# Introduction to Deep Learning with TensorFlow™

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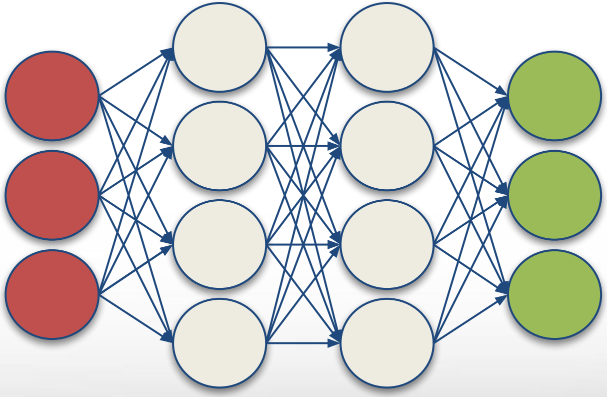
# Deep Learning

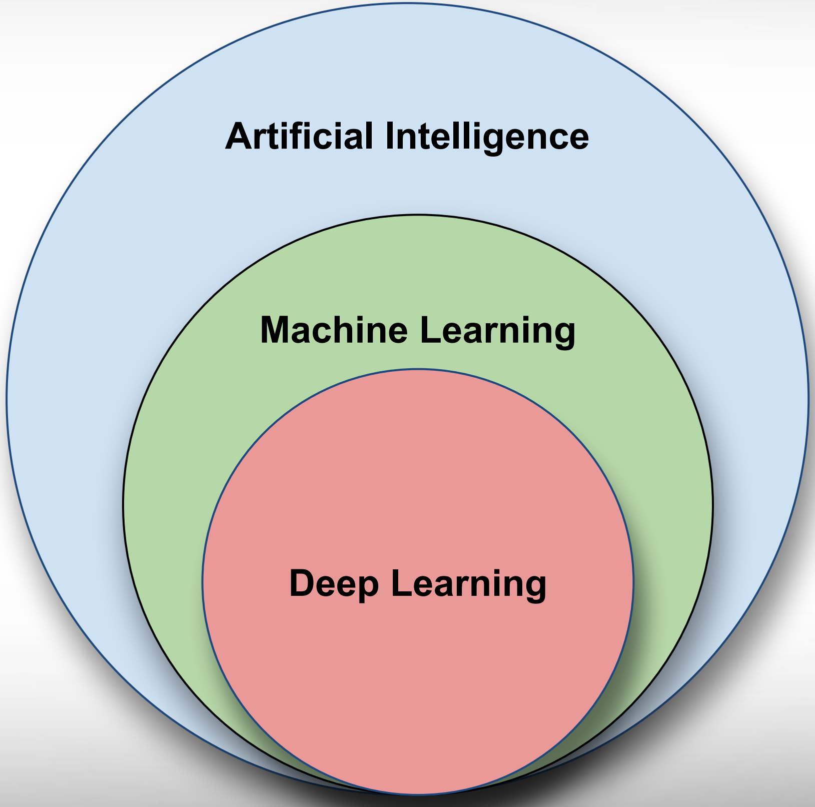
***Deep Learning***
by Ian Goodfellow, Yoshua Bengio, and Aaron Courville
*http://www.deeplearningbook.org/*

***Animation of Neutron Networks***
by Grant Sanderson
*https://www.3blue1brown.com/*

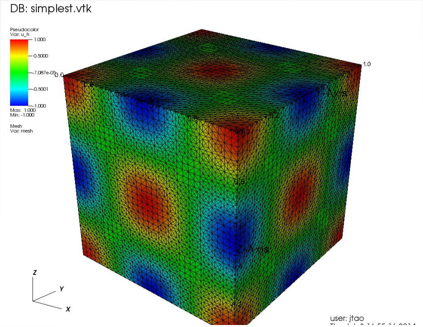


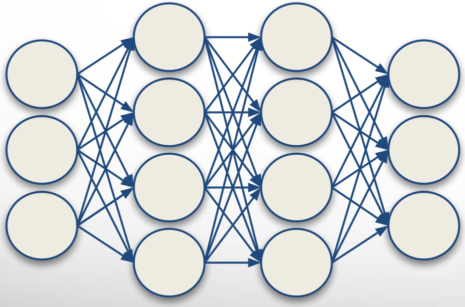
# Relationship of AI, ML, and DL

- **Artificial Intelligence (AI)** is anything about man-made intelligence exhibited by machines.
- **Machine Learning (ML)** is an approach to achieve **AI**.
- **Deep Learning (DL)** is one technique to implement **ML**.

