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agência regional para o desenvolvimento da investigação tecnologia e inovação

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MEO

2022

WHAT IS TENSORFLOW?

WHAT IS TENSORFLOW?

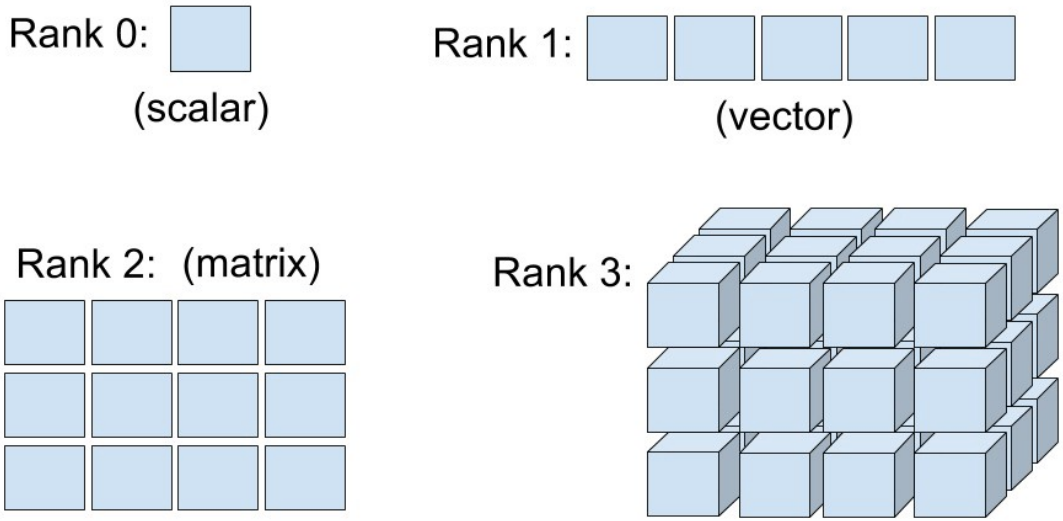
TensorFlow

WHAT IS TENSORFLOW?

Open source platform for numerical computation

Computations based on tensors

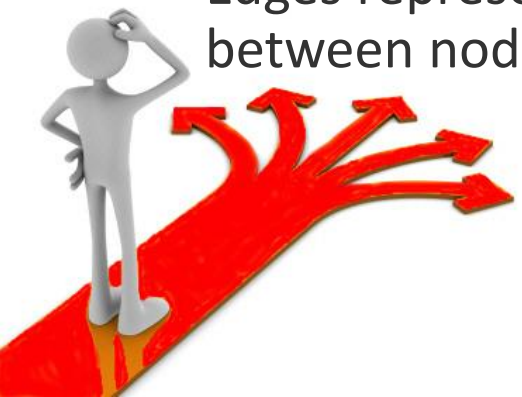
- Tensors are multi-dimensional arrays with a uniform type, backed by the accelerator memory (GPU), and are immutable

