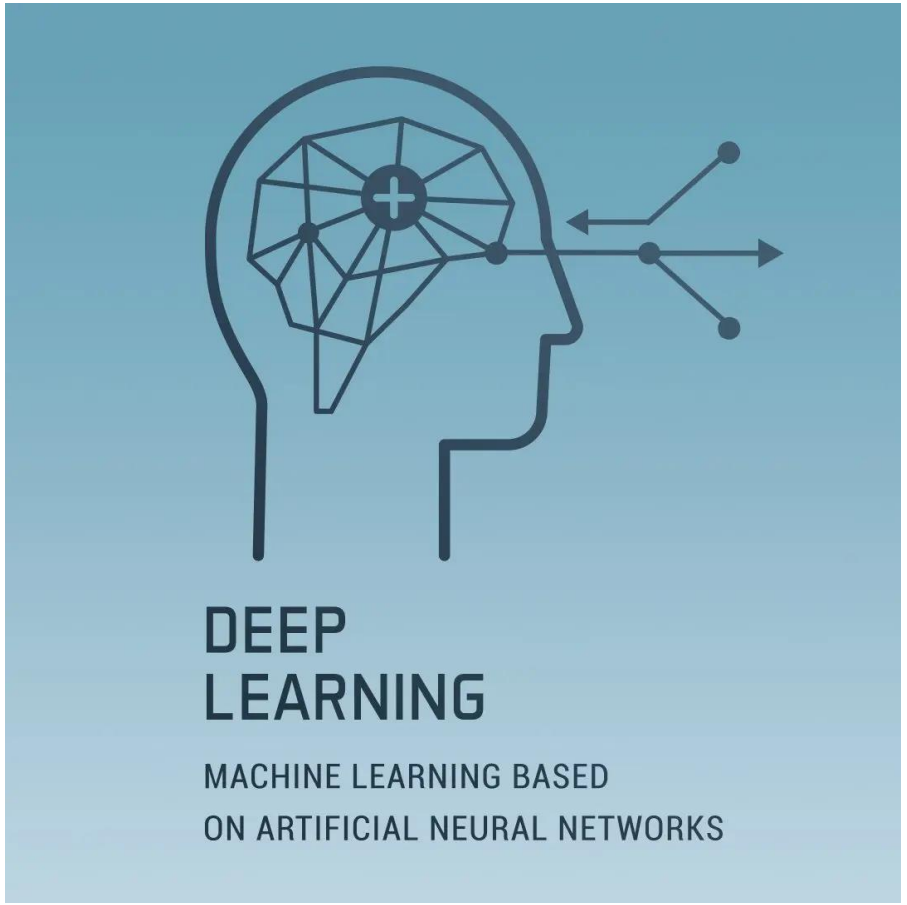
DEEP LEARNING

Content

- Deep Learning Basics
- Neural Network and Applications
- Components, Architecture, Activation Functions
- Working and Training of neural network
- Loss Functions and Gradient Descent
- Computer Vision
- Demo on OpenCV
- Demo on Building an NN from SK-learn
- Demo on Building an NN from Keras
- Case Study – Digit Recognizer using MNIST datasets

Deep Learning

- also known as **deep structured learning**
- part of a broader family of machine learning methods
- based on artificial neural networks
- learning can be supervised, semi-supervised or unsupervised.[1]



https://careers.edicomgroup.com/wp-content/uploads/2021/03/DeepLearning-2.jpg

What is a neural network?

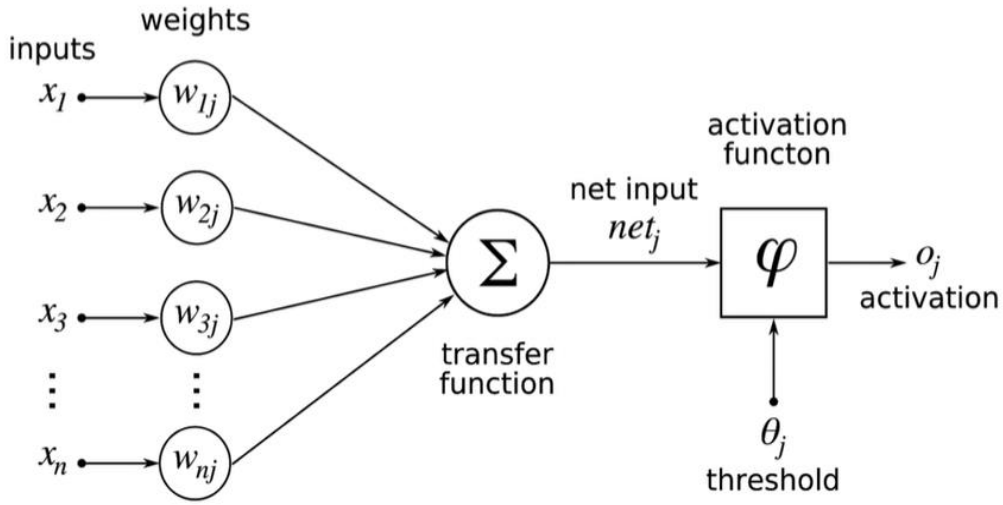
- Artificial replica of densely interconnected brain cells inside
- it can learn things, recognize patterns, and make decisions in a humanlike way.
- One don't have to program it to learn explicitly: ***it learns all by itself, just like a brain!***