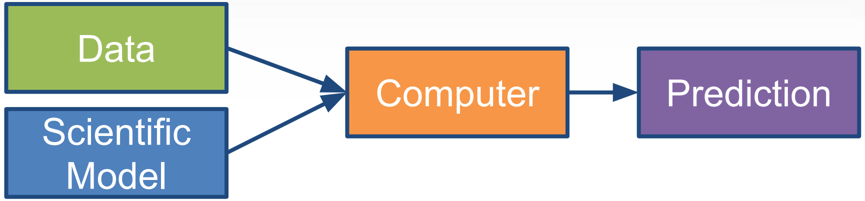


# Machine Learning

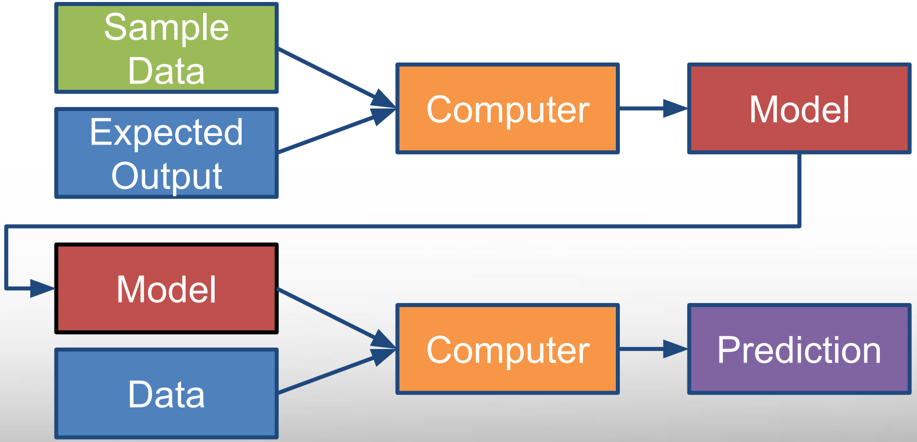




## Traditional Modeling

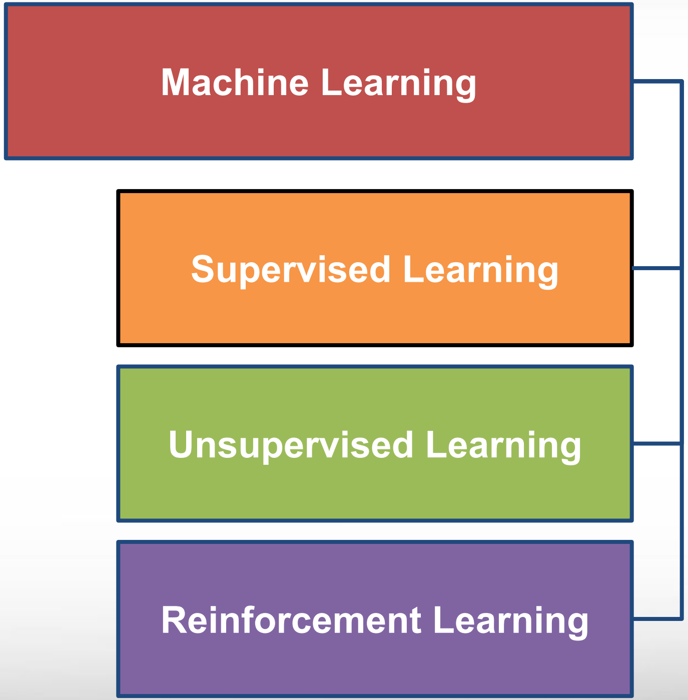


## Machine Learning (Supervised Learning)



# Types of ML Algorithms

- **Supervised Learning**
  - trained with labeled data; including regression and classification problems
- **Unsupervised Learning**
  - trained with unlabeled data; clustering and association rule learning problems.
- **Reinforcement Learning**
  - no training data; stochastic Markov decision process; robotics and self-driving cars.



Machine Learning

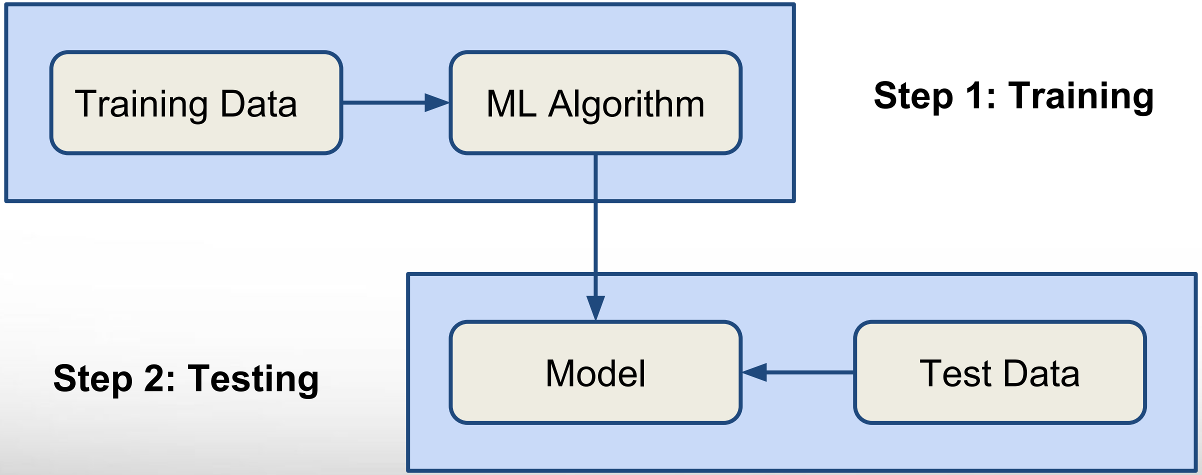
Supervised Learning

Unsupervised Learning

Reinforcement Learning

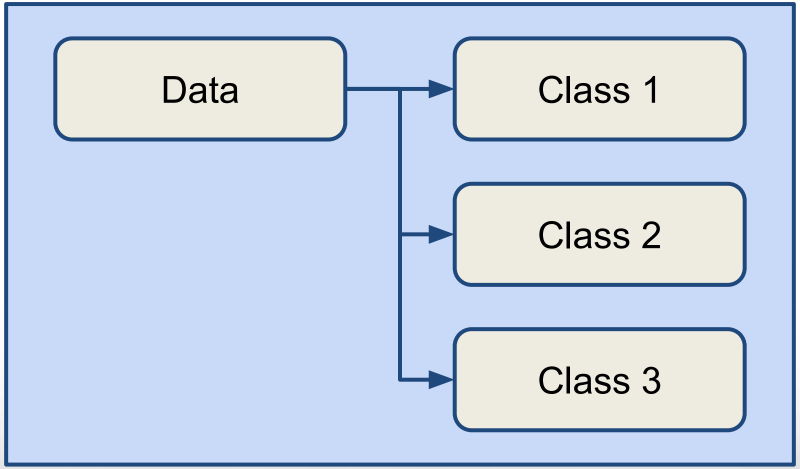
# Supervised Learning

When both input variables - X and output variables - Y are known, one can approximate the mapping function from  X to Y.



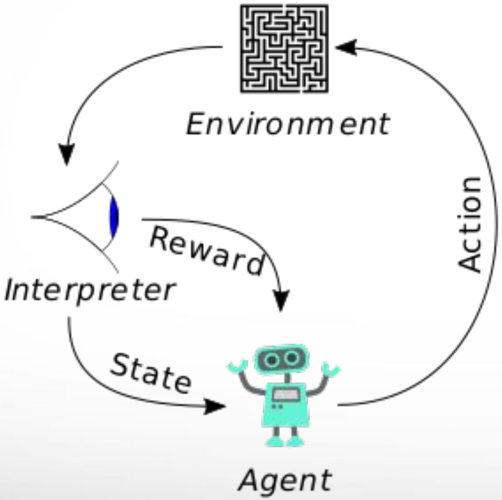
# Unsupervised Learning

When only input variables - X are known and the training data is neither classified nor labeled. It is usually used for clustering problems.

