.0	502	0	42	8	159660.8	3	1	0	113931.57
3	0.0	0.0	699	0	39	1	0.0	2	0	0	93826.63
4	0.0	1.0	850	0	43	2	125510.82	1	1	1	79084.1
5	0.0	1.0	645	1	44	8	113755.78	2	1	0	149756.71
6	0.0	0.0	822	1	50	7	0.0	2	1	1	10062.8
7	1.0	0.0	376	0	29	4	115046.74	4	1	0	119346.88
8	0.0	0.0	501	1	44	4	142051.07	2	0	1	74940.5
9	0.0	0.0	684	1	27	2	134603.88	1	1	1	71725.73
10	0.0	0.0	528	1	31	6	102016.72	2	0	0	80181.12
11	0.0	1.0	497	1	24	3	0.0	2	1	0	76390.01
12	0.0	0.0	476	0	34	10	0.0	2	1	0	26260.98
13	0.0	0.0	549	0	25	5	0.0	2	0	0	190857.79
14	0.0	1.0	635	0	35	7	0.0	2	1	1	65951.65
15	1.0	0.0	616	1	45	3	143129.41	2	0	1	64327.26
16	1.0	0.0	653	1	58	1	132602.88	1	1	0	5097.67
17	0.0	1.0	549	0	24	9	0.0	2	1	1	14406.41
18	0.0	1.0	587	1	45	6	0.0	1	0	0	158684.81

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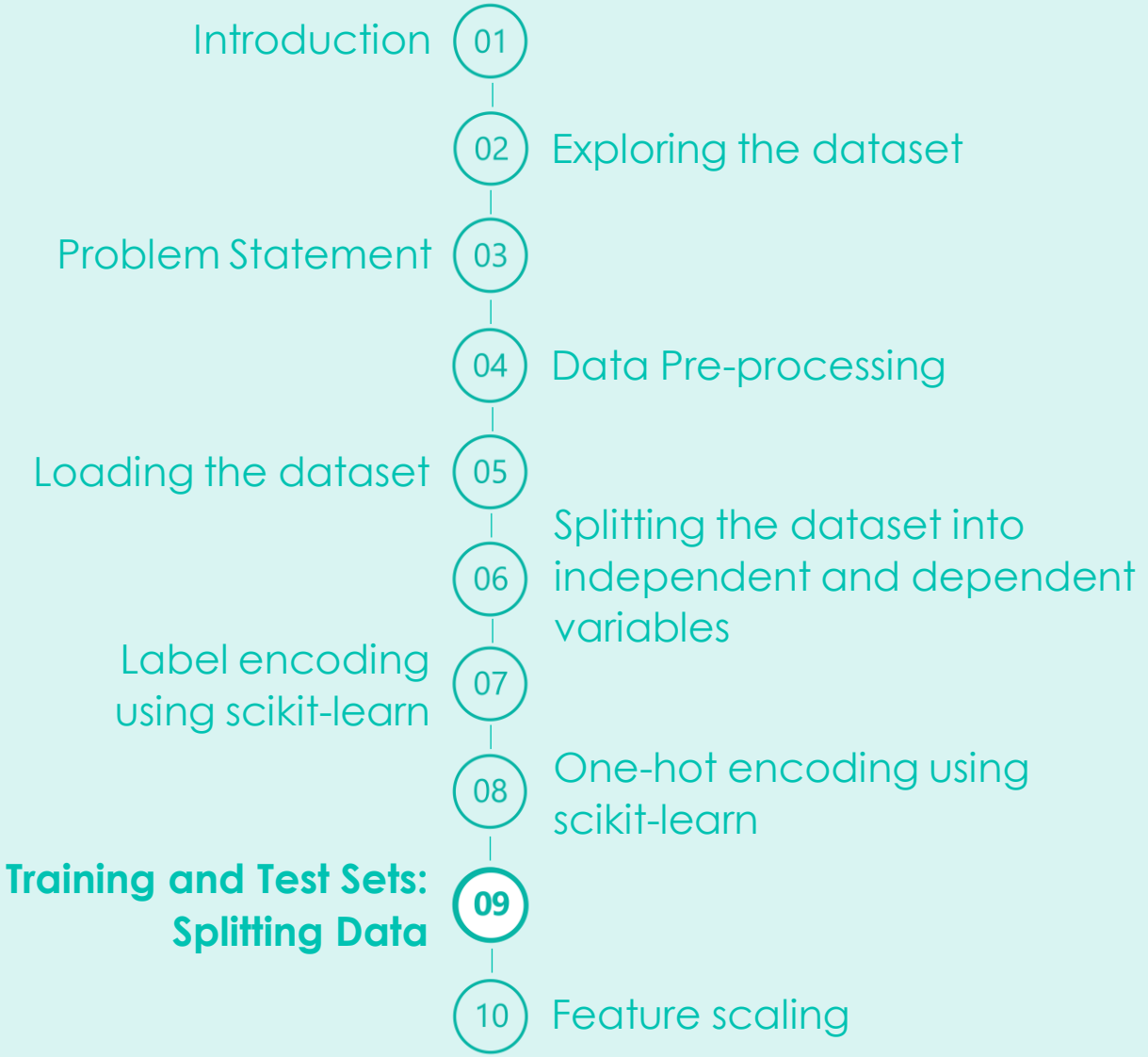

Data Preprocessing

Split the X and Y Dataset into Training set and Test set-

```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y,
                                                    test_size = 0.2, random_state = 0)
```

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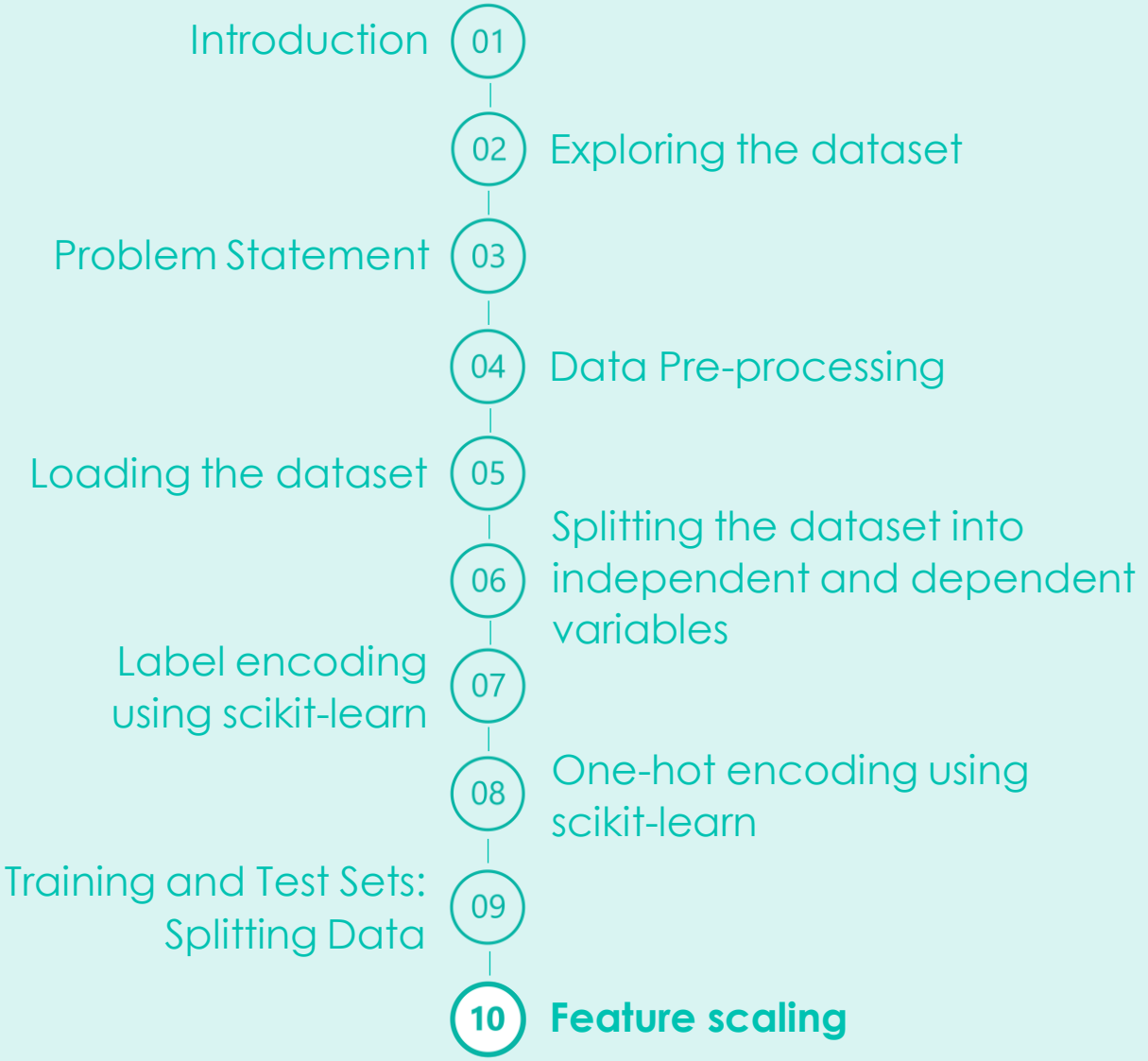

Data Preprocessing

Perform Feature Scaling-

```
from sklearn.preprocessing import StandardScaler
sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)
```