Application of neural networks

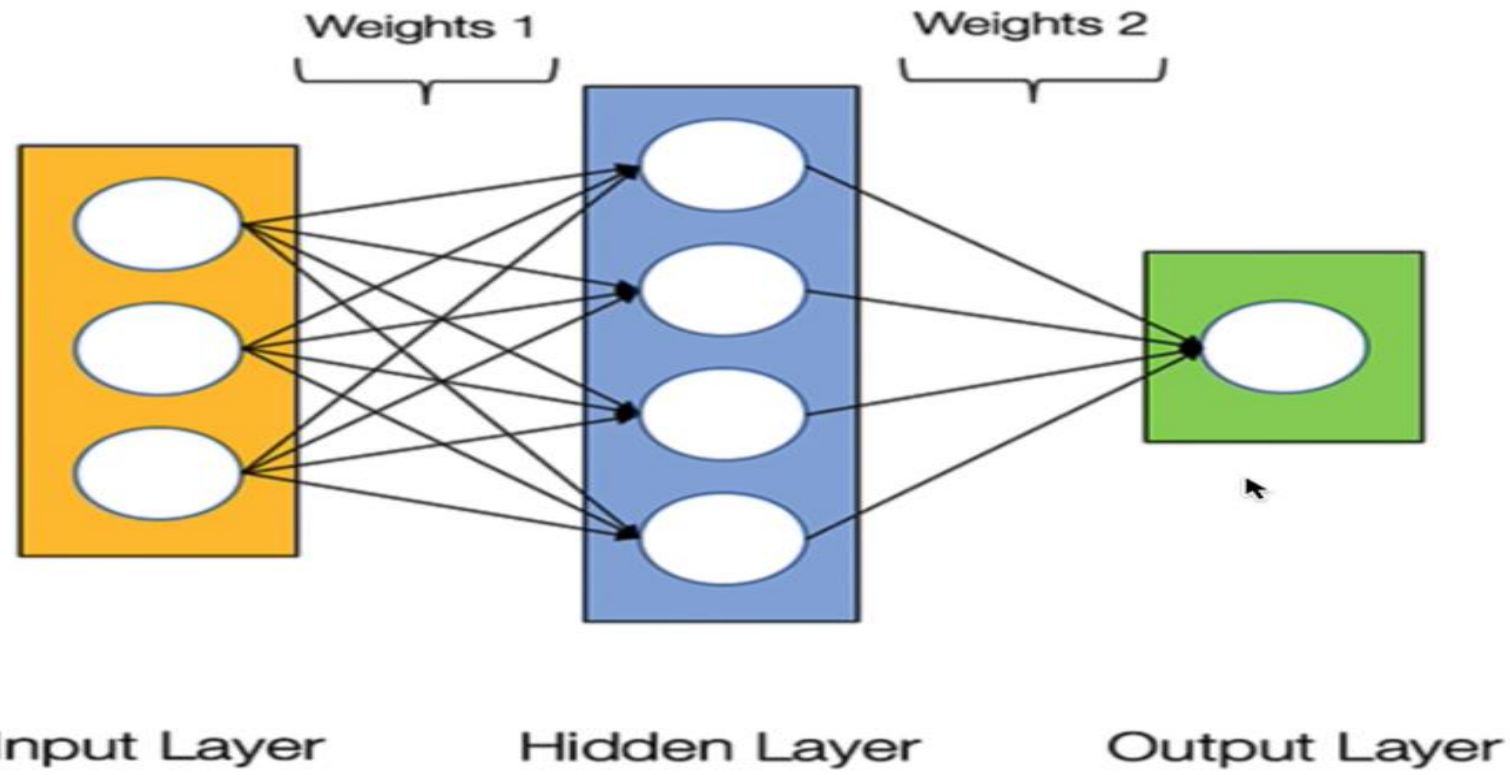
- Process modelling and control
- Machine Diagnostics
- Portfolio Management
- Target Recognition
- Medical Diagnosis
- Credit Rating
- Targeted Marketing
- Voice recognition
- Face recognition
- Financial Forecasting
- Fraud detection

Components

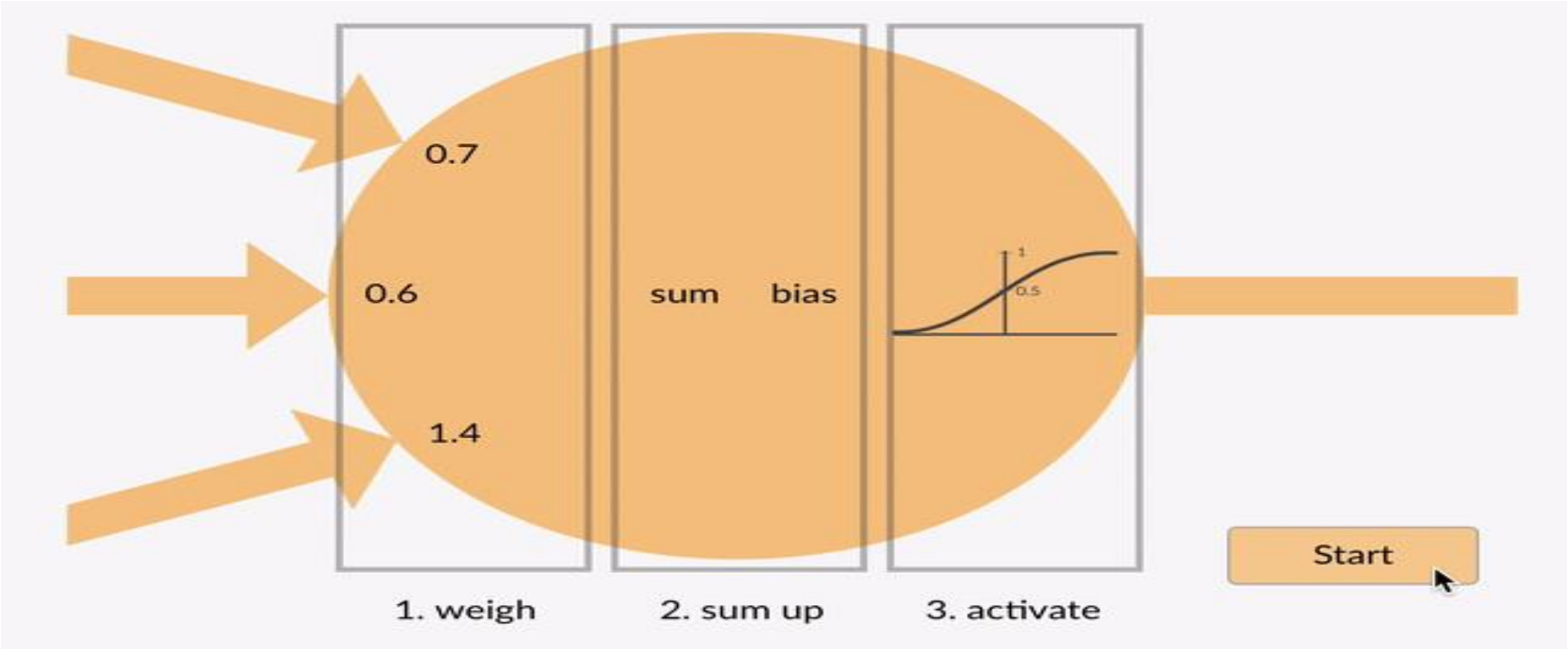
- Input Layer
- Hidden Layer
- Output Layer
- Weights and Biases between Layers
- Activation Function



2 Layer Architecture



Single Neuron



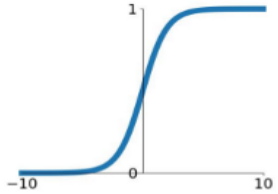
https://www.analyticsvidhya.com/blog/2020/02/cnn-vs-rnn-vs-mlp-analyzing-3-types-of-neural-networks-in-deep-learning/