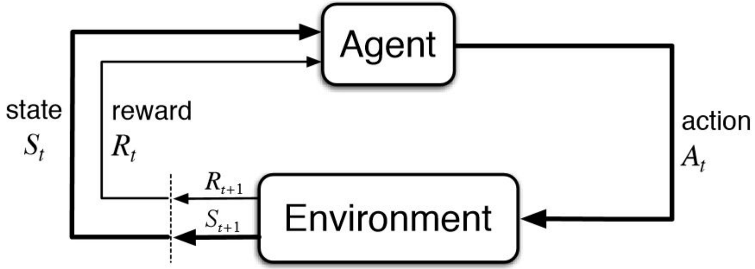


# Reinforcement Learning

When the input variables are only available via interacting with the environment, reinforcement learning can be used to train an "**agent**".



(Image Credit: Wikipedia.org)



(Image Credit: deeplearning4j.org)

# Why Deep Learning?

- Limitations of traditional machine learning algorithms
  - not good at handling high dimensional data.
  - difficult to do feature extraction and object recognition.

- Advantages of deep learning
  - DL is computationally expensive, but it is capable of handling high dimensional data.
  - feature extraction is done automatically.

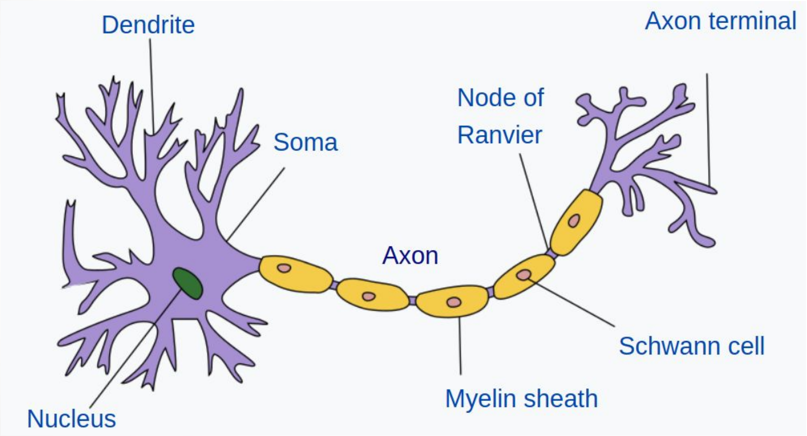
# What is Deep Learning?

Deep learning is a class of machine learning algorithms that:

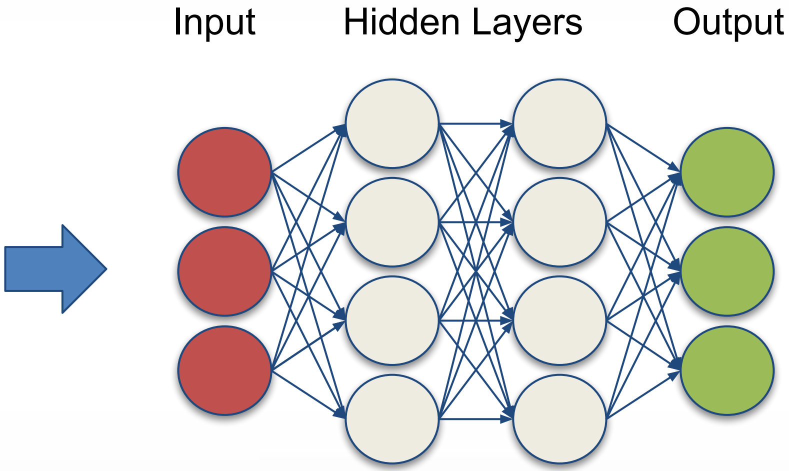
- use a cascade of multiple layers of nonlinear processing units for feature extraction and transformation. Each successive layer uses the output from the previous layer as input.
- learn in supervised (e.g., classification) and/or unsupervised (e.g., pattern analysis) manners.
- learn multiple levels of representations that correspond to different levels of abstraction; the levels form a hierarchy of concepts.

(Source: Wikipedia)

# Artificial Neural Network



(Image Credit: Wikipedia)

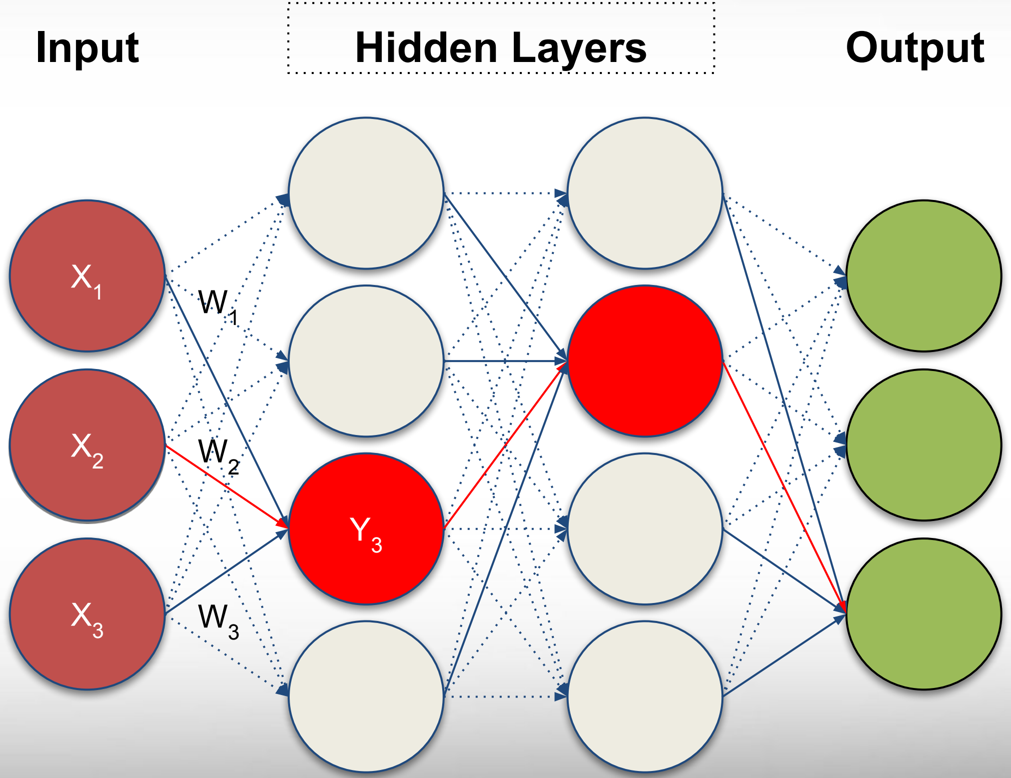


# Supervised Deep Learning with Neural Networks

From one layer to the next

$$Y_j = f\left(\sum_i W_i X_i + b_i\right)$$

f is the activation function, $W_i$ is the weight, and $b_i$ is the bias.