Data Preprocessing

	0	1	2	3	4	5	6	7	8	9	10
0	-0.569844	1.74309	0.169582	-1.09169	-0.464608	0.00666099	-1.21572	0.809503	0.642595	-1.03227	1.10643
1	1.75487	-0.573694	-2.30456	0.916013	0.301026	-1.37744	-0.00631193	-0.921591	0.642595	0.968738	-0.748664
2	-0.569844	-0.573694	-1.1912	-1.09169	-0.943129	-1.03142	0.579935	-0.921591	0.642595	-1.03227	1.48533
3	-0.569844	1.74309	0.0355658	0.916013	0.109617	0.00666099	0.473128	-0.921591	0.642595	-1.03227	1.27653
4	-0.569844	1.74309	2.05611	-1.09169	1.73659	1.04474	0.810193	0.809503	0.642595	0.968738	0.558378
5	1.75487	-0.573694	1.29325	-1.09169	-0.177495	-1.03142	0.442535	0.809503	0.642595	-1.03227	1.63252
6	-0.569844	-0.573694	1.61283	0.916013	0.779547	-1.37744	0.304328	-0.921591	-1.55619	-1.03227	0.481496
7	-0.569844	1.74309	-0.541734	0.916013	0.205321	1.04474	-1.21572	0.809503	0.642595	0.968738	1.07382
8	-0.569844	1.74309	-0.149995	0.916013	3.55497	1.39076	0.80633	-0.921591	0.642595	0.968738	-1.0495
9	-0.569844	-0.573694	-0.29432	-1.09169	-0.656016	0.352686	1.48636	0.809503	0.642595	-1.03227	0.0153936
10	-0.569844	-0.573694	0.324216	-1.09169	-0.560312	1.04474	-0.017786	-0.921591	0.642595	0.968738	-1.17149
11	-0.569844	-0.573694	0.612865	0.916013	1.44948	0.352686	1.5191	-0.921591	0.642595	0.968738	1.16193
12	1.75487	-0.573694	-0.58297	-1.09169	-0.943129	-0.68539	0.874975	-0.921591	0.642595	-1.03227	-0.680001
13	-0.569844	1.74309	1.49943	0.916013	0.205321	1.04474	0.502554	-0.921591	0.642595	-1.03227	-1.41935
14	1.75487	-0.573694	-0.459262	0.916013	-0.0817912	-0.68539	0.380665	-0.921591	-1.55619	-1.03227	-1.09703
15	-0.569844	-0.573694	-0.222157	0.916013	0.492434	0.00666099	-1.21572	4.27169	-1.55619	-1.03227	0.302431
16	-0.569844	-0.573694	-1.25305	0.916013	0.301026	-1.37744	1.30115	-0.921591	0.642595	0.968738	-0.311041
17	-0.569844	-0.573694	1.68499	0.916013	-0.751721	-1.37744	0.683863	-0.921591	0.642595	-1.03227	0.0266257
18	-0.569844	-0.573694	-0.108759	-1.09169	-0.751721	1.39076	1.00325	-0.921591	0.642595	-1.03227	-0.895658

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Building the Artificial Neural Network

11 Building the Artificial Neural Network
12 Adding the input layer and the first hidden layer
13 Adding the next hidden layer
14 Adding the output layer
15 Compiling the artificial neural network
16 Fitting the ANN model to the training set
17 Predicting the test set results

Building Artificial Neural Network

The first step is-

Import the Keras libraries and packages-

```
from tensorflow.keras.models import Sequential
#from keras.models import Sequential
from keras.layers import Dense
```

Initialize the Artificial Neural Network-

```
classifier = Sequential()
```

Building Artificial Neural Network

Add the input layer and the first hidden layer-

```
classifier.add(Dense(units = 6, kernel_initializer = 'uniform', activation = 'relu', input_dim = 11))
```

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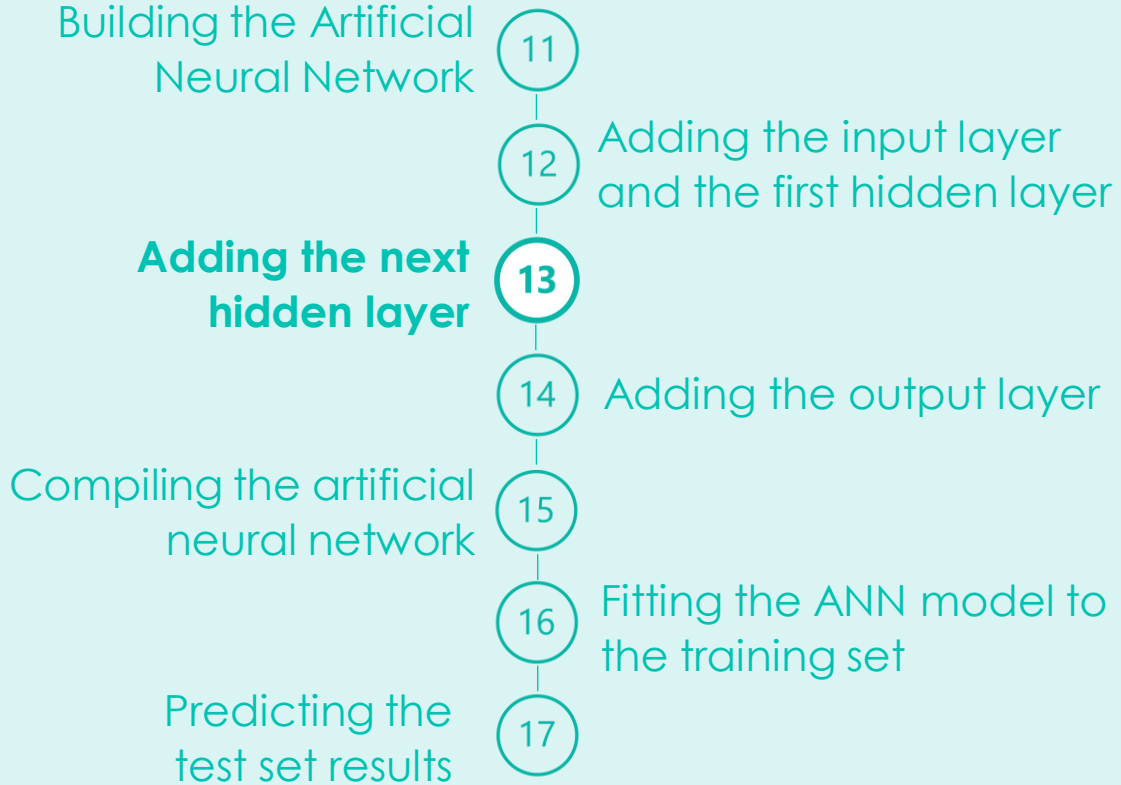

Building Artificial Neural Network

Add the second hidden layer-

```
classifier.add(Dense(units = 6, kernel_initializer = 'uniform', activation = 'relu'))
```

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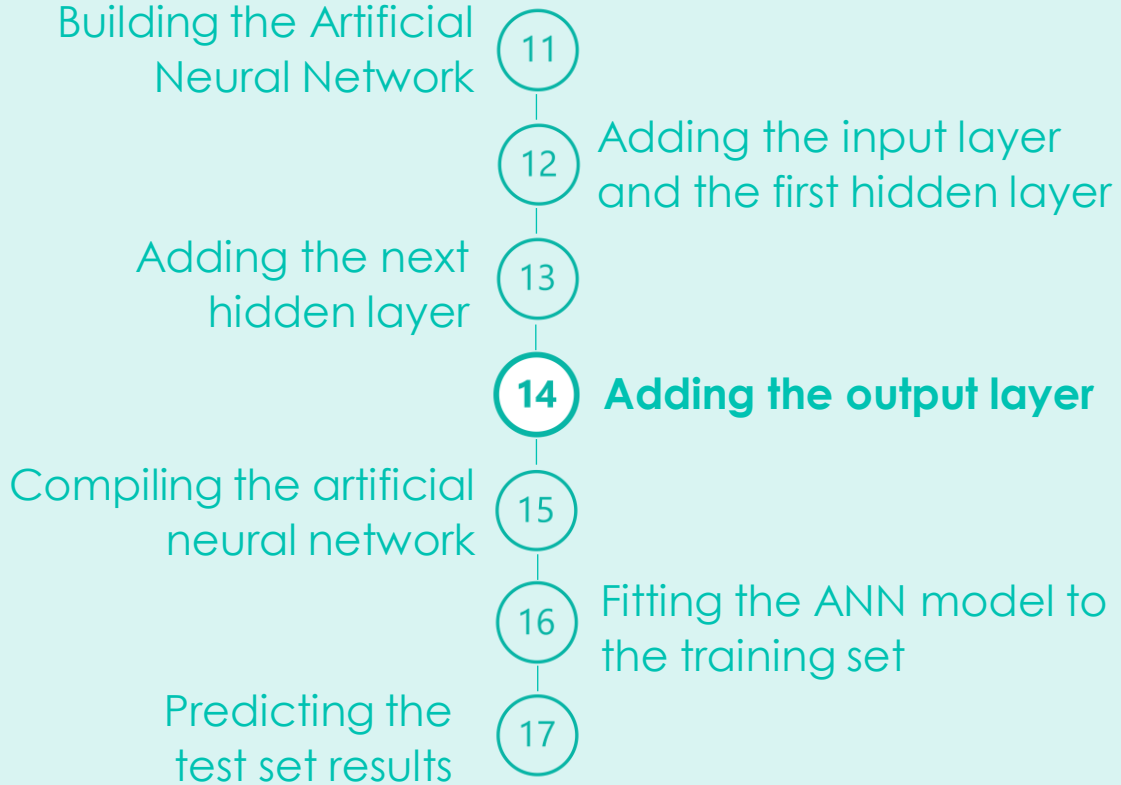

Building Artificial Neural Network

Add the output layer-

```
classifier.add(Dense(units = 1, kernel_initializer = 'uniform', activation = 'sigmoid'))
```