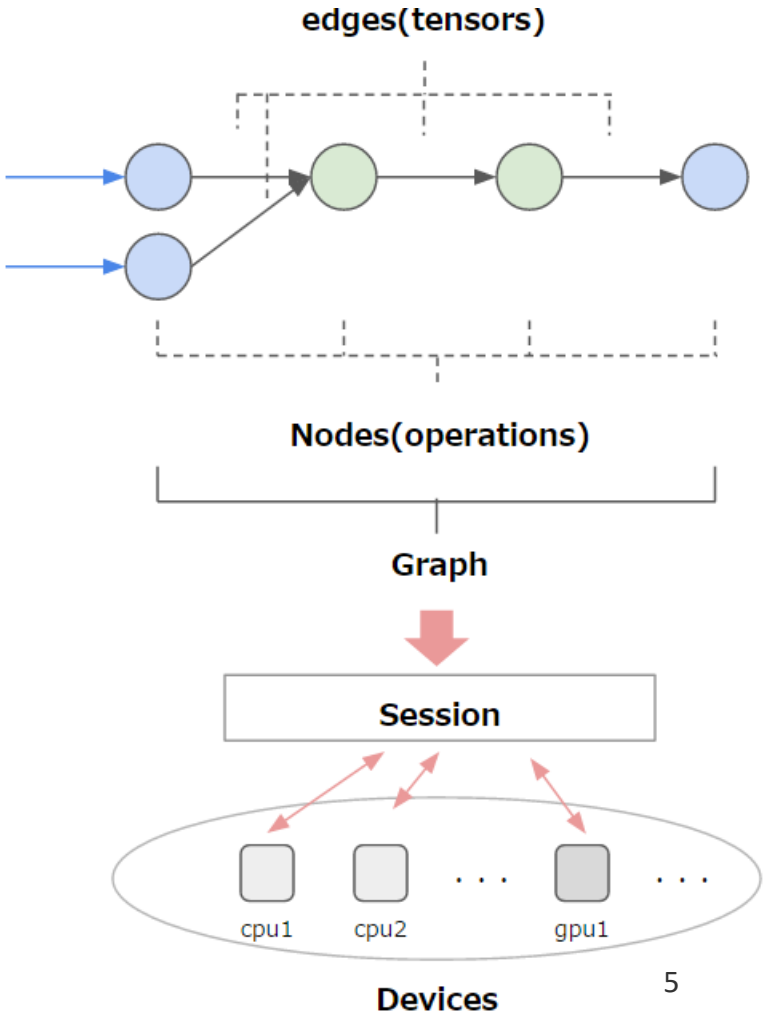


WHAT IS TENSORFLOW?

Concept:

- Create a directed graph to represent the computation
- Mathematical operations are represented by nodes
- Edges represent the data flow between nodes (the tensors)





WHAT IS TENSORFLOW?

Simple example

- Compute: z = (x × y) - (x + y)

```
1 # impot the library
2 import tensorflow as tf
3
4 # function to be traced
5 @tf.function # tensorflow graph function
6 def myFunction(x, y):
7   o1 = tf.add(x, y)
8   o2 = tf.multiply(x, y)
9   o3 = tf.subtract(o2, o1)
10  return o3
```

WHAT IS TENSORFLOW?

Simple example

- With x = 5 and y = 7

```
11
12 # inputs
13 x = 5
14 y = 7
15
```

WHAT IS TENSORFLOW?

Simple example

- Track the graph

```
16 # set up logging
17 stamp = datetime.now().strftime("%Y%m%d-%H%M%S")
18 logdir = 'logs/func/%s' % stamp
19 writer = tf.summary.create_file_writer(logdir)
20
21 # track the graph
22 tf.summary.trace_on(graph=True, profiler=True)
```

WHAT IS TENSORFLOW?

Simple example

- Estimate z (it is (5 × 7) - (5 + 7) = 23)

```
23 # examine the myFunction
24 z = myFunction (x, y)
25 print(z)
```

```
tf.Tensor(23, shape=(), dtype=int32)
```

Estimated value: 23

Tensor shape: () is scalar

Data type: integer

WHAT IS TENSORFLOW?