Activation Function

Activation Functions

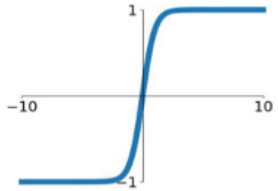
Sigmoid

$$\sigma(x) = \frac{1}{1+e^{-x}}$$



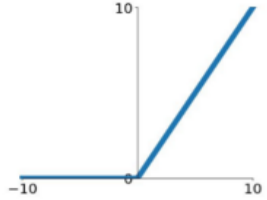
tanh

$$\tanh(x)$$



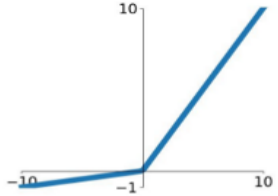
ReLU

$$\max(0, x)$$



Leaky ReLU

$$\max(0.1x, x)$$

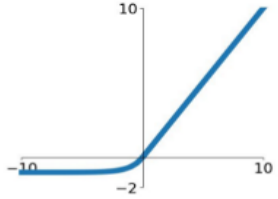


Maxout

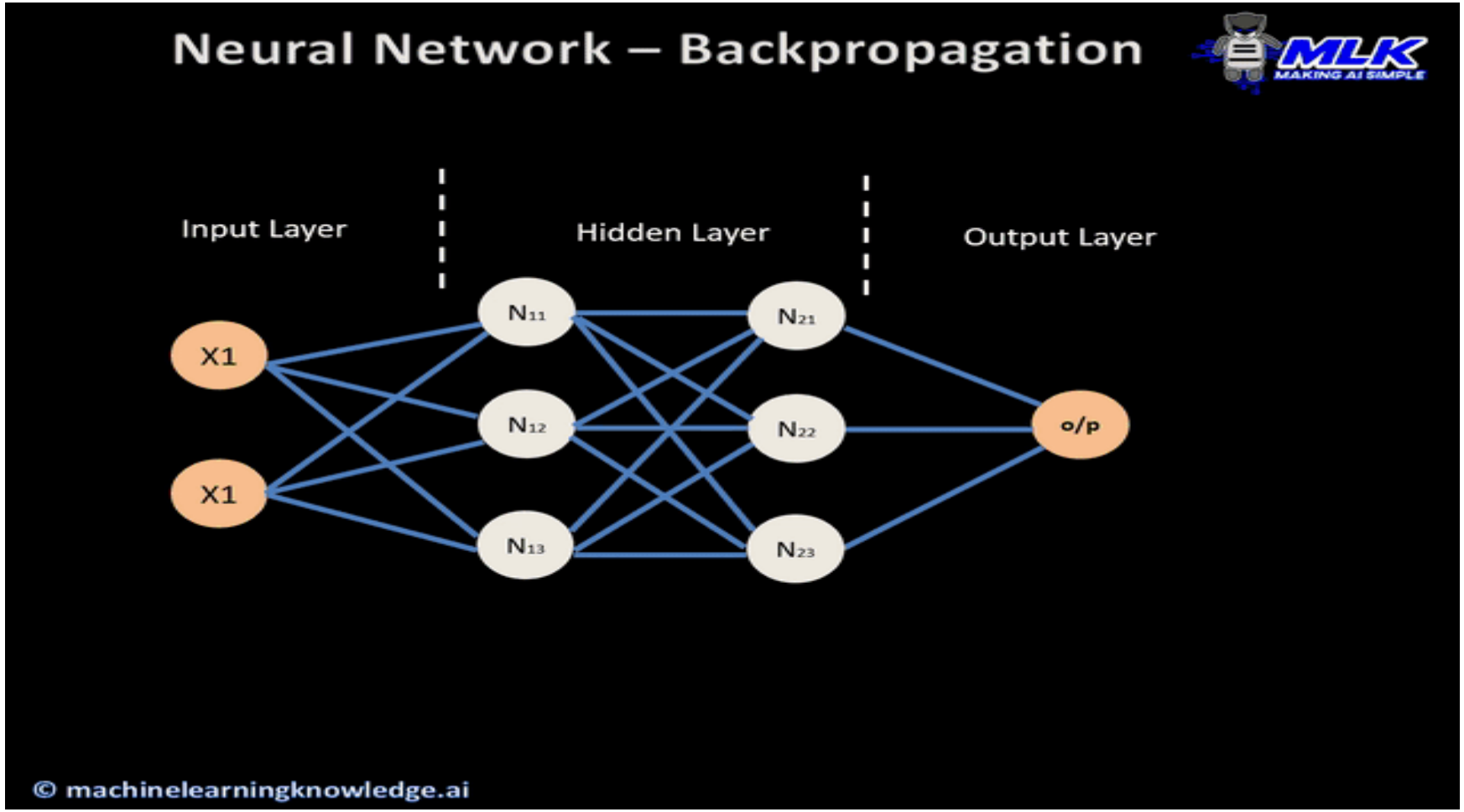
$$\max(w_1^T x + b_1, w_2^T x + b_2)$$

ELU

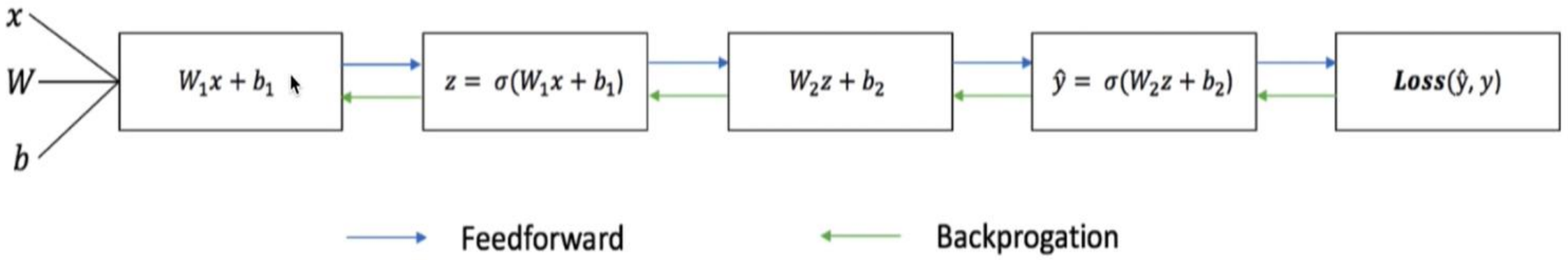
$$\begin{cases} x & x \geq 0 \\ \alpha(e^x - 1) & x < 0 \end{cases}$$



Working of ANN

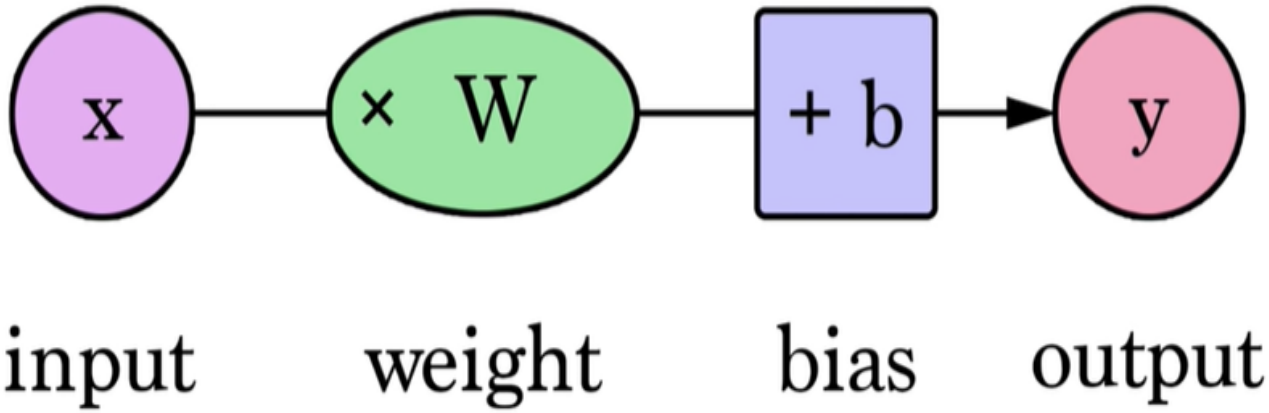


Sequential Graph



Training a Neural Network

- Output is designated by the following function:
  - $Y = \sigma(W_2\sigma(W_1x+b_1)+b_2)$
    - Weights are represented by W_1 and W_2
    - Biases represented by b_1 and b_2
- Two Steps in Training:
  - Feedforward
  - Backpropagation