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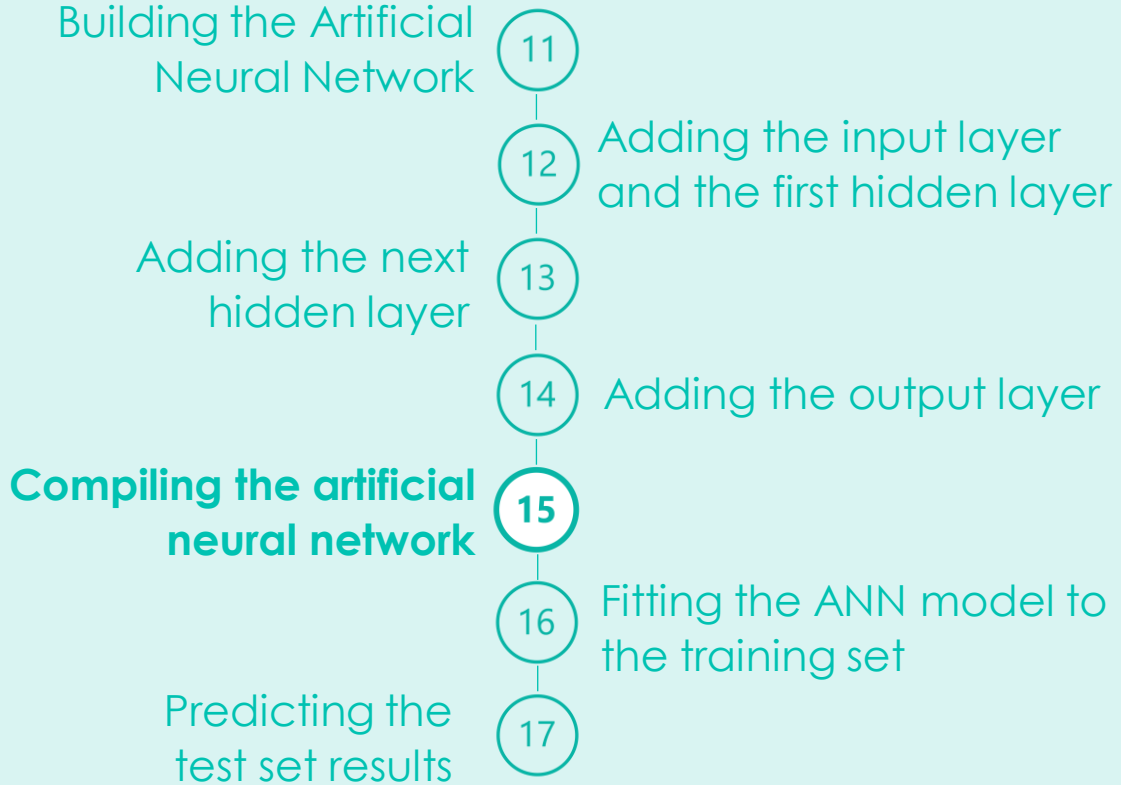

Train the ANN

The training part requires two steps- Compile the ANN, and Fit the ANN to the Training set. So let's start with the first step-

Compile the ANN-

```
classifier.compile(optimizer = 'adam', loss = 'binary_crossentropy', metrics = ['accuracy'])
```

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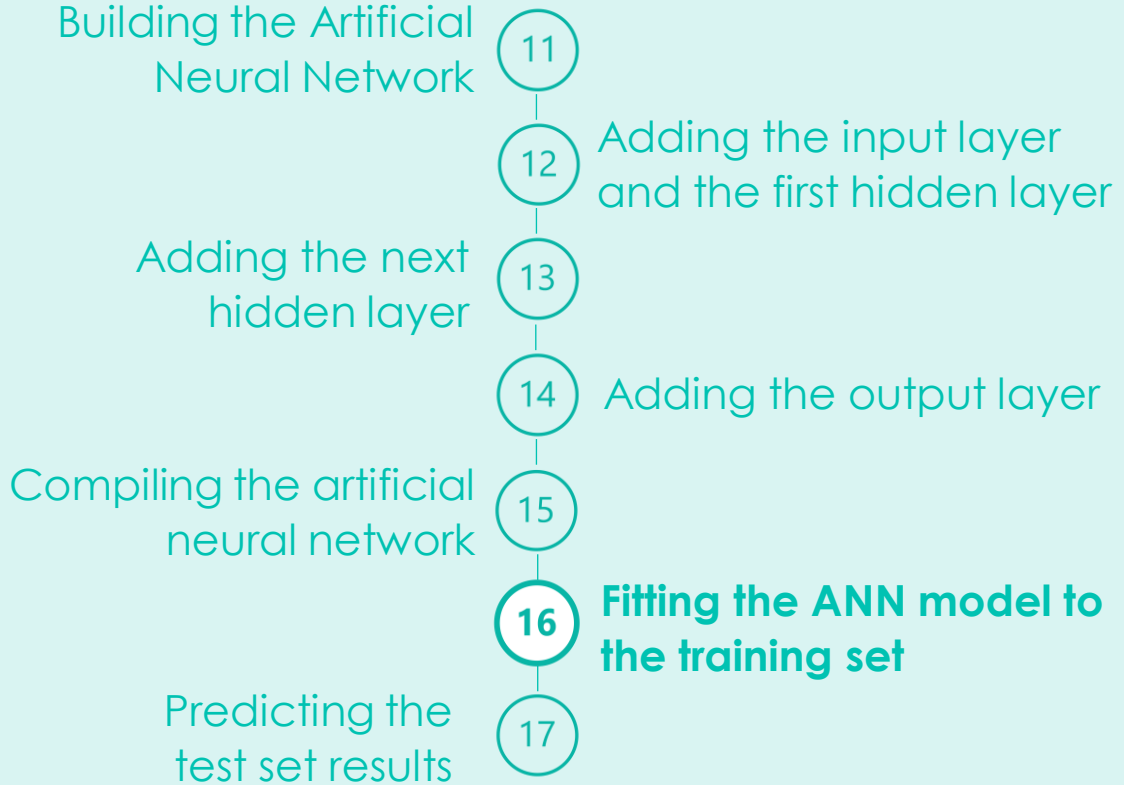

Train the ANN

The next step is-

Fit the ANN to the Training set-

```
classifier.fit(X_train, y_train, batch_size = 10, epochs = 100)
```

Train the ANN

In the first few epochs the accuracy scores are as follow-

```
Epoch 1/100
800/800 [==============================] - 2s 2ms/step - loss: 0.5559 - accuracy: 0.7959
Epoch 2/100
800/800 [==============================] - 1s 2ms/step - loss: 0.4309 - accuracy: 0.8191
Epoch 3/100
800/800 [==============================] - 1s 2ms/step - loss: 0.4158 - accuracy: 0.8263
```

Which is around 80%, but after running all 100 epoch, the accuracy increase, and we get the final accuracy-

```
Epoch 98/100
800/800 [==============================] - 1s 2ms/step - loss: 0.3323 - accuracy: 0.8609
Epoch 99/100
800/800 [==============================] - 2s 2ms/step - loss: 0.3381 - accuracy: 0.8611
Epoch 100/100
800/800 [==============================] - 1s 2ms/step - loss: 0.3531 - accuracy: 0.8544: 0s - loss: 0.3555 - accura
```

That is 85.44%. Quite good. Now we are done with the training part. The last but not least part is Predicting the test set results-

Train the ANN

The next step is-

Prediction-

```
y_pred = classifier.predict(X_test)
y_pred = (y_pred > 0.5)
```

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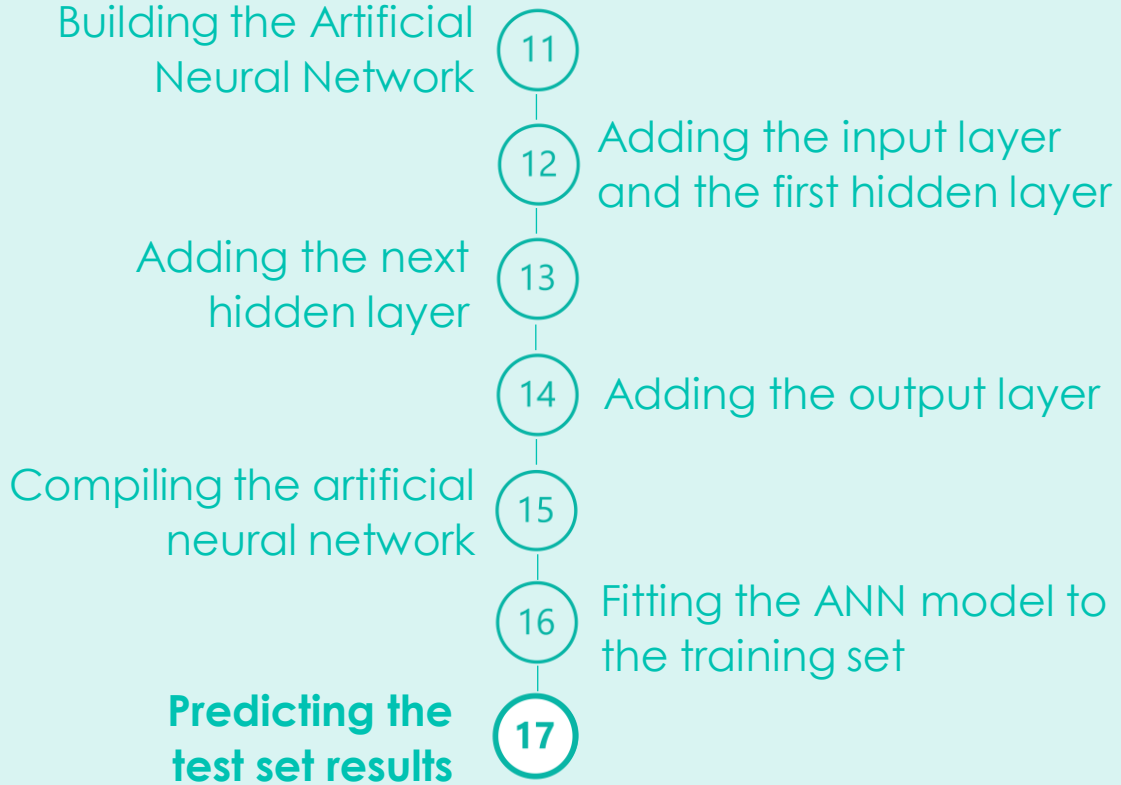
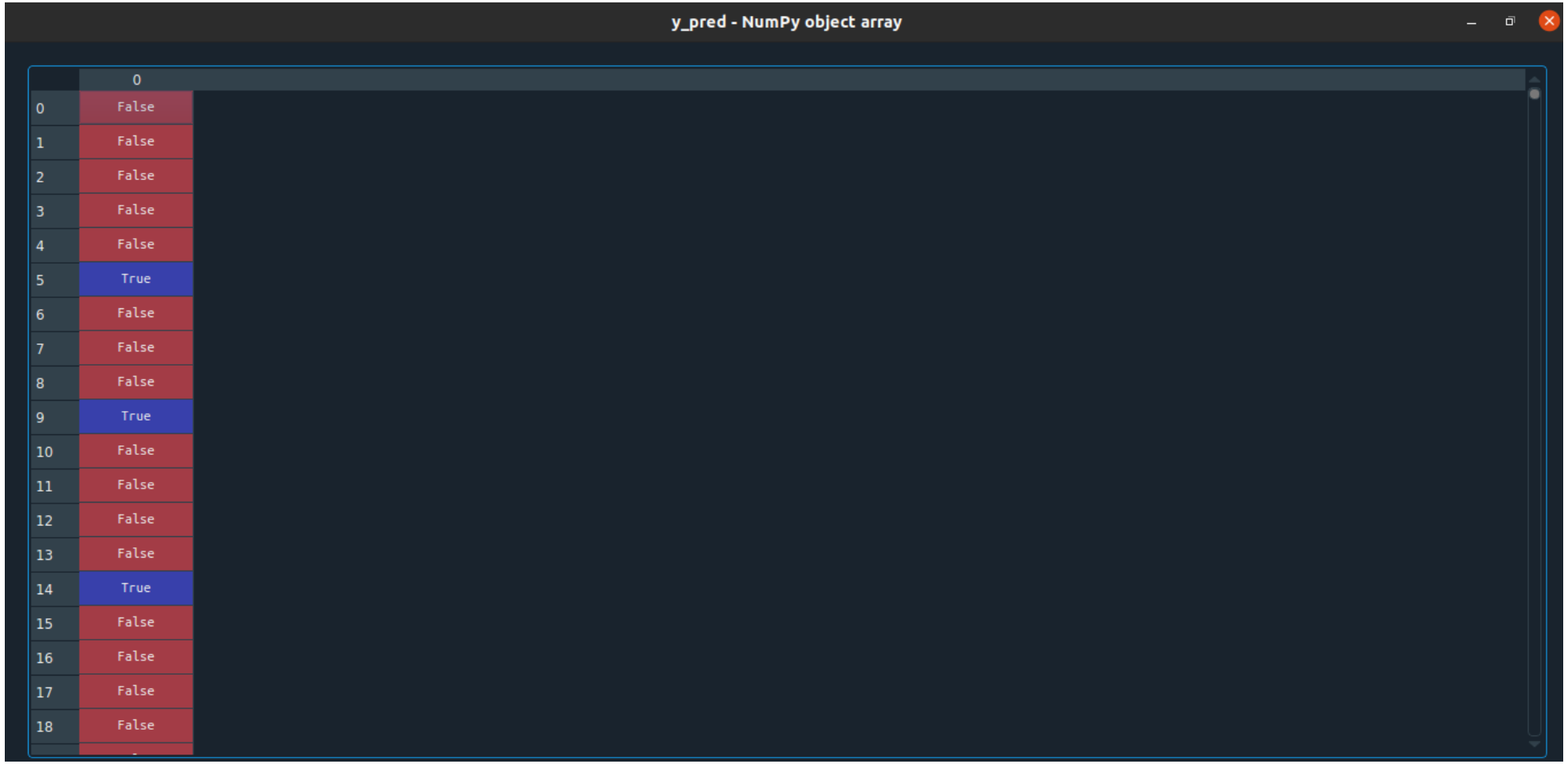