# Training - Minimizing the Loss

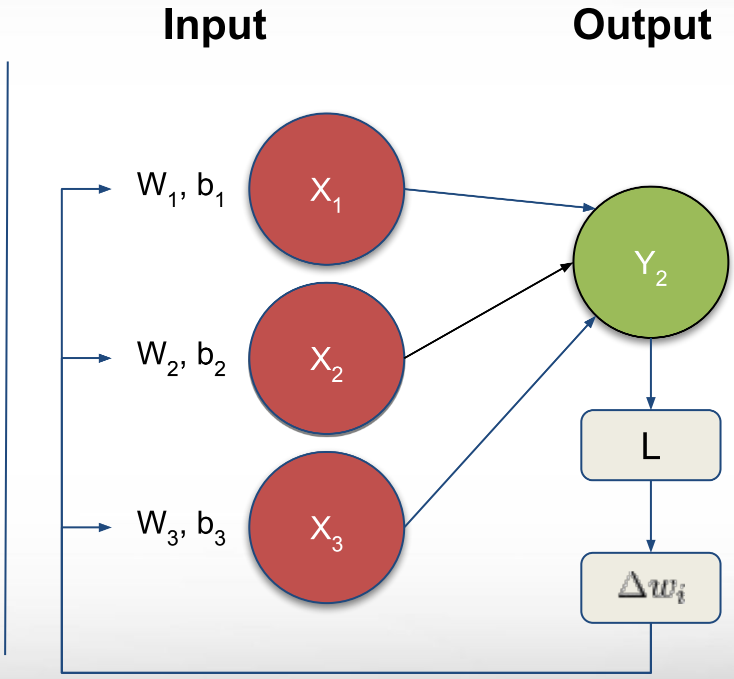
The loss function with regard to weights and biases can be defined as

$$L(\mathbf{w}, \mathbf{b}) = \frac{1}{2}\sum_i (\mathbf{Y}(\mathbf{X}, \mathbf{w}, \mathbf{b}) - \mathbf{Y}'(\mathbf{X}, \mathbf{w}, \mathbf{b}))^2$$

The weight update is computed by moving a step to the opposite direction of the cost gradient.

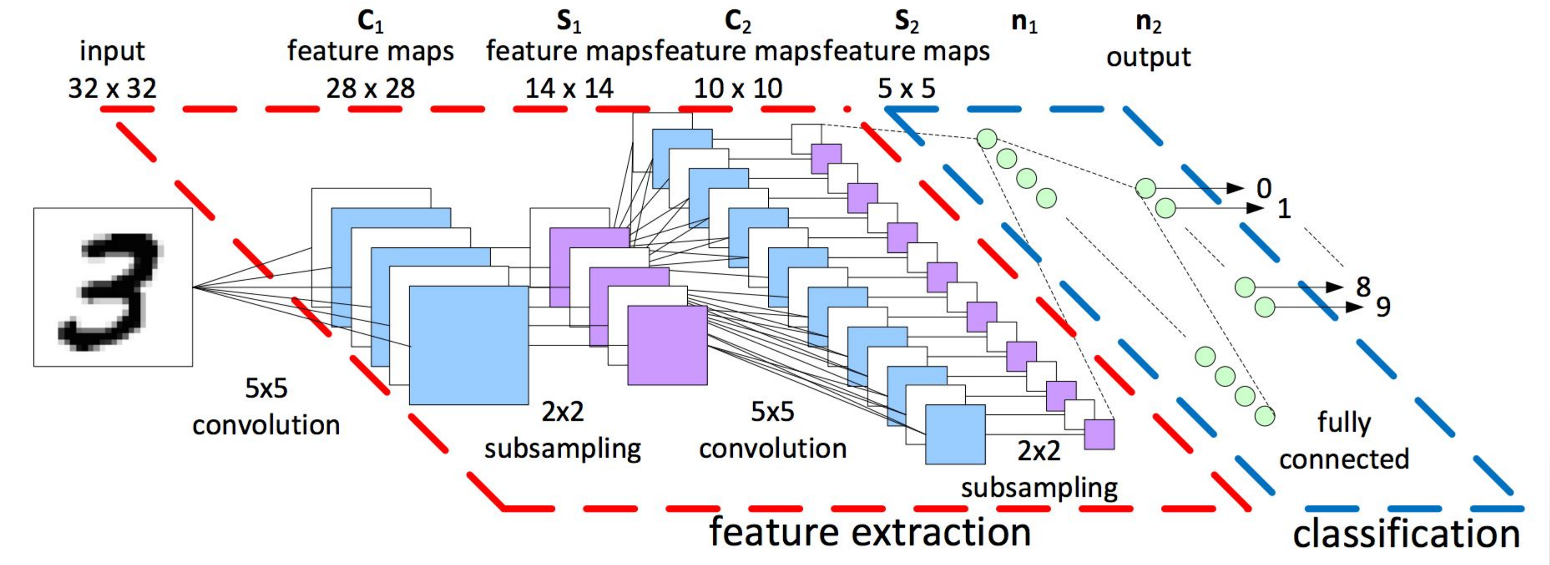
$$\Delta w_i = -\alpha \frac{\partial L}{\partial w_i}$$

Iterate until L stops decreasing.