Loss Functions

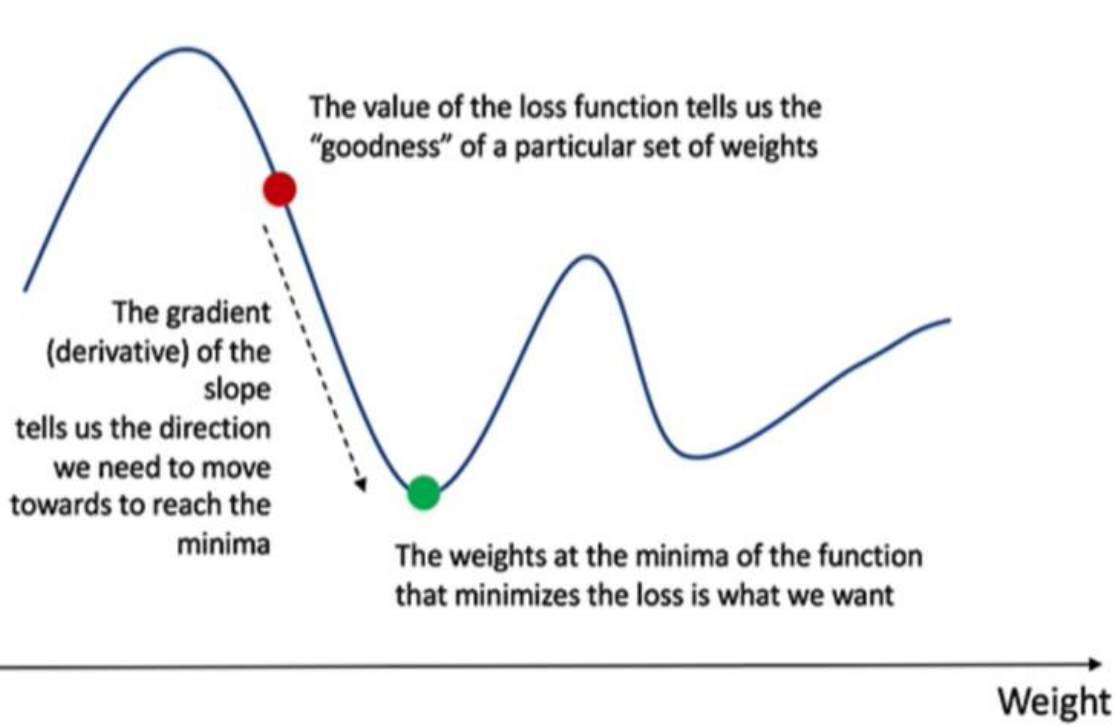
A loss function, that can be used to estimate the loss of the model so that the weights can be updated to reduce the loss on the next evaluation.

Gradient Descent

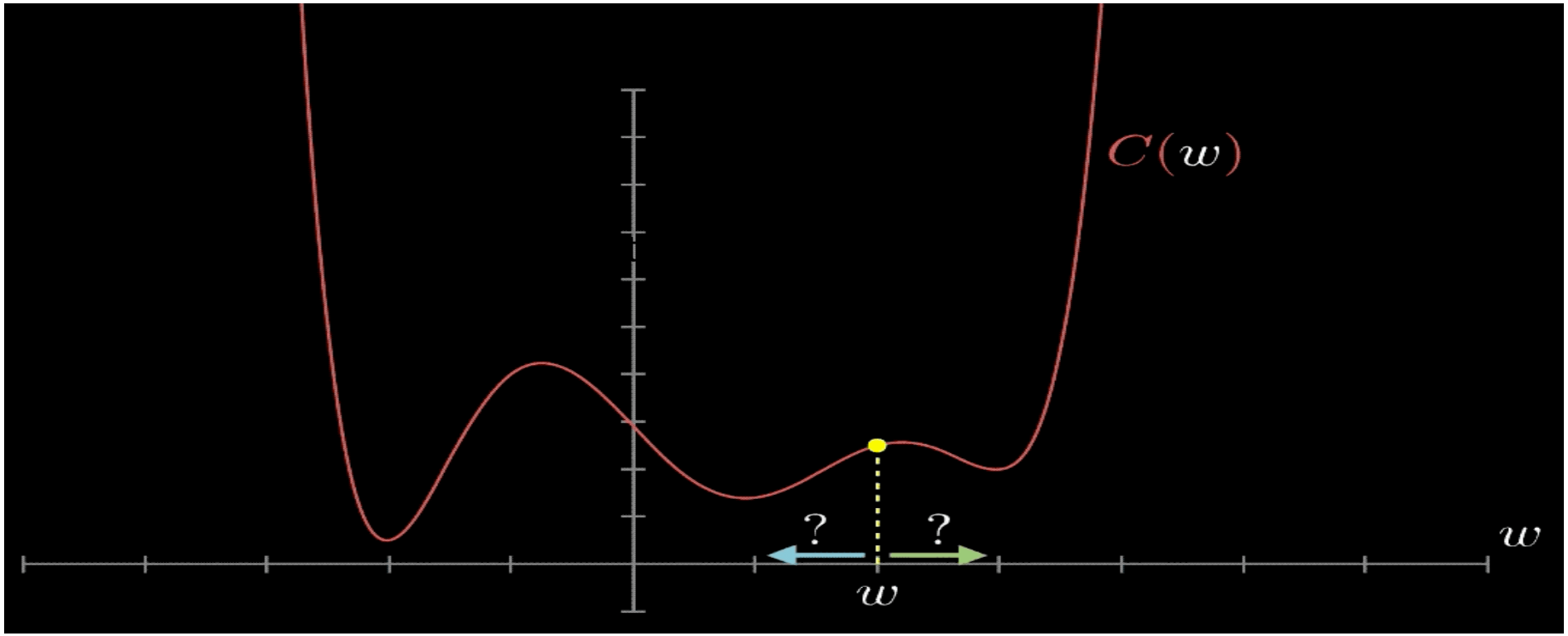
- Derivative of the Loss Function with respect to weights and biases

$$W_1 = W_1 - \alpha \frac{dL}{dW_1}$$

$$W_2 = W_2 - \alpha \frac{dL}{dW_2}$$



Gradient Descent



Ref: mlfromscratch.com

COMPUTER VISION

Gaining High-level understanding from digital images or videos

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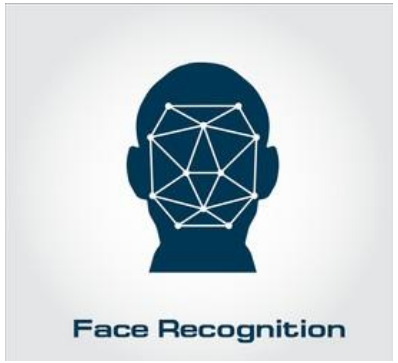
Popular Python Libraries

SimpleCV

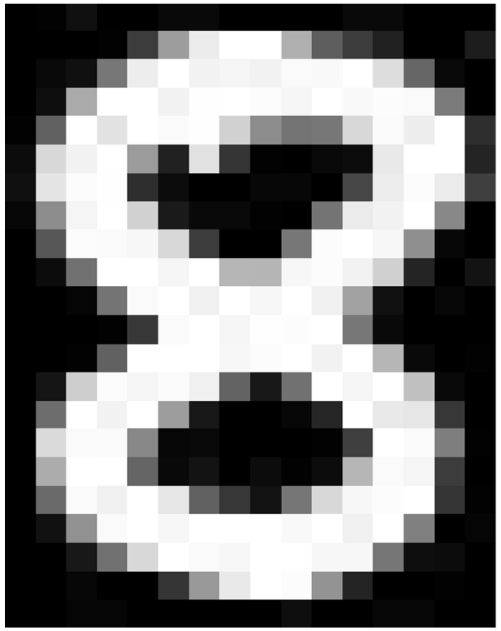


python

PYTESSERACT

What is an Image?