Predict the Test Set Results

So, after running this code, you will get y_pred something like this-



Meta Brains

Make the confusion Matrix

```
from sklearn.metrics import confusion_matrix, accuracy_score
cm = confusion_matrix(y_test, y_pred)
print(cm)
accuracy_score(y_test,y_pred)
```

```
[[1499   96]
 [ 189  216]]

0.8575
```

And we got 85.75% accuracy-.

Meta Brains

Quiz Time

The number of nodes in the input layer is 10 and the hidden layer is 5. The maximum number of connections from the input layer to the hidden layer are

a) 50

b) Less than 50

c) More than 50

d) It is an arbitrary value

Quiz Time

The number of nodes in the input layer is 10 and the hidden layer is 5. The maximum number of connections from the input layer to the hidden layer are

a) 50

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02 Components of convolutional neural networks

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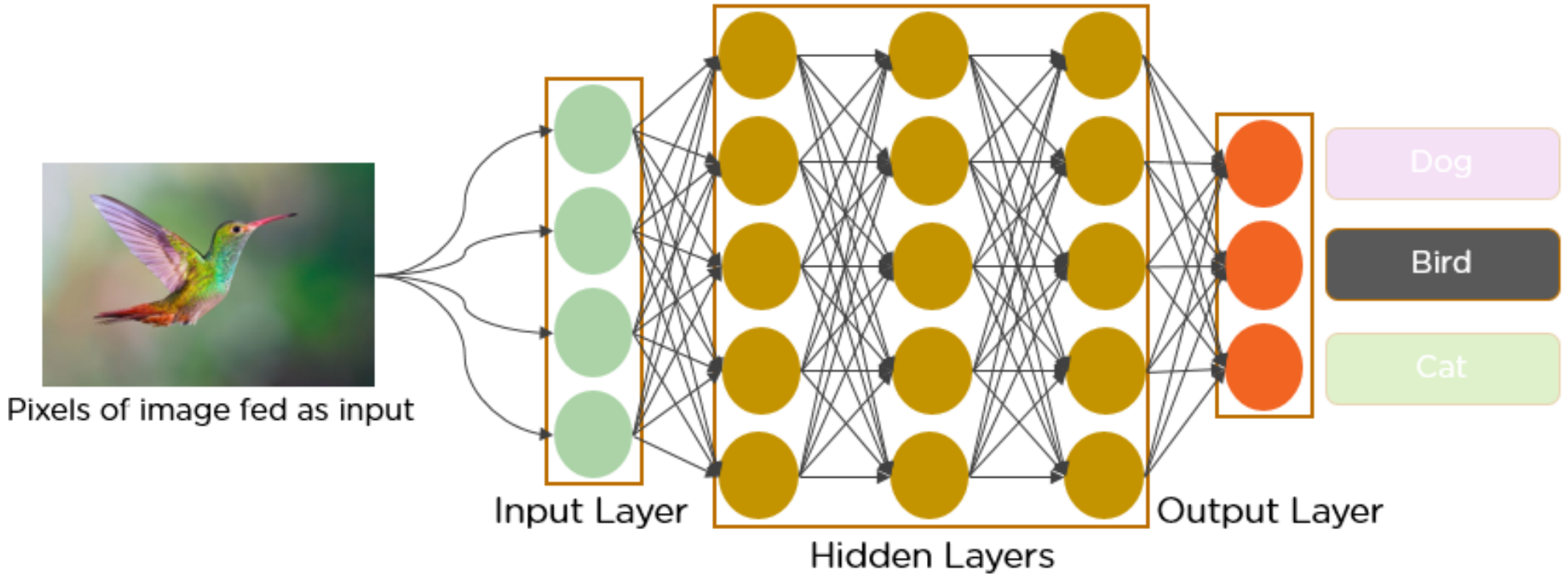
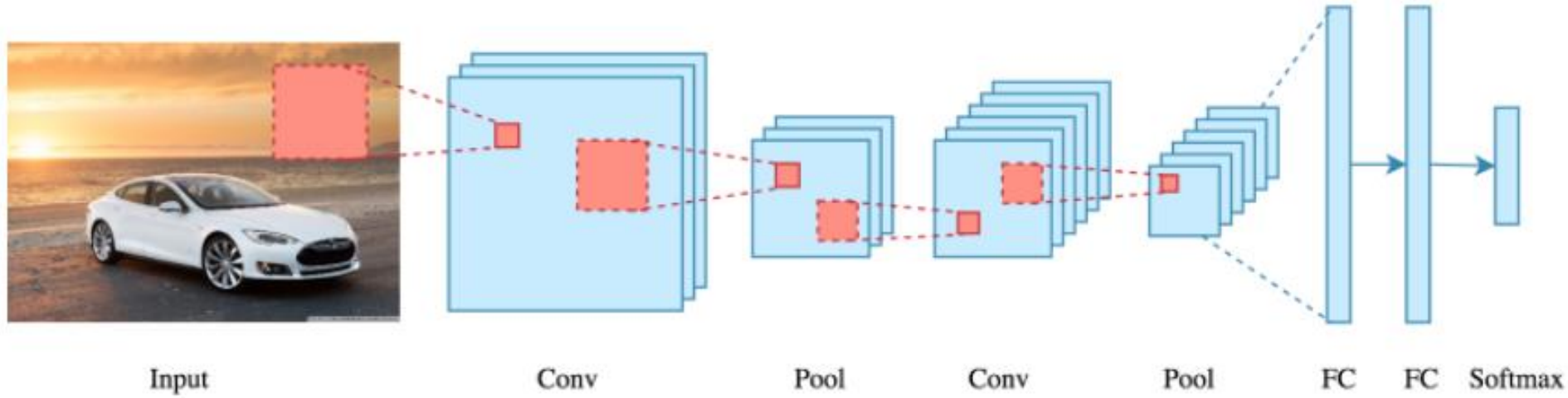
CNN-Introduction



What exactly is a CNN



Bottom line is that the role of the ConvNet is to reduce the images into a form that is easier to process, without losing features that are critical for getting a good prediction.