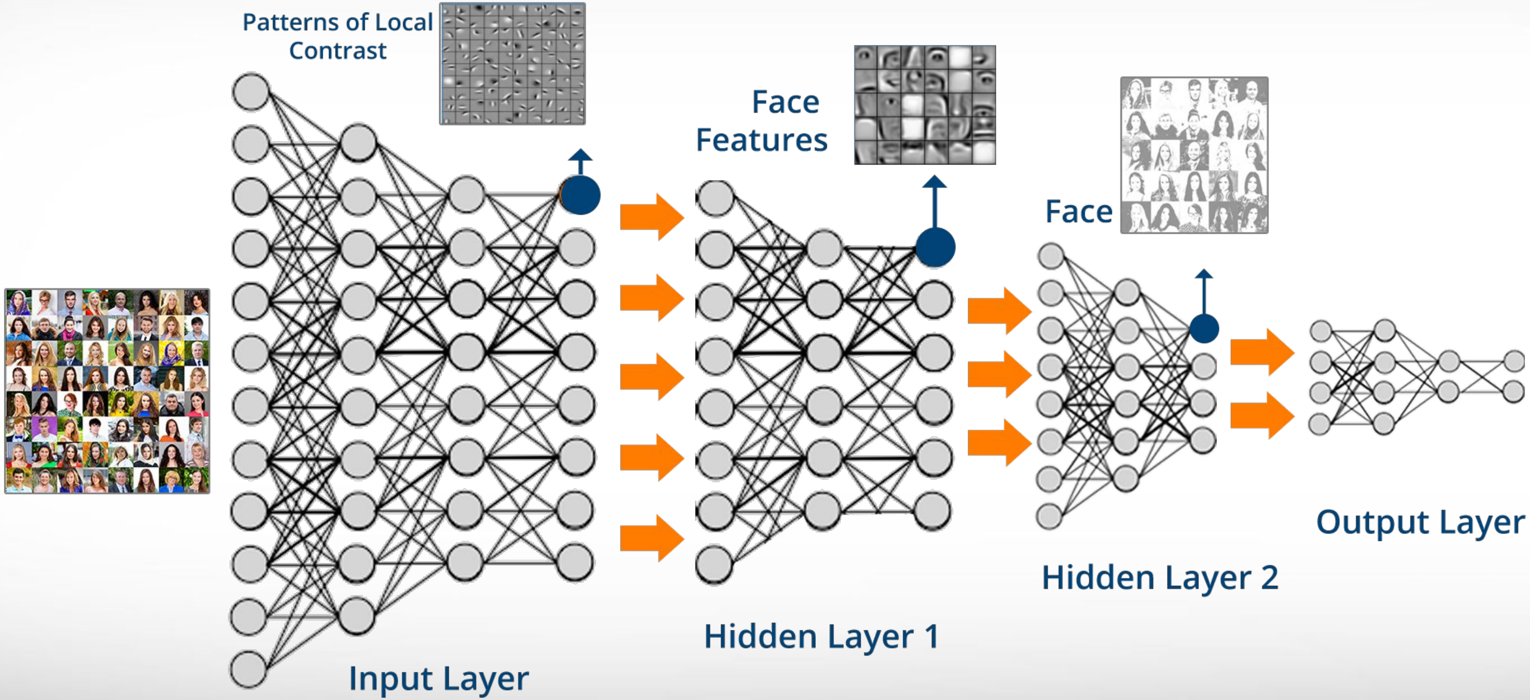
# Convolutional Neural Networks

A convolutional neural network (**CNN**, or **ConvNet**) is a class of deep, feed-forward artificial neural networks that explicitly assumes that the inputs are images, which allows us to encode certain properties into the architecture.



(Image Credit: https://becominghuman.ai)

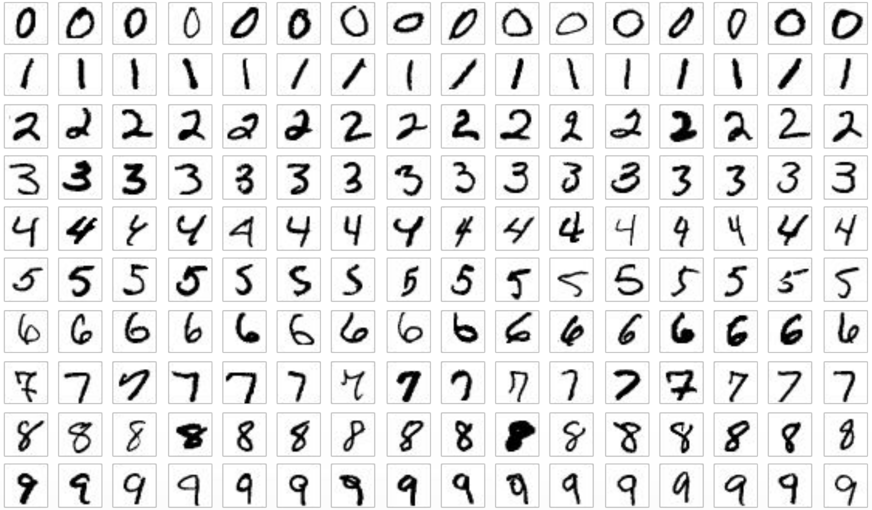
# Deep Learning for Facial Recognition



(Image Credit: www.edureka.co)

# MNIST - Introduction

- **MNIST** (Mixed National Institute of Standards and Technology) is a database for handwritten digits, distributed by Yann Lecun.
- 60,000 examples, and a test set of 10,000 examples.
- 28x28 pixels each.
- Widely used for research and educational purposes.