Data in the form of matrix(Rows and Columns) consisting of Pixels



0	2	15	0	0	11	10	0	0	0	0	9	9	0	0	0
0	0	0	4	60	157	236	255	255	177	95	61	32	0	0	29
0	10	16	119	238	255	244	245	243	250	249	255	222	103	10	0
0	14	170	255	255	244	254	255	253	245	255	249	253	251	124	1
2	98	255	228	255	251	254	211	141	116	122	215	251	238	255	49
13	217	243	255	155	33	226	52	2	0	10	13	232	255	255	36
16	229	252	254	49	12	0	0	7	7	0	70	237	252	235	62
6	141	245	255	212	25	11	9	3	0	115	236	243	255	137	0
0	87	252	250	248	215	60	0	1	121	252	255	248	144	6	0
0	13	113	255	255	245	255	182	181	248	252	242	208	36	0	19
1	0	5	117	251	255	241	255	247	255	241	162	17	0	7	0
0	0	0	4	58	251	255	246	254	253	255	120	11	0	1	0
0	0	4	97	255	255	255	248	252	255	244	255	182	10	0	4
0	22	206	252	246	251	241	100	24	113	255	245	255	194	9	0
0	111	255	242	255	158	24	0	0	6	39	255	232	230	56	0
0	218	251	250	137	7	11	0	0	0	2	62	255	250	125	3
0	173	255	255	101	9	20	0	13	3	13	182	251	245	61	0
0	107	251	241	255	230	98	55	19	118	217	248	253	255	52	4
0	18	146	250	255	247	255	255	255	249	255	240	255	129	0	5
0	0	23	113	215	255	250	248	255	255	248	248	118	14	12	0
0	0	6	1	0	52	153	233	255	252	147	37	0	0	4	1
0	0	5	5	0	0	0	0	0	14	1	0	6	6	0	0

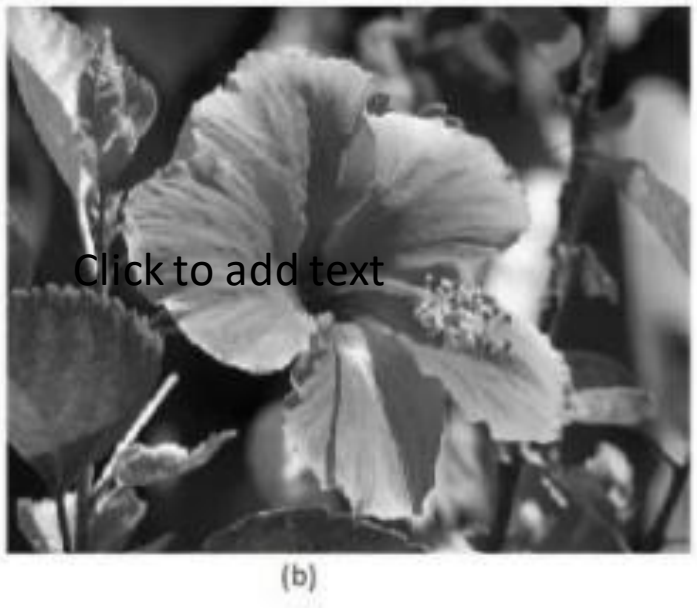
0	2	15	0	0	11	10	0	0	0	0	9	9	0	0	0
0	0	0	4	60	157	236	255	255	177	95	61	32	0	0	29
0	10	16	119	238	255	244	245	243	250	249	255	222	103	10	0
0	14	170	255	255	244	254	255	253	245	255	249	253	251	124	1
2	98	255	228	255	251	254	211	141	116	122	215	251	238	255	49
13	217	243	255	155	33	226	52	2	0	10	13	232	255	255	36
16	229	252	254	49	12	0	0	7	7	0	70	237	252	235	62
6	141	245	255	212	25	11	9	3	0	115	236	243	255	137	0
0	87	252	250	248	215	60	0	1	121	252	255	248	144	6	0
0	13	113	255	255	245	255	182	181	248	252	242	208	36	0	19
1	0	5	117	251	255	241	255	247	255	241	162	17	0	7	0
0	0	0	4	58	251	255	246	254	253	255	120	11	0	1	0
0	0	4	97	255	255	255	248	252	255	244	255	182	10	0	4
0	22	206	252	246	251	241	100	24	113	255	245	255	194	9	0
0	111	255	242	255	158	24	0	0	6	39	255	232	230	56	0
0	218	251	250	137	7	11	0	0	0	2	62	255	250	125	3
0	173	255	255	101	9	20	0	13	3	13	182	251	245	61	0
0	107	251	241	255	230	98	55	19	118	217	248	253	255	52	4
0	18	146	250	255	247	255	255	255	249	255	240	255	129	0	5
0	0	23	113	215	255	250	248	255	255	248	248	118	14	12	0
0	0	6	1	0	52	153	233	255	252	147	37	0	0	4	1
0	0	5	5	0	0	0	0	0	14	1	0	6	6	0	0