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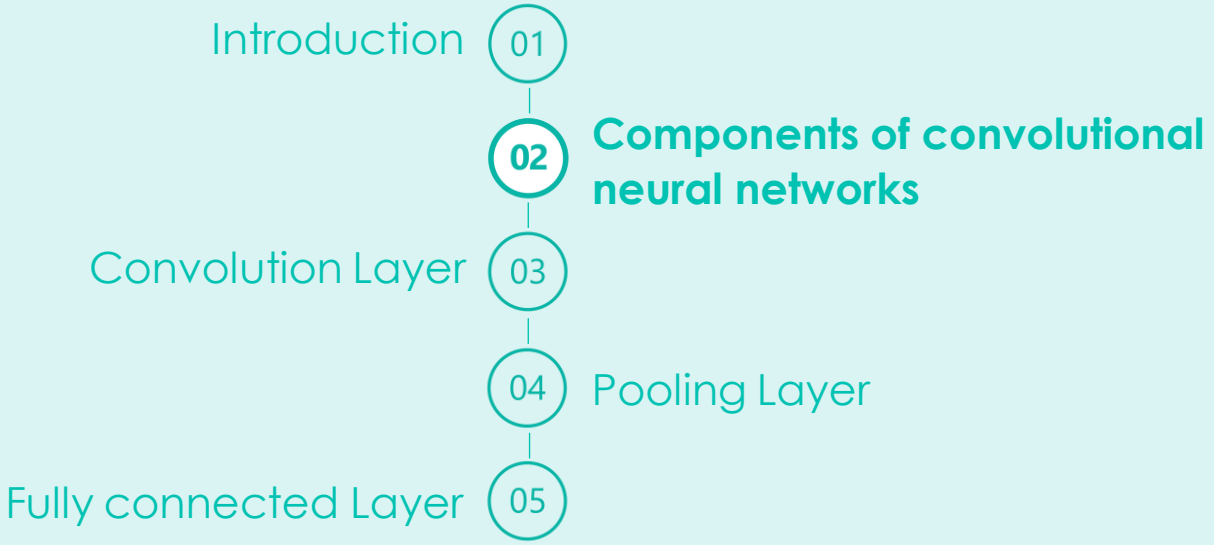


Components of CNN

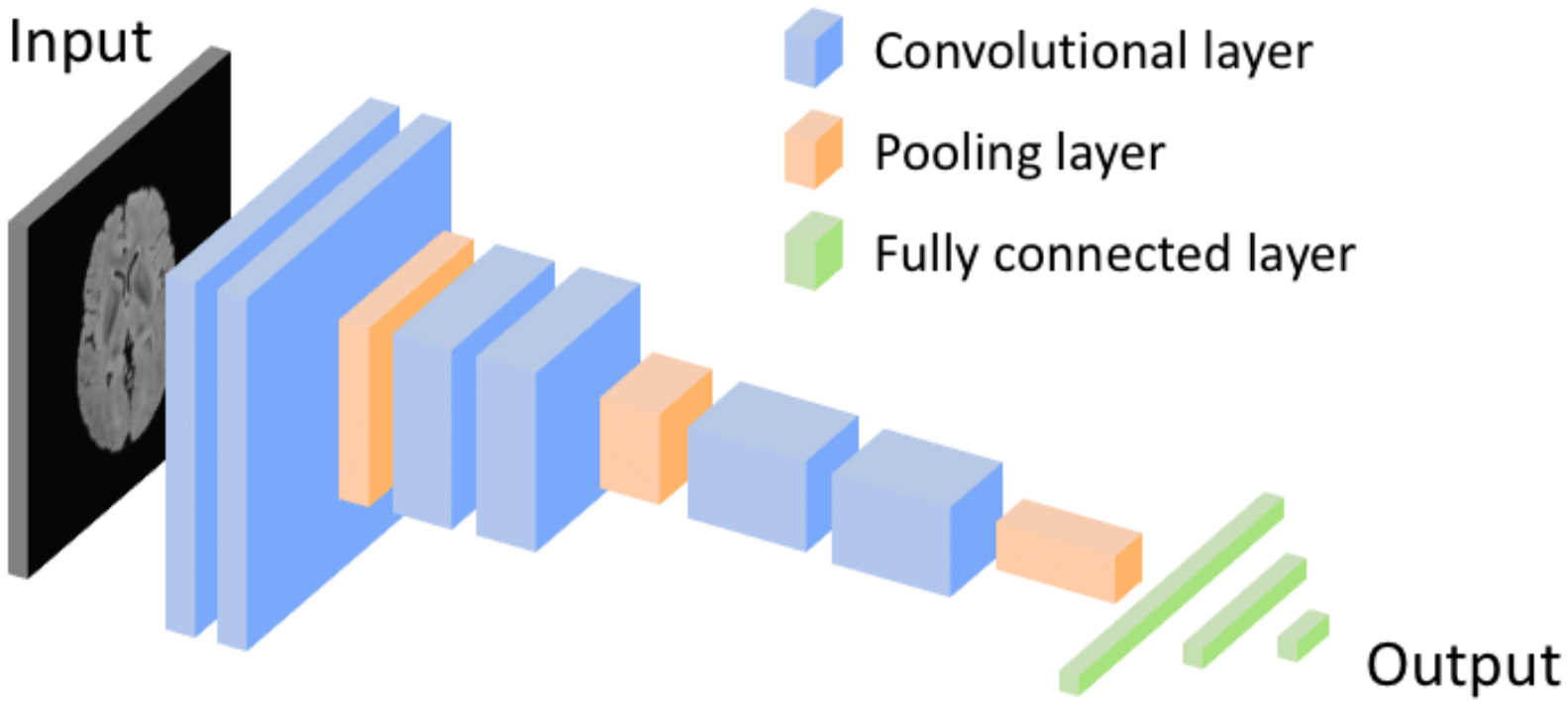
The CNN model works in two steps: **feature extraction and Classification**

Feature Extraction is a phase where various filters and layers are applied to the images to extract the information and features out of it and once it's done it is passed on to the next phase i.e **Classification** where they are classified based on the target variable of the problem.

A typical CNN model looks like this:

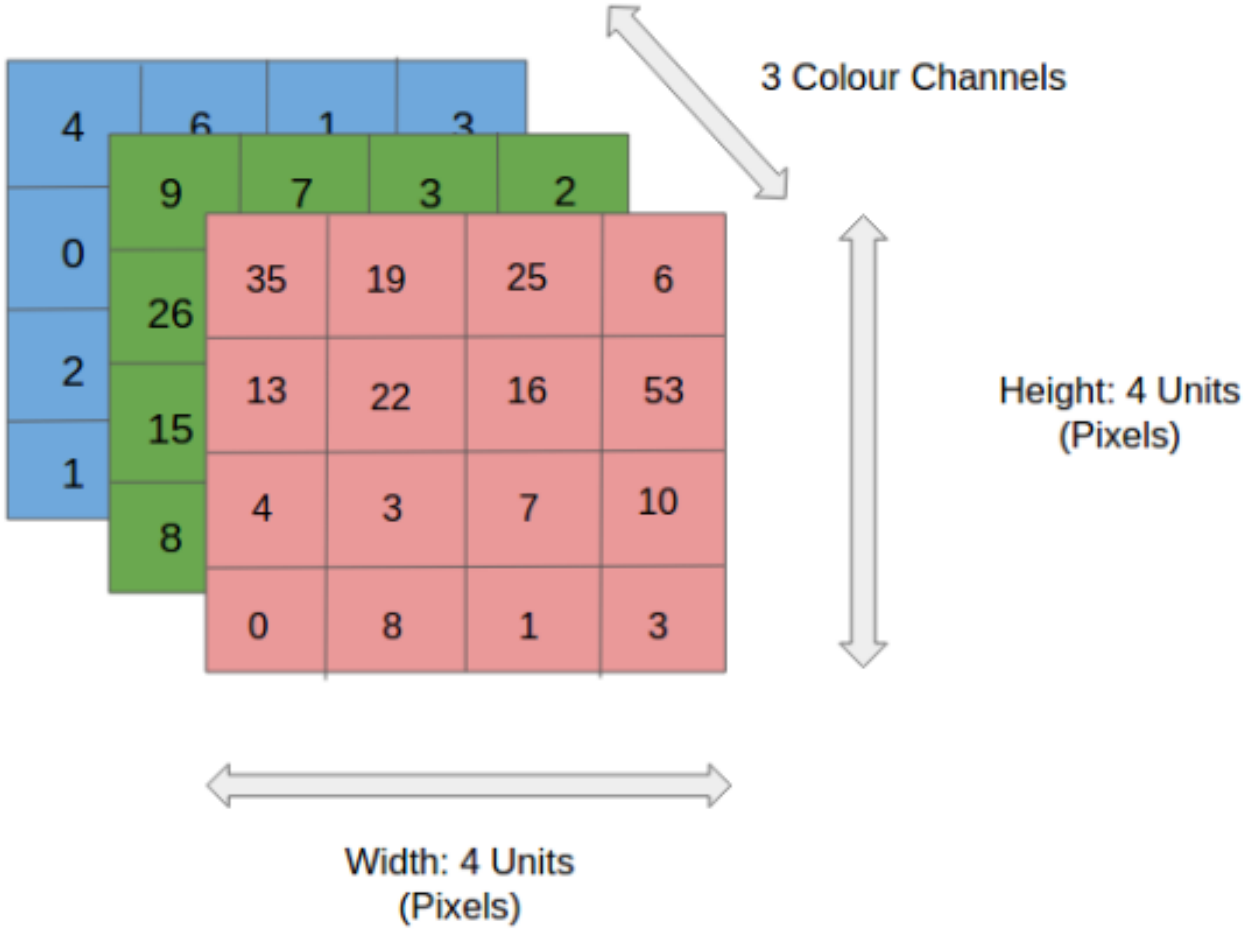
- Input layer
- Convolution layer + Activation function
- Pooling layer
- Fully Connected Layer