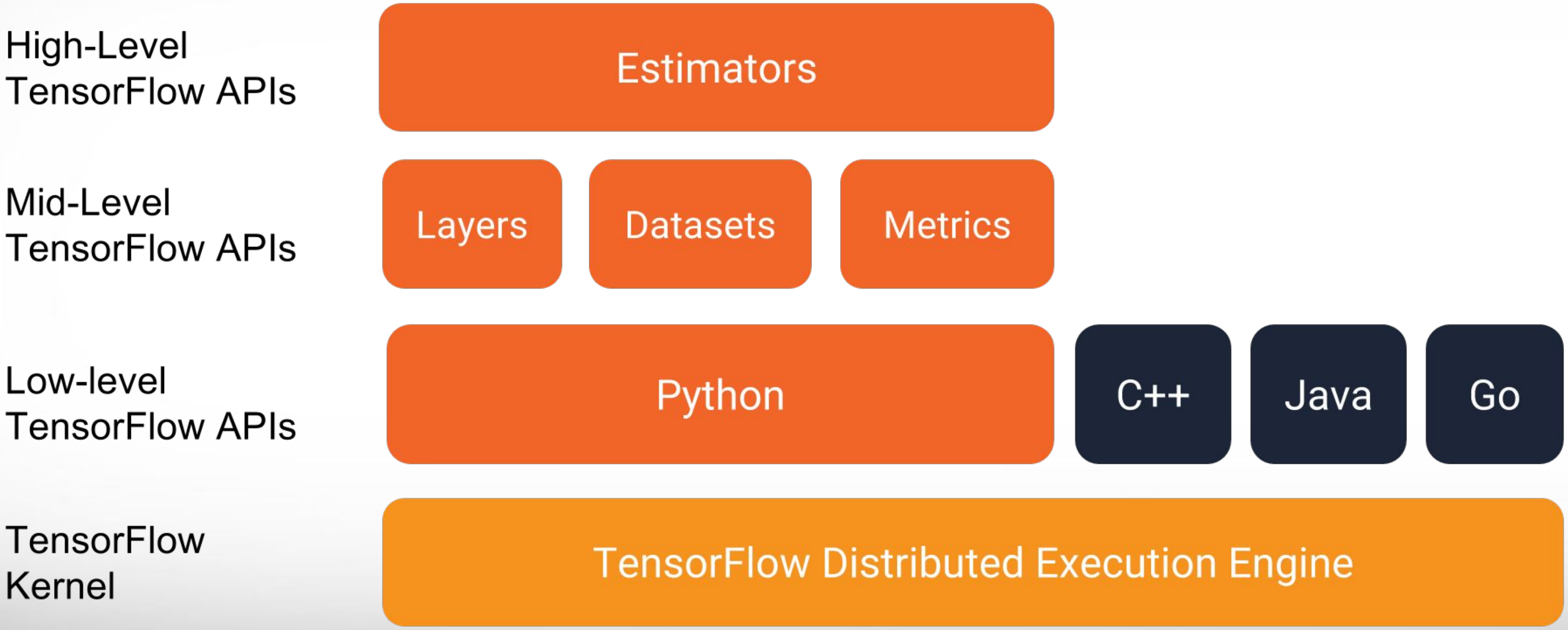


(Image Credit: Wikipedia)

# TensorFlow

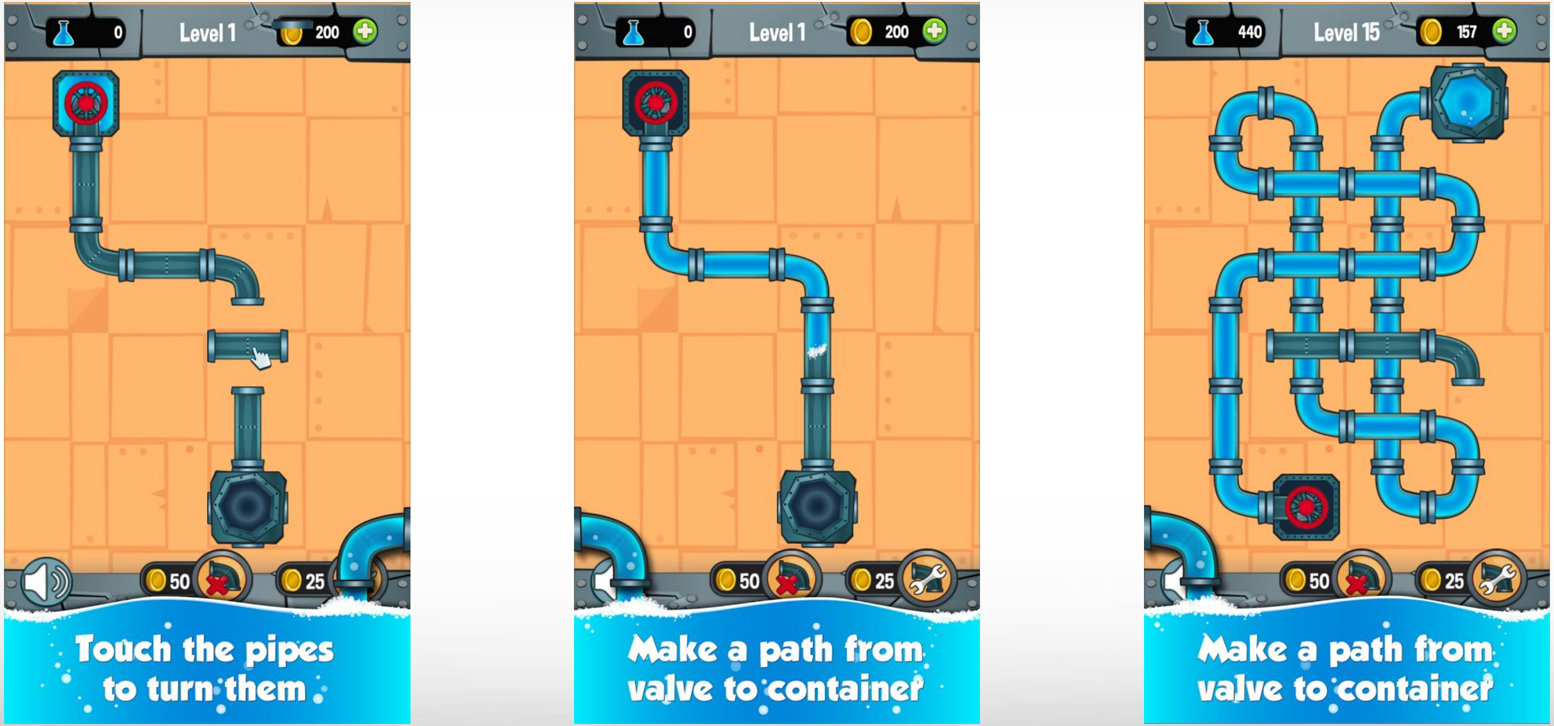
Tensorflow web site:
https://www.tensorflow.org/

# Programming Environment


High-Level TensorFlow APIs
Estimators
Mid-Level TensorFlow APIs
Layers
Datasets
Metrics
Low-level TensorFlow APIs
Python
C++
Java
Go
TensorFlow Kernel
TensorFlow Distributed Execution Engine

(Image Credit: tensorflow.org)