Image : Image with Pixels

https://mozanunal.com/images/pixel.png

Types of Images

Color Image



Grayscale Image

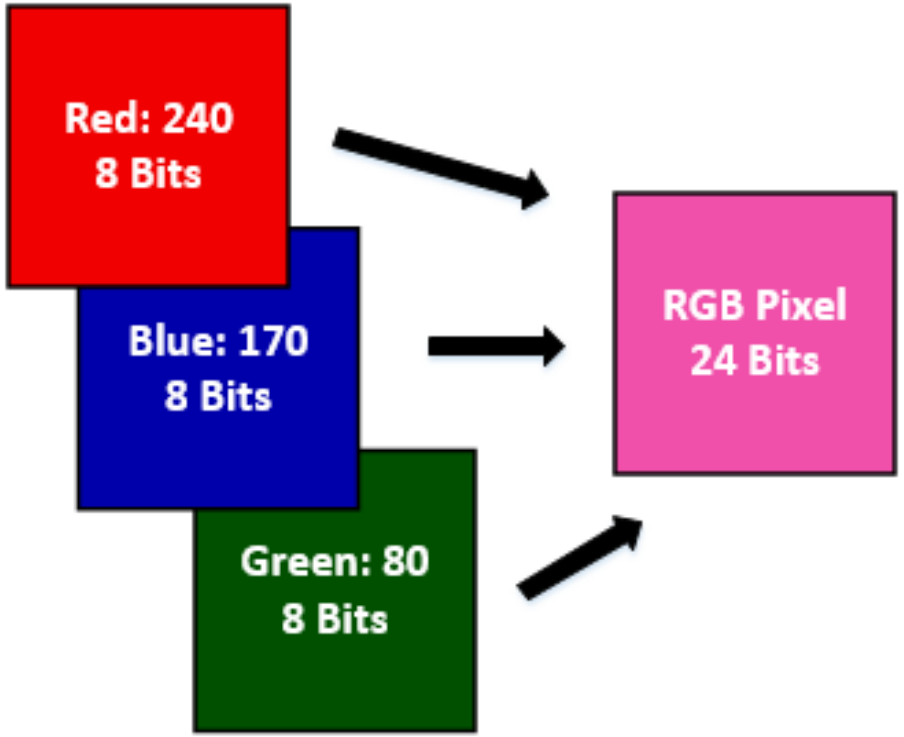
Binary Image

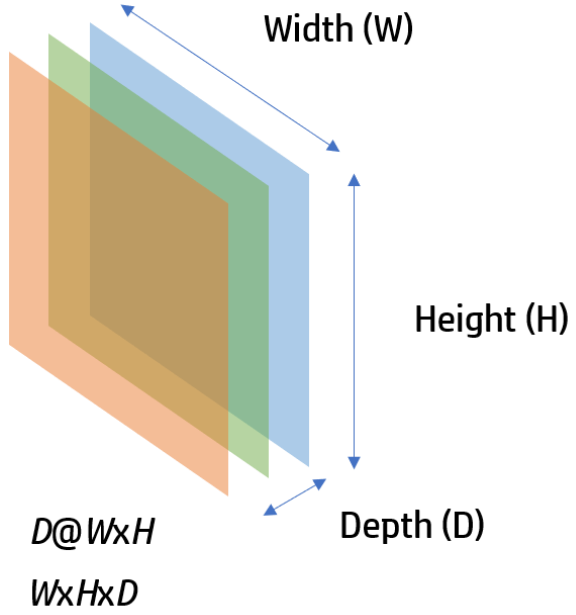
https://www.researchgate.net/profile/Sanskruti-Patel-2/publication/344249310/figure/fig2/AS:935972338425861@1600164603821/Figure2-a-RGB-image-b-Gray-Scale-image-c-Binary-image.jpg

Color Image

Width * Height * Depth

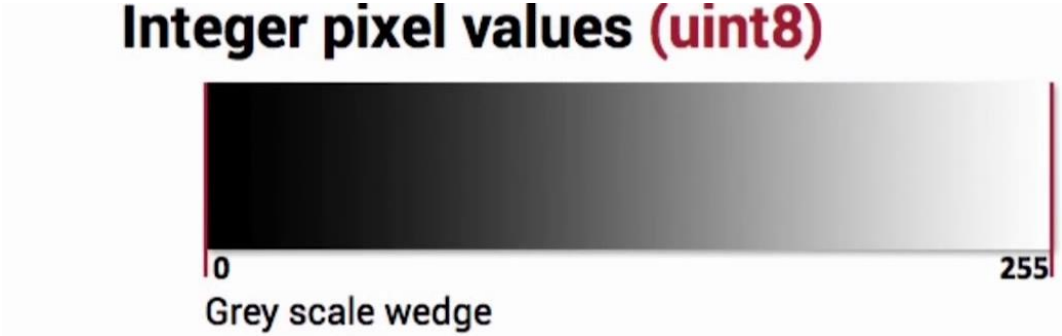
Depth : [Red, Green, Blue]





https://www.codeproject.com/KB/tips/1112774/rgbPixelEx.PNG

How to get Binary Image in Opencv?



https://i.ytimg.com/vi/tSBuwNpIUdI/maxresdefault.jpg

Main methods of OpenCV

1. cv2.imread() - method loads an image from the specified file
2. cv2.resize() – Resizing the pixels value of an image
3. cv2.cvtColor()- convert an image from one color space to another.
4. cv2.threshold() – Changing the pixels value with respect to a threshold

Threshold Function

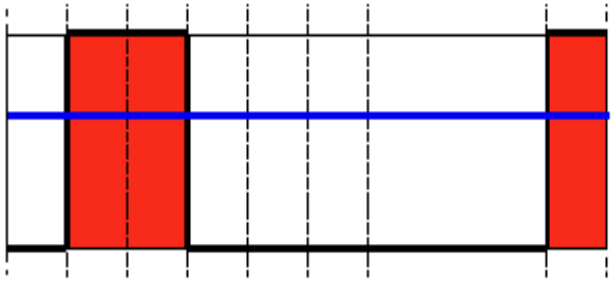
ret,binary = cv2.threshold(img,127,255,cv2.THRESH_BINARY)

Threshold Binary

- This thresholding operation can be expressed as:

$$\texttt{dst}(x,y) = \begin{cases} \texttt{maxVal} & \text{if } \texttt{src}(x,y) > \texttt{thresh} \\ 0 & \text{otherwise} \end{cases}$$

- So, if the intensity of the pixel $\texttt{src}(x,y)$ is higher than $\texttt{thresh}$, then the new pixel intensity is set to a $\texttt{MaxVal}$. Otherwise, the pixels are set to 0.



https://docs.opencv.org/2.4.13.7/doc/tutorials/imgproc/threshold/threshold.html#threshold-binary

Build ANN Using Scikit-learn

Microsoft

SAP

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Extensions to SciPy (Scientific Python) are called SciKits. SciKit-Learn provides machine learning algorithms.

- Algorithms for supervised & unsupervised learning
- Built on SciPy and Numpy
- Standard Python API interface
- Sits on top of c libraries, LAPACK, LibSVM, and Cython
- Open Source: BSD License (part of Linux)

Building Model using Scikit Package

Applying same dataset over MLPClassifier under Scikit Package

```
#With scikit learn - with multilayer perceptron classifier
from sklearn.neural_network import MLPClassifier
from sklearn.metrics import accuracy_score

sknet = MLPClassifier(hidden_layer_sizes=(8),learning_rate_init=0.001, max_iter=100)
```

```
#Fit the data to the classifier model
sknet.fit(Xtrain, ytrain)
preds_train = sknet.predict(Xtrain)
preds_test = sknet.predict(Xtest)

#Print the accuracy of the train and test datasets
print("Train accuracy of sklearn neural network: {}".format(round(accuracy_score(preds_train, ytrain),2)*100))
print("Test accuracy of sklearn neural network: {}".format(round(accuracy_score(preds_test, ytest),2)*100))
```

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Build ANN Using Keras

What is Keras

- High Level neural network API
- Written in Python
- Integration with TensorFlow, Theano & CNTK.
  - (MXNet backend for Keras on the way!)