Simple example

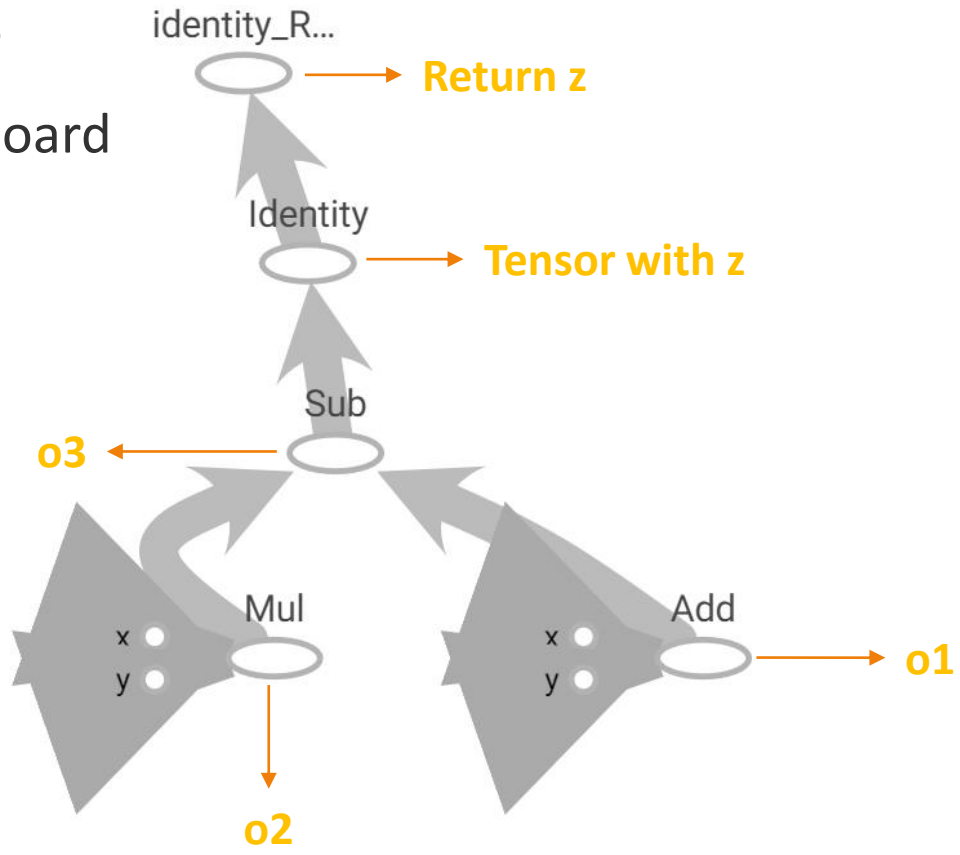
- Check TensorBoard

```
26
27 with writer.as_default():
28   tf.summary.trace_export(
29       name="myFunctionTrace",
30       step=0,
31       profiler_outdir=logdir)
32
33 %tensorboard --logdir logs/func
```

WHAT IS TENSORFLOW?

Simple example

- Check TensorBoard



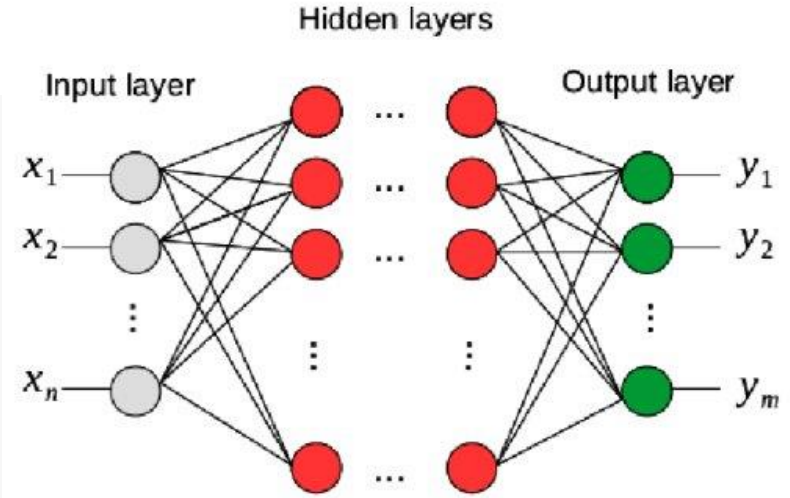
WHAT IS TENSORFLOW?