# A Connected Pipeline for the Flow of Tensors


0
Level 1
200
50
25
Touch the pipes to turn them
0
Level 1
200
50
25
Make a path from valve to container
440
Level 15
157
50
25
Make a path from valve to container

(Image Credit: Plumber Game by Mobiloids)

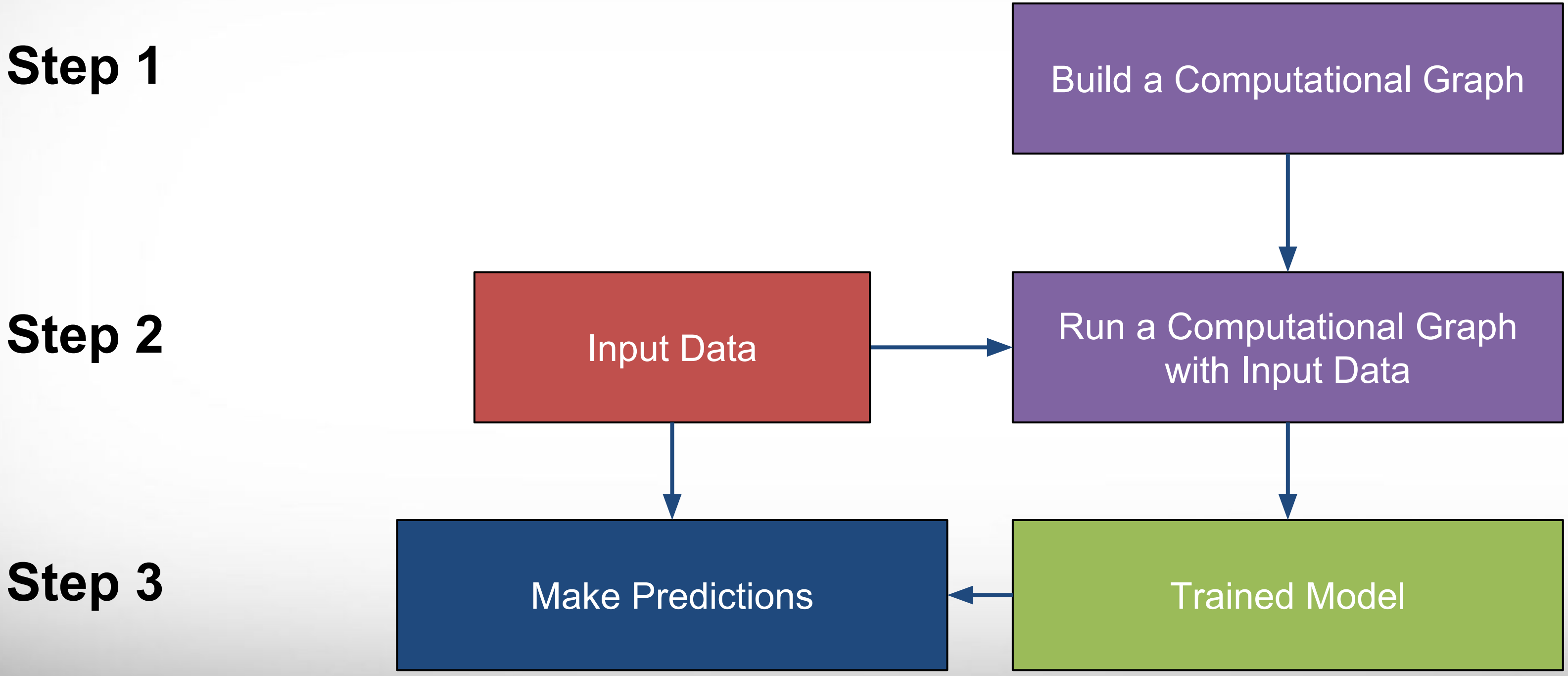
# What is a Tensor in TensorFlow?

- **TensorFlow** uses a tensor data structure to represent all data. A TensorFlow tensor as an n-dimensional array or list. A tensor has a static type, a rank, and a shape.

| Rank | Tensor |
|---|---|
| 0 | [5] |
| 1 | [1 2 3] |
| 2 | [[1 2 3 4],<br>[5 6 7 8]] |
| 3 | ... |

# TensorFlow Application

**Eager Execution** is supported from TensofFlow 1.5


Step 1
Step 2
Step 3
Build a Computational Graph
Input Data
Run a Computational Graph with Input Data
Make Predictions
Trained Model

# Hello World with TensorFlow

```
import tensorflow as tf

v = tf.constant("Hello World!")
```

Build a Graph

```
sess = tf.Session()

print(sess.run(v))
```

Run !

# TensorFlow Constants

TensorFlow provides several operations to generate constant tensor.

```
import tensorflow as tf

x = tf.constant(1)
zeros = tf.zeros([2, 3], tf.int32)
ones = tf.ones([2, 3], tf.int32)
y = x *(zeros + ones + ones)

sess = tf.Session()
print(sess.run(y))
```

# TensorFlow Placeholders

TensorFlow provides a placeholder operation that must be fed with data on execution. **Training/testing data sets** are usually stored in placeholders.

```
import tensorflow as tf
x = tf.placeholder(tf.float32, shape=(4, 4))
y = tf.matmul(x, x)

rand_array = np.random.rand(4, 4)
sess = tf.Session()
print(sess.run(y, {x: rand_array}))
```

# TensorFlow Variables

TensorFlow variables can represent shared, persistent state manipulated by your program. **Weights** and **biases** are usually stored in variables.