Components of CNN



Source: researchgate.net

Input Layer



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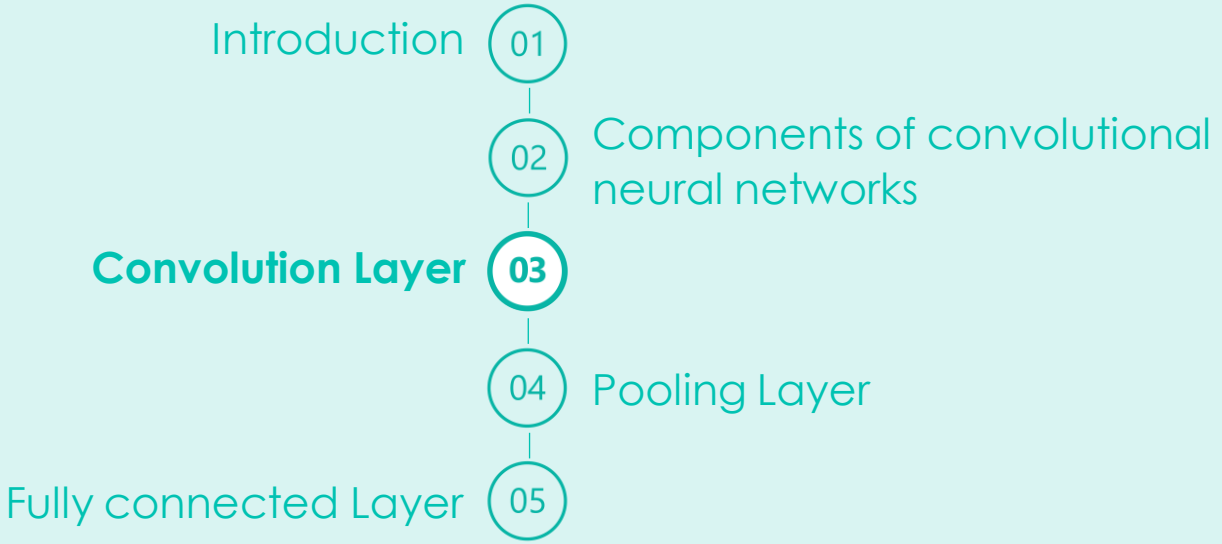
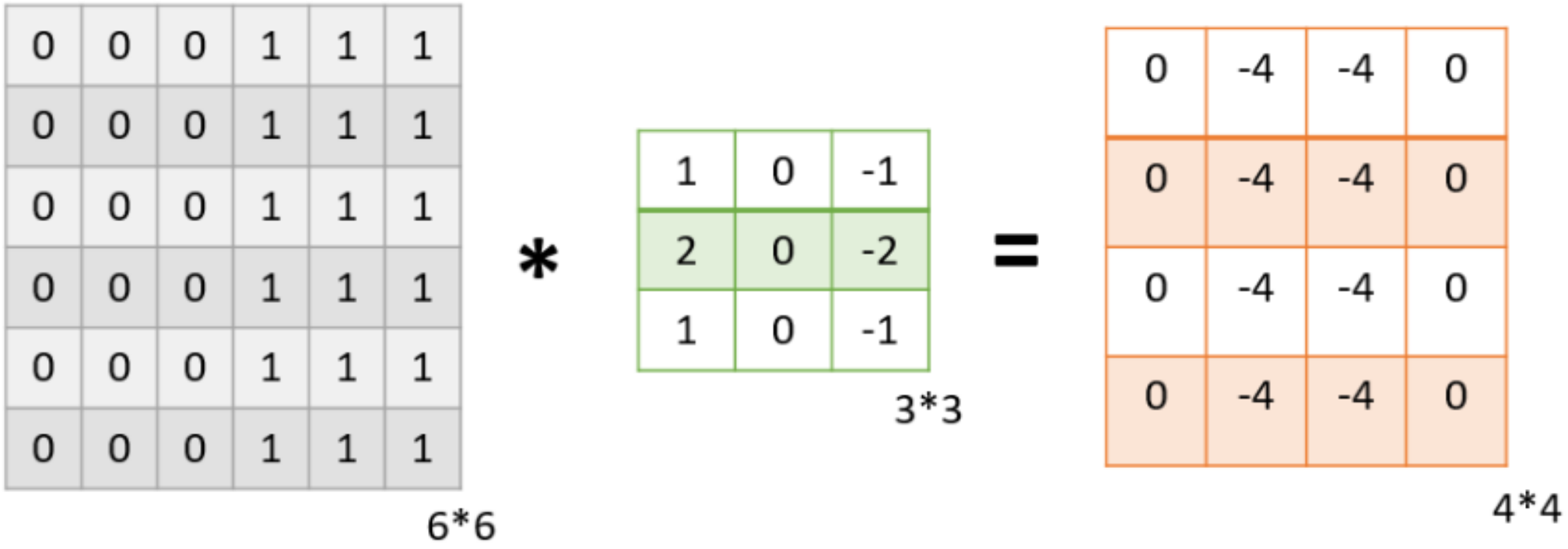


Convolution Layer (1/4)



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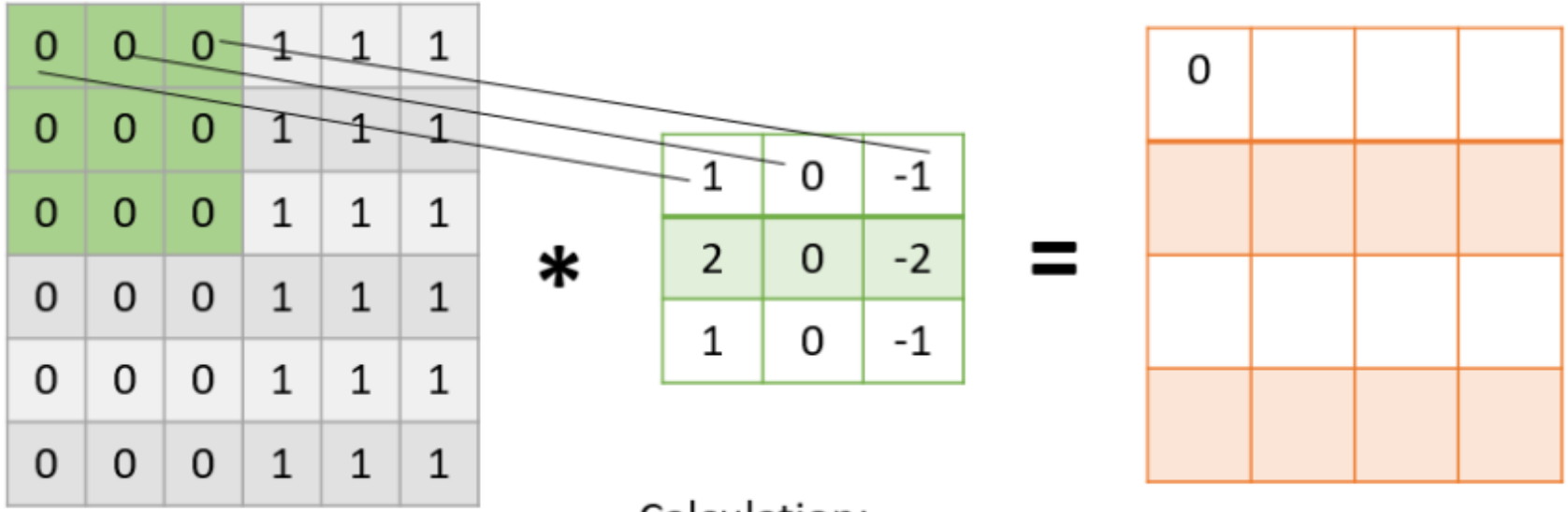
Convolution Layer (2/4)

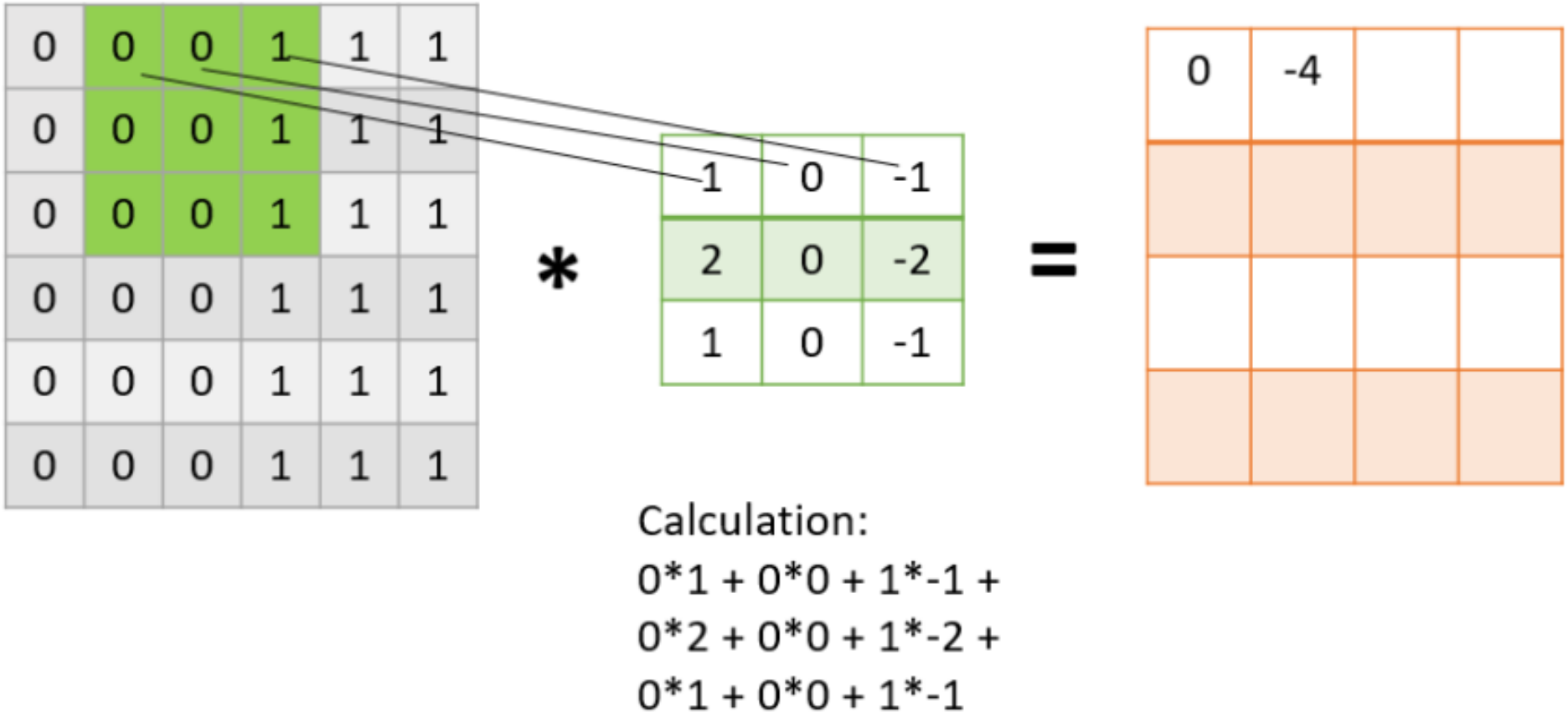
The result of applying the filter to the image is that we get a Feature Map of 4*4



Calculation:

0*1 + 0*0 + 0*-1 +
0*2 + 0*0 + 0*-2 +
0*1 + 0*0 + 0*-1

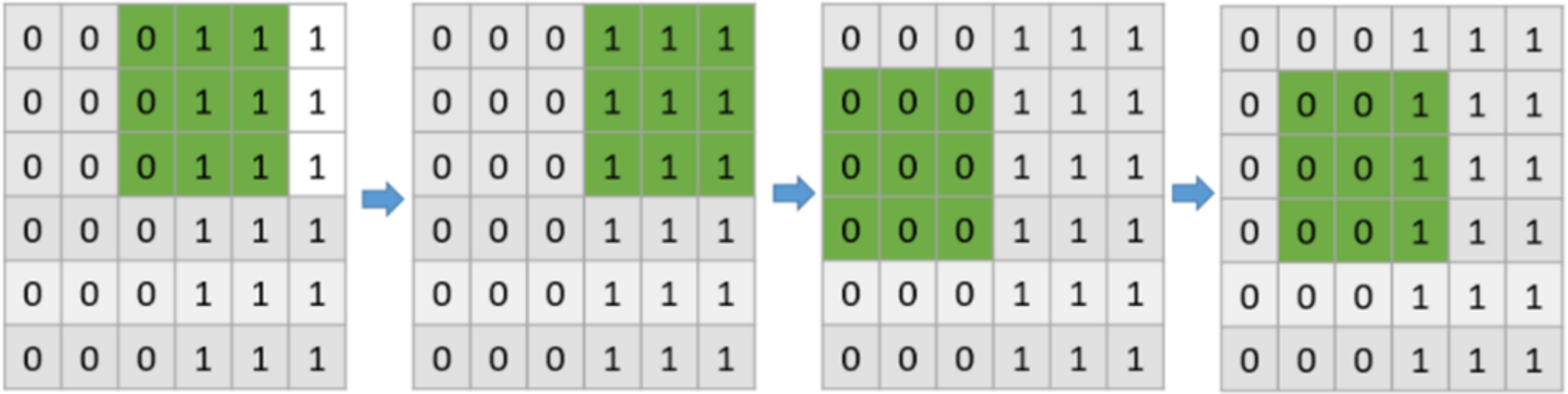
Convolution Layer (3/4)



Calculation:

0*1 + 0*0 + 1*-1 +
0*2 + 0*0 + 1*-2 +
0*1 + 0*0 + 1*-1

Convolution Layer (4/4)



This is how a filter passes through the entire image with the stride of 1

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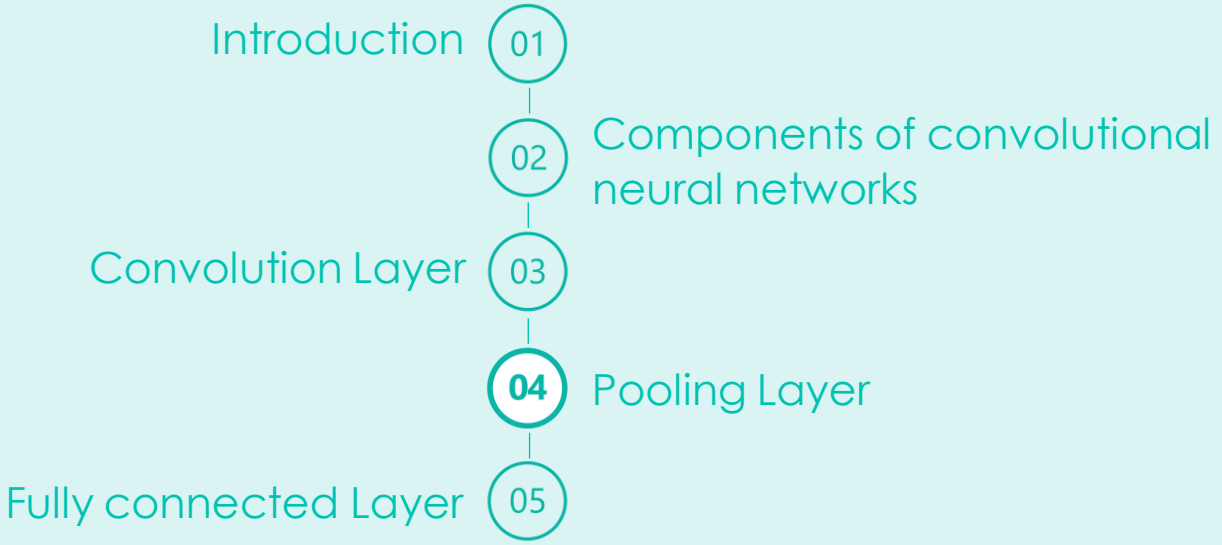
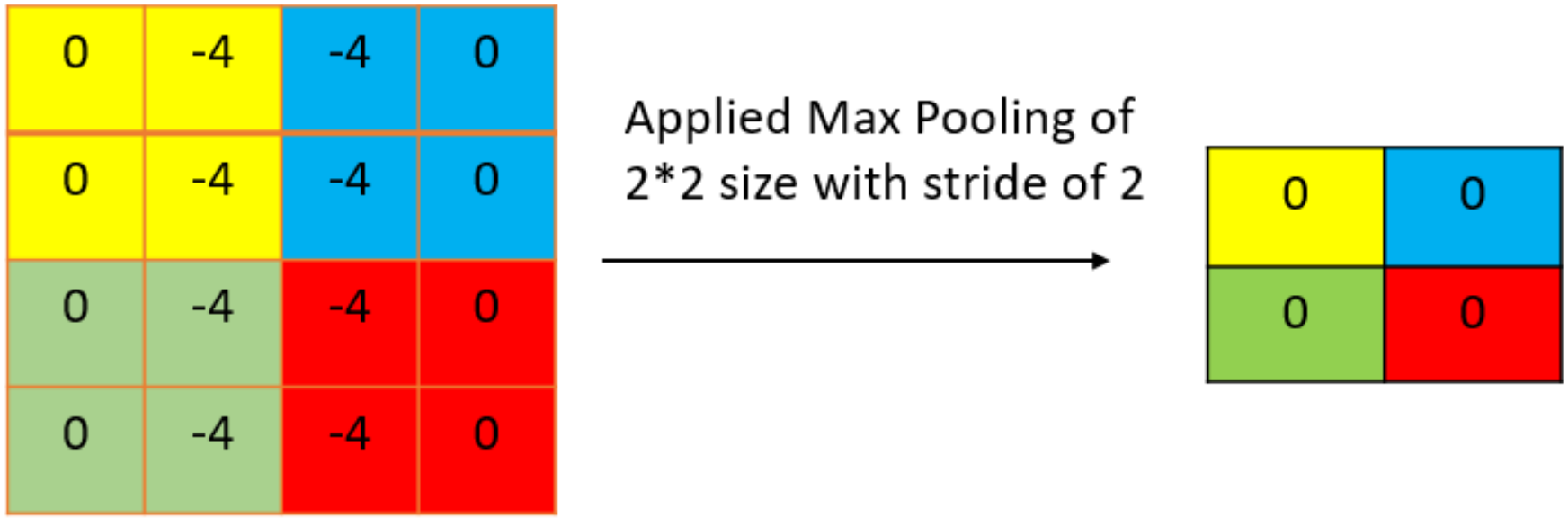


Pooling Layer

The pooling layer is applied after the Convolutional layer.
It is used to reduce the dimensions of the feature maps. Thus, it reduces the number of parameters to learn. it preserves the important information or features of the input image.



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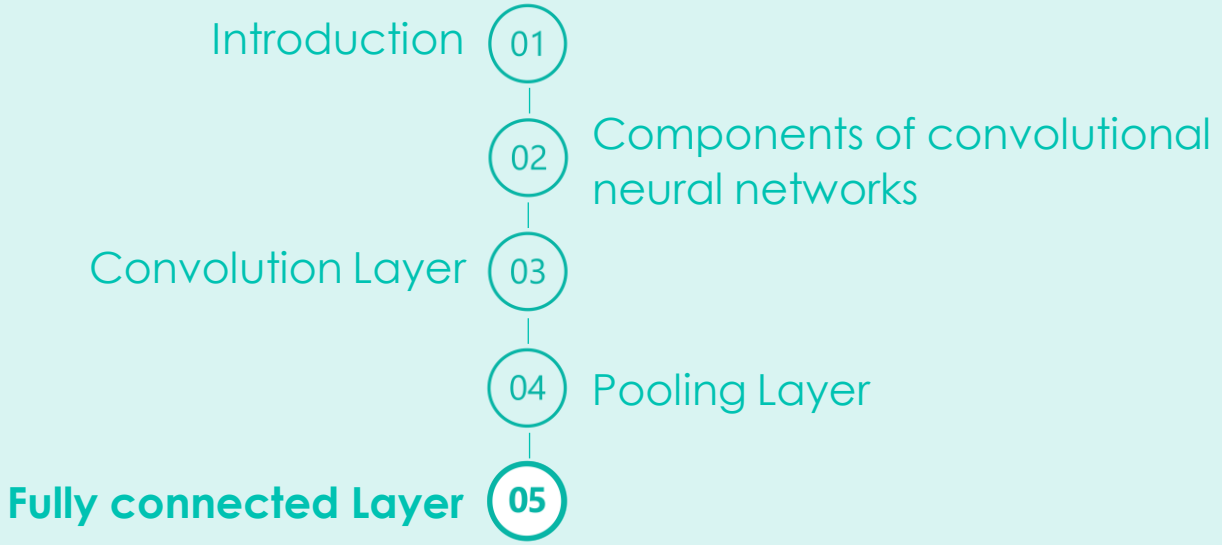
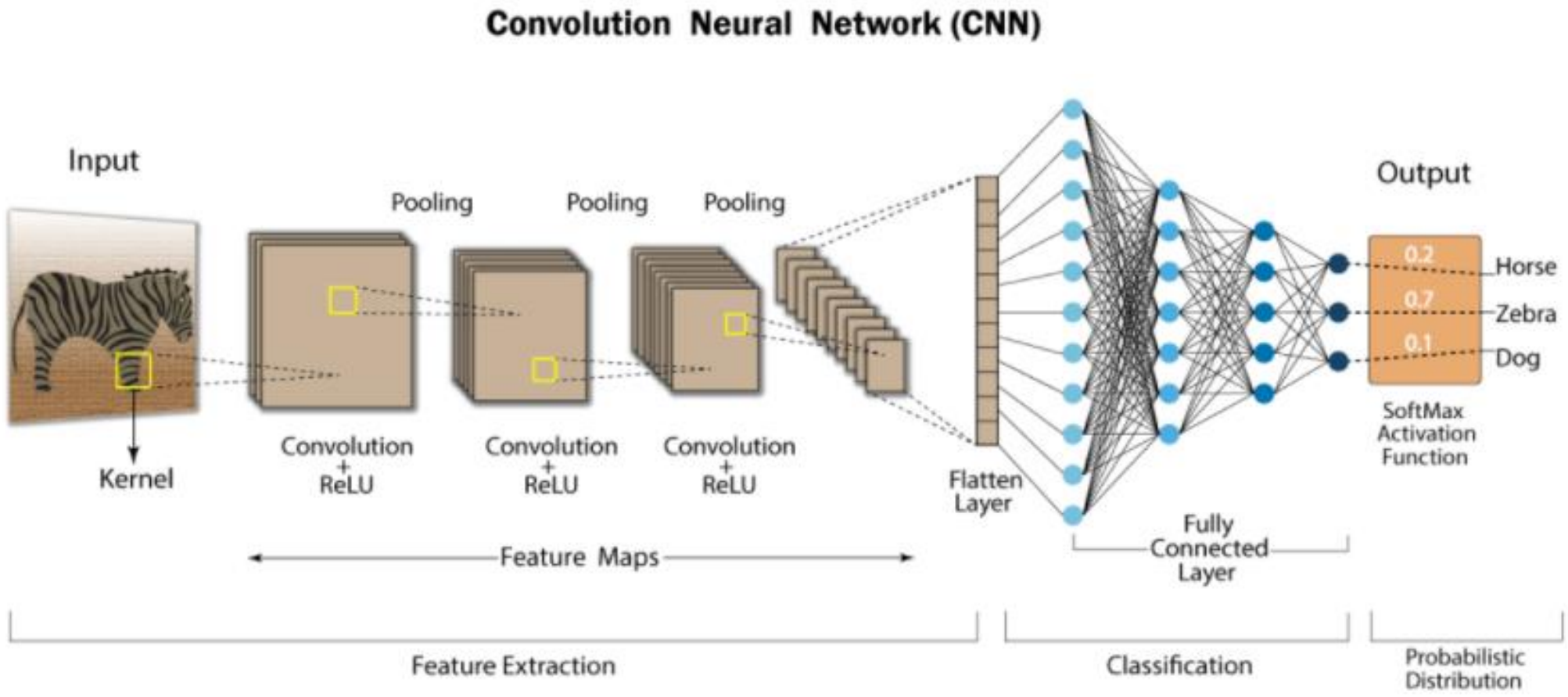