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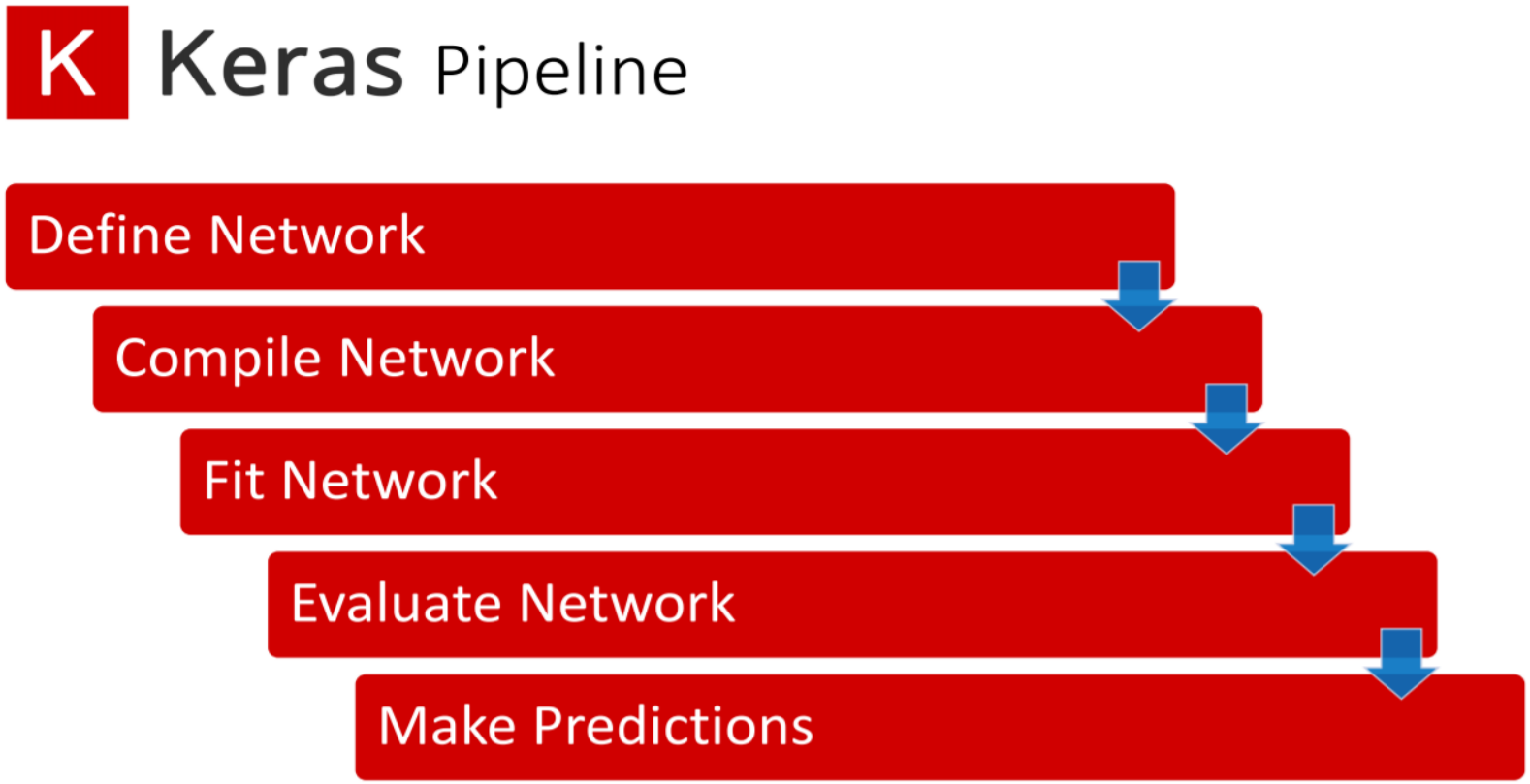
Why K Keras

- Fast prototyping
- Supports CNN, RNN & combination of both
- Modularity
- Easy extensibility
- Simple to get started, simple to keep going
- Deep enough to build serious models.
- Well-written document.
- Runs seamlessly on CPU and GPU.



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Building Model using K Keras

```
#With Keras

from tensorflow.keras import Sequential
from tensorflow.keras.layers import Dense
from tensorflow.keras.optimizers import Adam

#Define the model
model = Sequential()
model.add(Dense(8,input_shape=(13,)))
model.add(Dense(1, activation='sigmoid'))
#model.summary()
```

```
# compile the model
opt = Adam(learning_rate=0.001)
model.compile(optimizer=opt, loss='binary_crossentropy', metrics=['accuracy'])
```

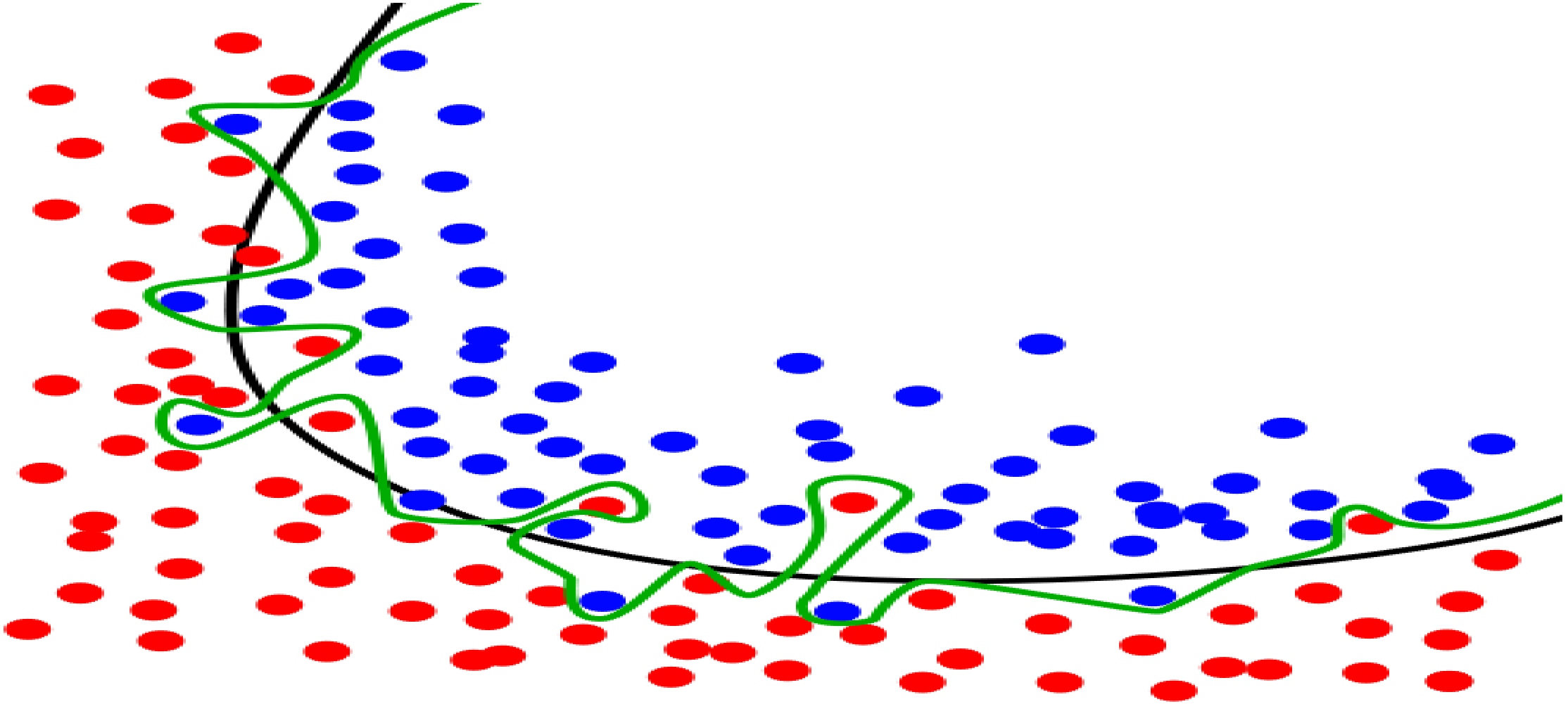
```
#Fitting the model to data - Training
model.fit(Xtrain, ytrain, epochs=10, verbose=1)
```