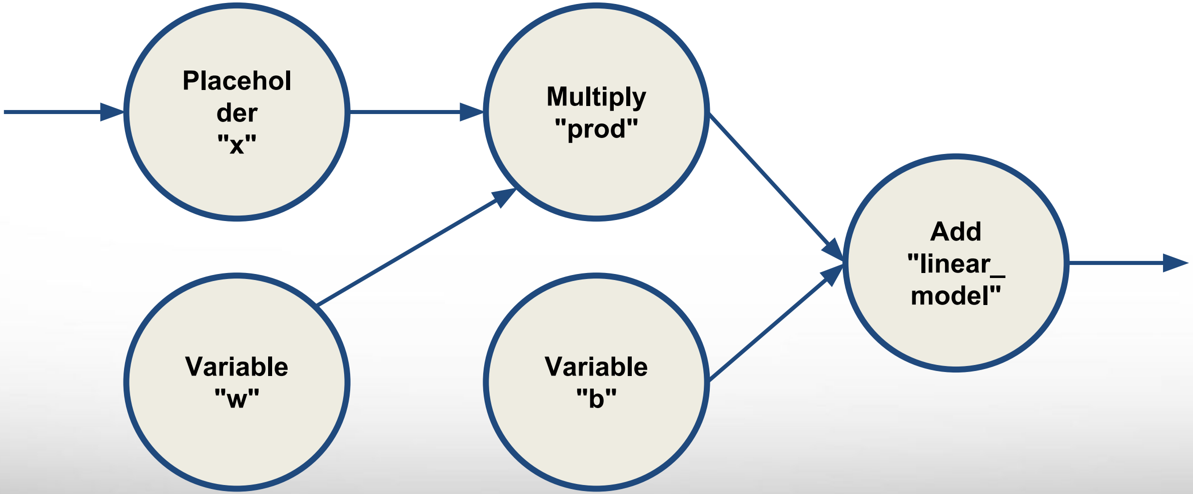
```
import tensorflow as tf

v = tf.Variable(tf.random_normal([5, 2], stddev=0.1))
init = tf.global_variables_initializer()

sess = tf.Session()
sess.run(init)
print(sess.run(v))
```

# Build a Simple Linear Model Graph

```
x = tf.placeholder(tf.float32, name = 'x')
w = tf.Variable([.3], tf.float32, name = 'w')
b = tf.Variable([-.3], tf.float32, name = 'b')
linear_model = w * x + b
```



# Loss of the Linear Model

TensorFlow provides functions to facilitate the calculation of standard loss functions.

```
squared_deltas = tf.square(linear_model - y)
loss = tf.reduce_sum(squared_deltas)

init = tf.global_variables_initializer()
sess=tf.Session()
sess.run(init)
print(sess.run(loss, {x: [1,2,3,4], y: [0,-1,-2,-3]}))
```

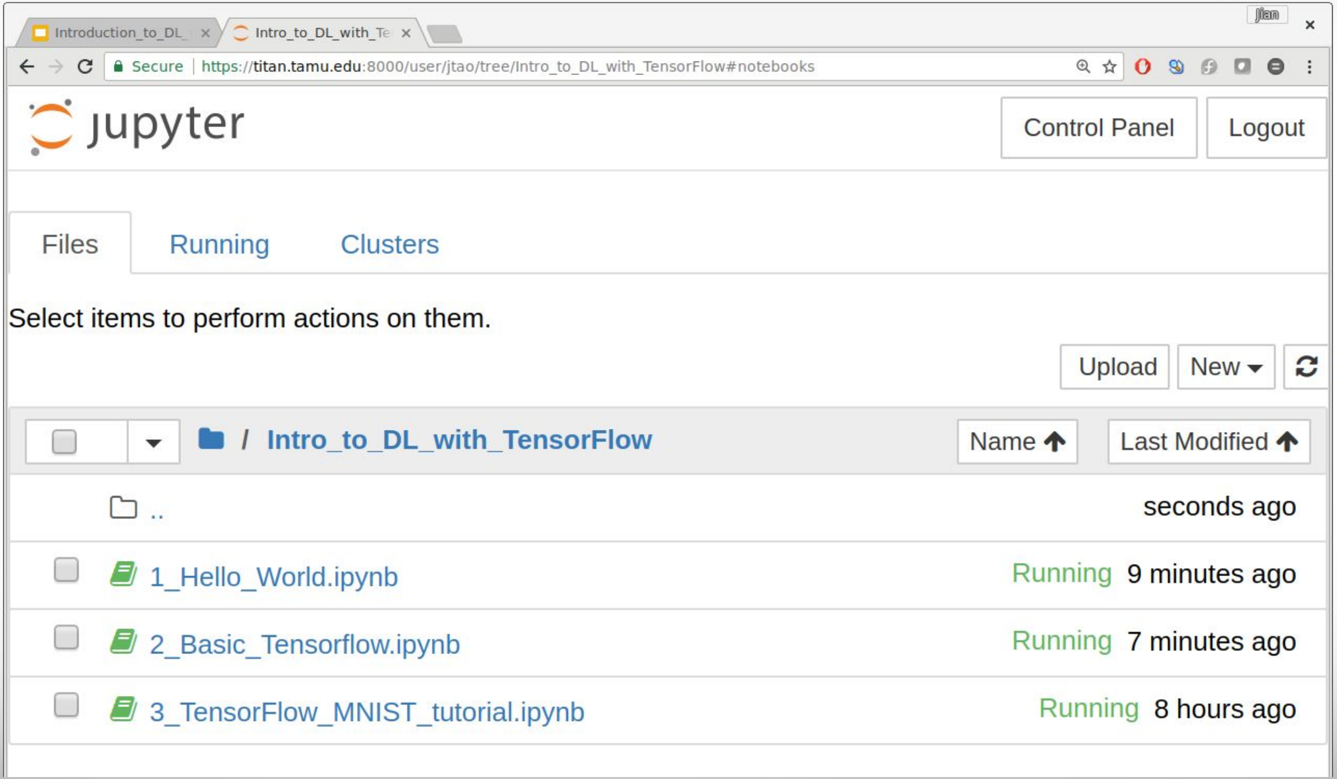
# Train the Linear Model

TensorFlow Estimator APIs also provide optimizers to minimize the loss.

```
optimizer = tf.train.GradientDescentOptimizer(0.01)
train = optimizer.minimize(loss)

init = tf.global_variables_initializer()
sess=tf.Session()
sess.run(init)
for i in range(1000):
    sess.run(train, {x: [1,2,3,4], y: [0,-1,-2,-3]})
print(sess.run([w, b]))
```

# Exercises on Jupyter Hub



Select items to perform actions on them.

/ Intro_to_DL_with_TensorFlow

| Name | Status | Last Modified |
|---|---|---|
| .. | | seconds ago |
| 1_Hello_World.ipynb | Running | 9 minutes ago |
| 2_Basic_Tensorflow.ipynb | Running | 7 minutes ago |
| 3_TensorFlow_MNIST_tutorial.ipynb | Running | 8 hours ago |

# Acknowledgements

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