Fully Connected Layer



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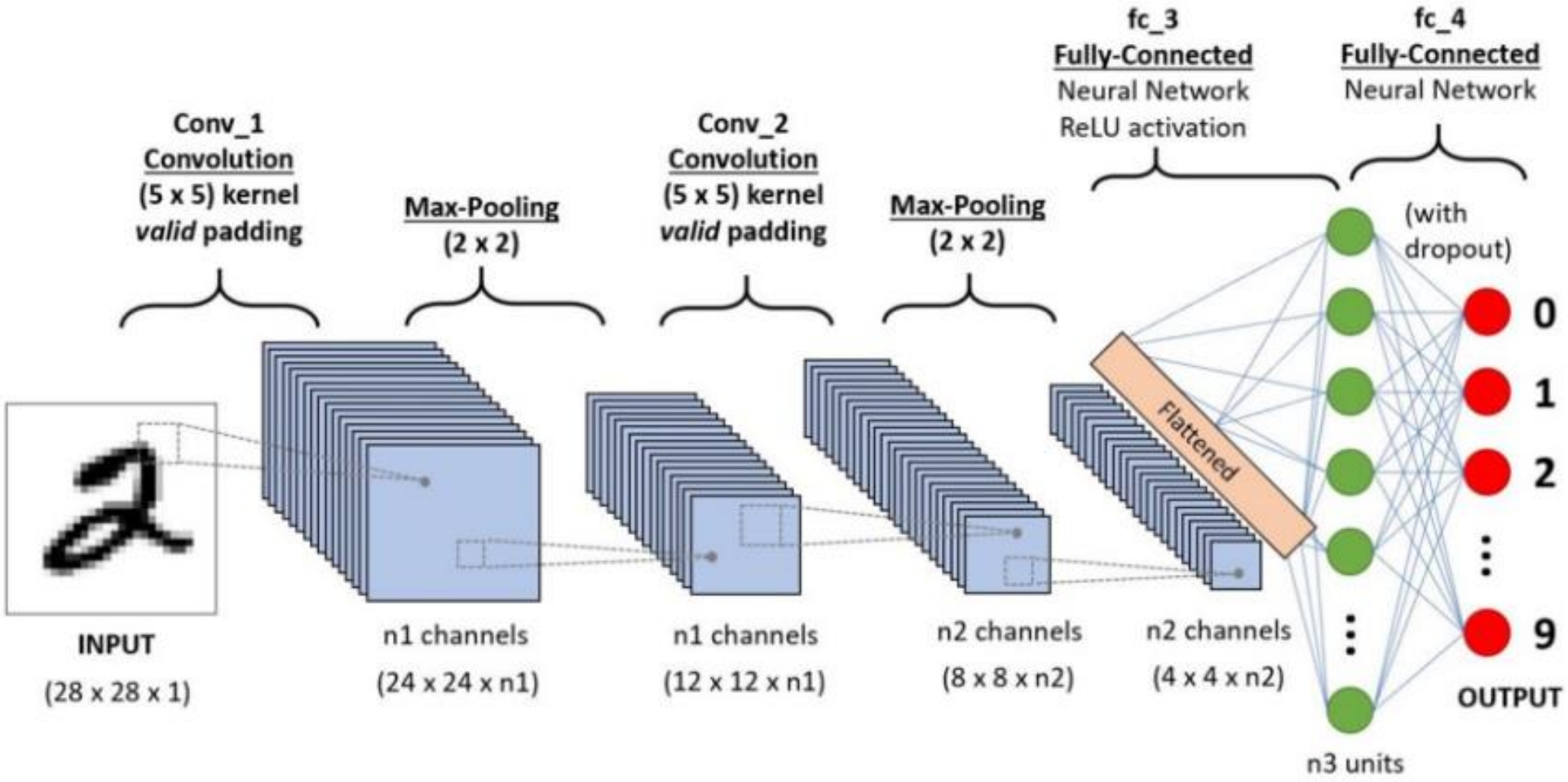
04 Accuracy of the model

We are going to use MNIST Handwritten Digit data which contains the images of handwritten digits.

Background of CNNs



Meta Brains

- Introduction to Deep Learning
- Artificial Neural Networks (ANN)
- Propagation of information in ANNs
- Neural Network Architectures
- Activation Functions
- Gradient Descent Algorithm
- Summary Overview of Neural Networks
- Implementation of ANN in Python
- Convolutional Neural Networks (CNN)
- **Implementation of CNN in Python**

01 Dataset

02 Importing libraries

03 Building the CNN model

04 Accuracy of the model

Implementation (1/5)

```
#importing the required libraries
from tensorflow.keras.datasets import mnist
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Conv2D
from tensorflow.keras.layers import MaxPool2D
from tensorflow.keras.layers import Flatten
from tensorflow.keras.layers import Dropout
from tensorflow.keras.layers import Dense
```

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Dataset 01

02 Importing libraries

Building the CNN model **03**

04 Accuracy of the model

Implementation (2/5)

```
#loading data
(X_train,y_train) , (X_test,y_test)=mnist.load_data()
#reshaping data
X_train = X_train.reshape((X_train.shape[0], X_train.shape[1], X_train.shape[2], 1))
X_test = X_test.reshape((X_test.shape[0],X_test.shape[1],X_test.shape[2],1))
#checking the shape after reshaping
print(X_train.shape)
print(X_test.shape)
#normalizing the pixel values
X_train=X_train/255
X_test=X_test/255
```

```
(60000, 28, 28, 1)
(10000, 28, 28, 1)
```

Implementation (3/5)

```
#defining model
model=Sequential()
#adding convolution layer
model.add(Conv2D(32,(3,3),activation='relu',input_shape=(28,28,1)))
#adding pooling layer
model.add(MaxPool2D(2,2))
#adding fully connected layer
model.add(Flatten())
model.add(Dense(100,activation='relu'))
#adding output layer
model.add(Dense(10,activation='softmax'))
#compiling the model
model.compile(loss='sparse_categorical_crossentropy',optimizer='adam',metrics=['accuracy'])
#fitting the model
model.fit(X_train,y_train,epochs=10)
```

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Implementation (4/5)

Output-

```
Epoch 1/10
1875/1875 [==============================] - 33s 16ms/step - loss: 0.3192 - accuracy: 0.9057
Epoch 2/10
1875/1875 [==============================] - 30s 16ms/step - loss: 0.0523 - accuracy: 0.9854
Epoch 3/10
1875/1875 [==============================] - 30s 16ms/step - loss: 0.0343 - accuracy: 0.9899
Epoch 4/10
1875/1875 [==============================] - 31s 16ms/step - loss: 0.0229 - accuracy: 0.9929
Epoch 5/10
1875/1875 [==============================] - 31s 16ms/step - loss: 0.0141 - accuracy: 0.9955
Epoch 6/10
1875/1875 [==============================] - 31s 16ms/step - loss: 0.0098 - accuracy: 0.9965
Epoch 7/10
1875/1875 [==============================] - 32s 17ms/step - loss: 0.0070 - accuracy: 0.9982
Epoch 8/10
1875/1875 [==============================] - 31s 17ms/step - loss: 0.0047 - accuracy: 0.9986
Epoch 9/10
1875/1875 [==============================] - 31s 17ms/step - loss: 0.0059 - accuracy: 0.9978
Epoch 10/10
1875/1875 [==============================] - 31s 17ms/step - loss: 0.0030 - accuracy: 0.9991
```

Implementation (5/5)

```
#evaluting the model
model.evaluate(X_test,y_test)
```

```
313/313 [==============================] - 2s 6ms/step - loss: 0.0610 - accuracy: 0.9864

[0.060965631157159805, 0.9864000082015991]
```

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Quiz Time

When pooling layer is added in a convolutional neural network, translation in-variance is preserved. True or False?

a) True

b) False

Quiz Time

When pooling layer is added in a convolutional neural network, translation in-variance is preserved. True or False?

a) True

b) False

THANK YOU

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