Overfitting

- In statistics, **overfitting** is "the production of an analysis that corresponds too closely or exactly to a particular set of data and may therefore fail to fit additional data or predict future observations reliably".
- An **overfitted model** is a statistical model that contains more parameters than can be justified by the data.[3]

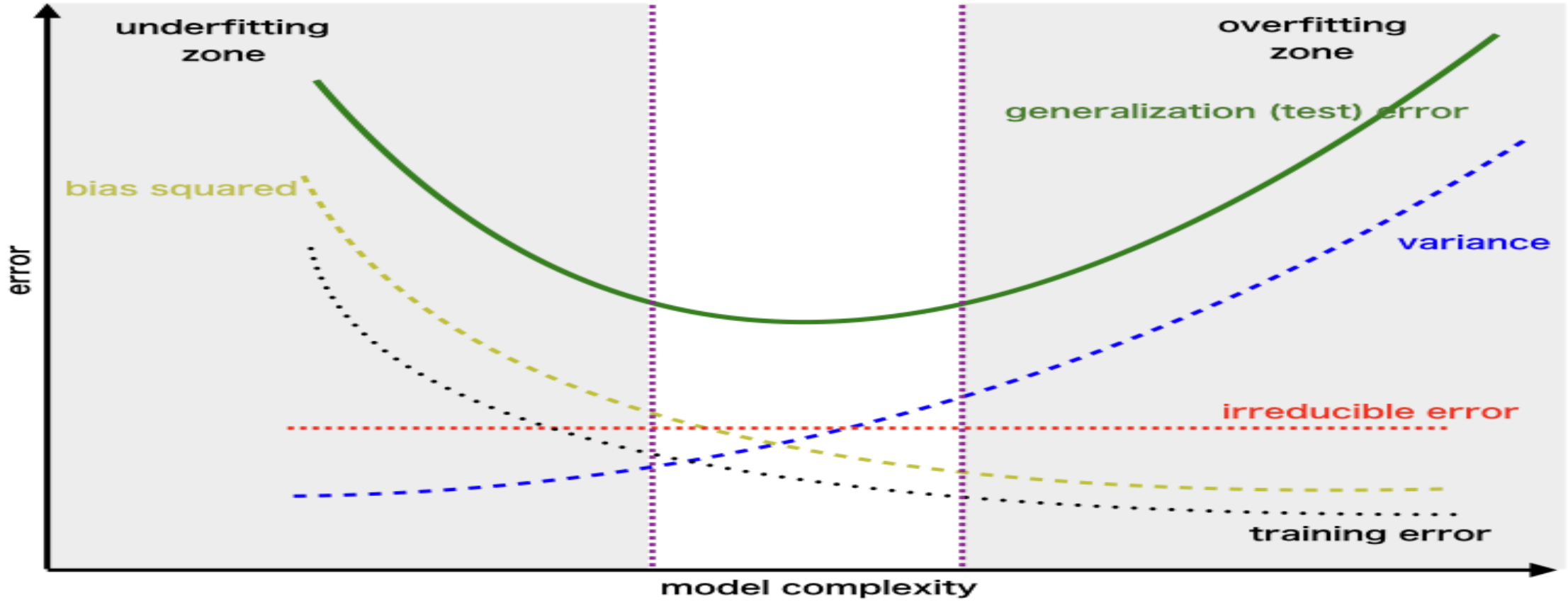
Underfitting

- Underfitting refers to a model that can neither model the training data nor generalize to new data.
- An underfit machine learning model is not a suitable model and will be obvious as it will have poor performance on the training data.[5]



Source - Chabacano, CC BY-SA 4.0 <https://creativecommons.org/licenses/by-sa/4.0>, via Wikimedia Commons [4]

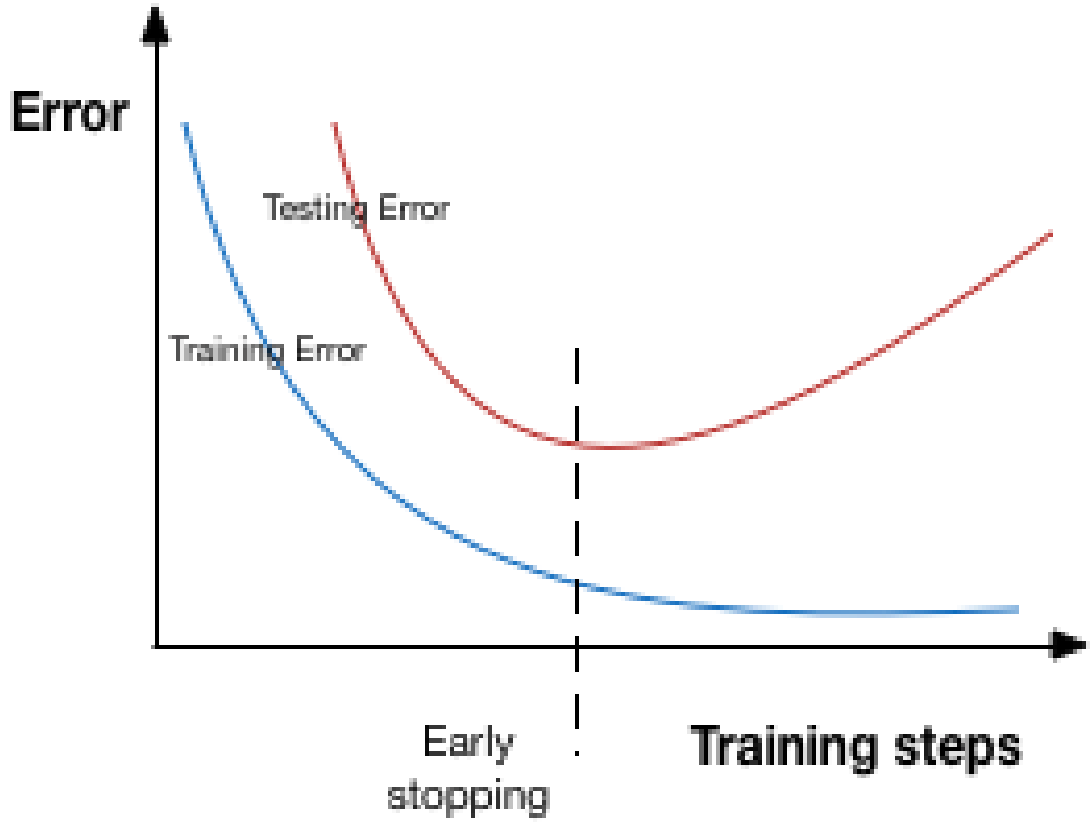
Bias - Variance Tradeoff



Source - https://www.geeksforgeeks.org/ml-bias-variance-trade-off/ [2]

Early Stopping

- One part of the training set as the validation set.
- When we see that the performance on the validation set is getting worse, we immediately stop the training on the model. This is known as early stopping.[7]



Source - https://www.analyticsvidhya.com/blog/2018/04/fundamentals-deep-learning-regularization-techniques/

Practical
Digit Recognizer using MNIST Dataset