Tensors flow trough the graph,

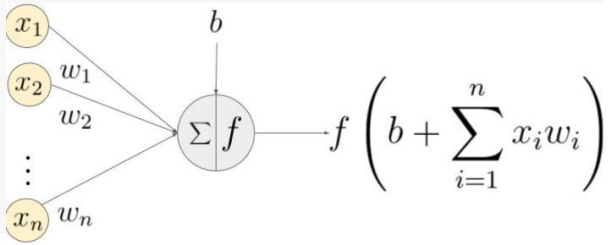
thus the name TensorFlow

WHAT IS TENSORFLOW?

How to create a neural network:




```python
class NeuralNetwork:
  def __init__(self, layers):
    self.layers = layers
    self.L = len(layers)
    self.num_features = layers[0]
    self.num_classes = layers[-1]
    self.W = {}
    self.b = {}
    # ...
  def setup(self):
    for i in range(1, self.L):
      self.W[i] = tf.Variable(tf.random.normal(shape=(self.layers[i],self.layers[i-1])))
      self.b[i] = tf.Variable(tf.random.normal(shape=(self.layers[i],1)))
  def predict(self, X):
    data = tf.convert_to_tensor(X, dtype=tf.float32)
    for i in range(1, self.L):
      Z = tf.matmul(data,tf.transpose(self.W[i])) + tf.transpose(self.b[i])
      if i != self.L-1:
        data = tf.nn.relu(Z)
      else:
        data = Z
    return tf.argmax(tf.nn.softmax(data), axis=1)
  # ...
```



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    # ...
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      if i != self.L-1:
        data = tf.nn.relu(Z)
      else:
        data = Z
    return tf.argmax(tf.nn.softmax(data), axis=1)
  # ...
```

Include:

- How parameters should be updated
- How the loss must be computed
- How to make the training

WHAT IS TENSORFLOW?

Is there any alternative?

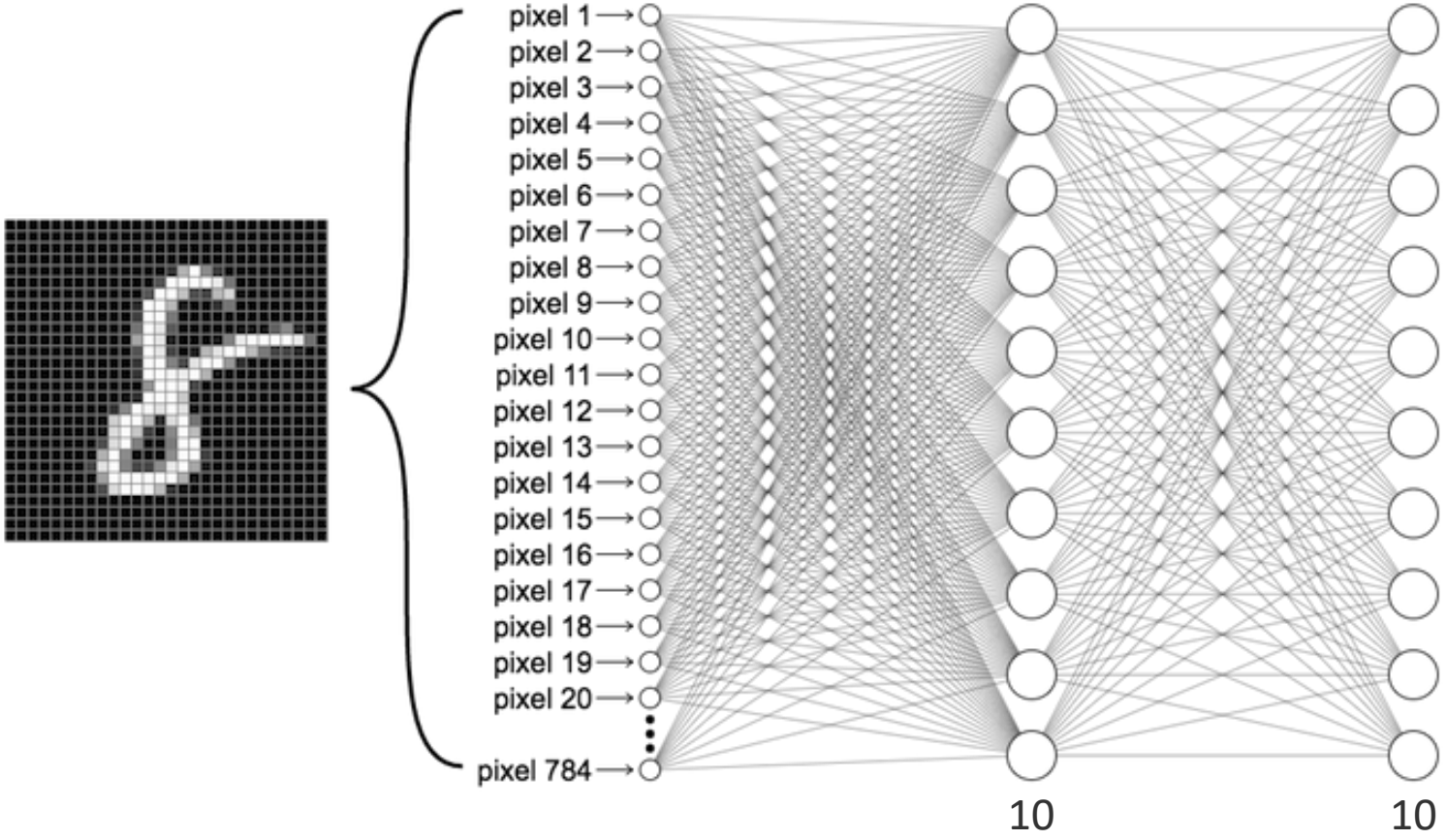
WHAT IS TENSORFLOW?

Use Keras API:

“API designed for human beings, not machines”

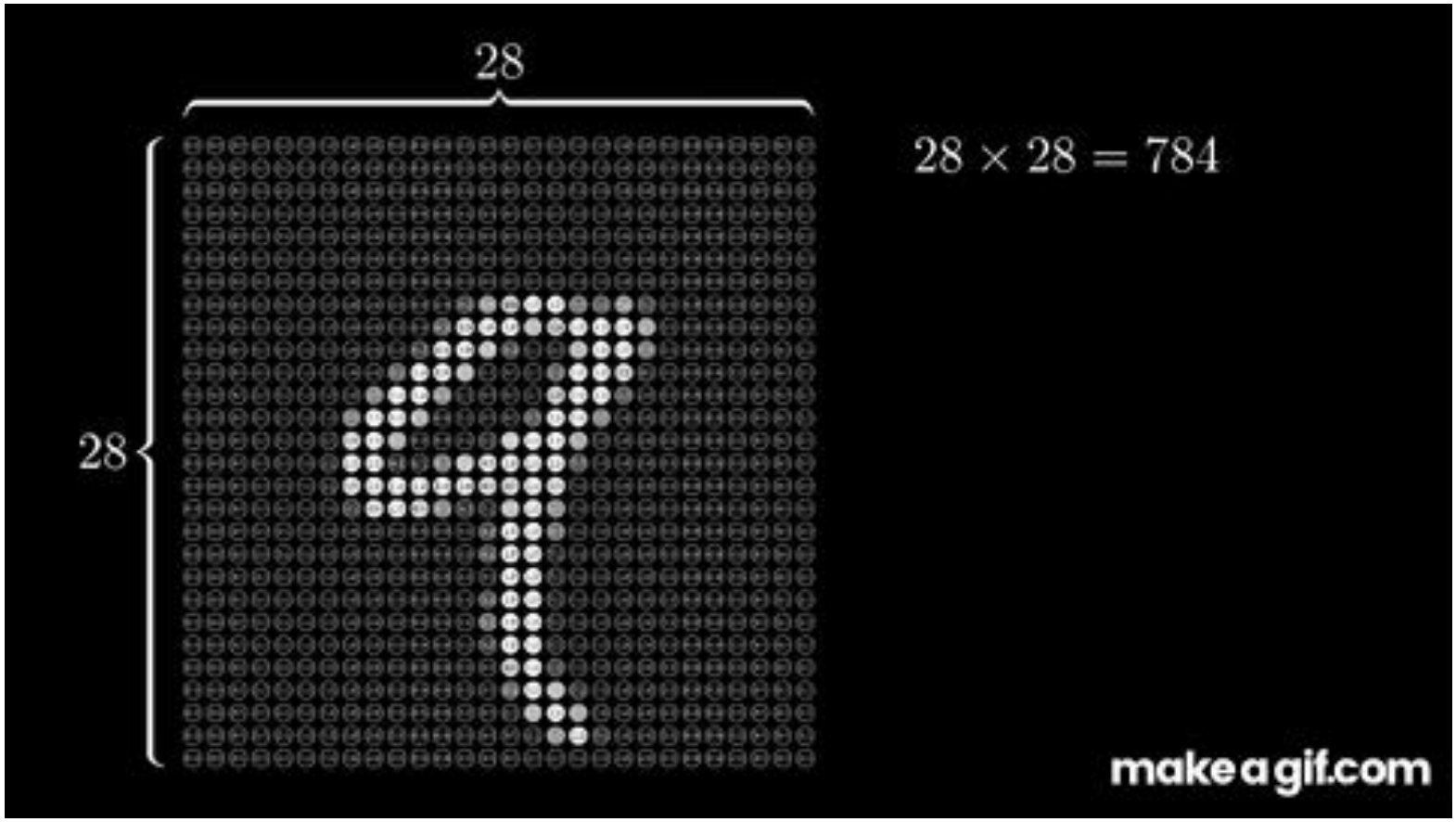
WHAT IS TENSORFLOW?

Methods to build a Keras model in TensorFlow:



WHAT IS TENSORFLOW?

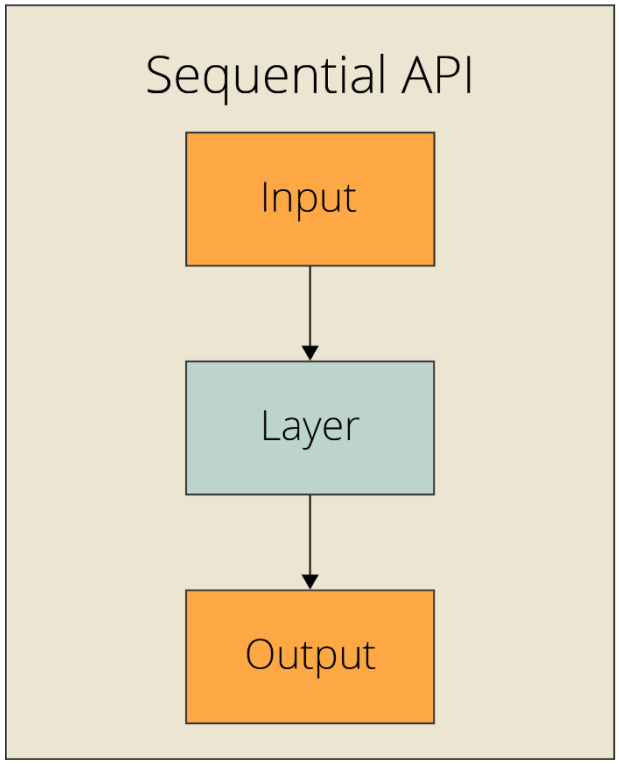
Methods to build a Keras model in TensorFlow:



WHAT IS TENSORFLOW?

Methods to build a Keras model in TensorFlow:

- Sequential API



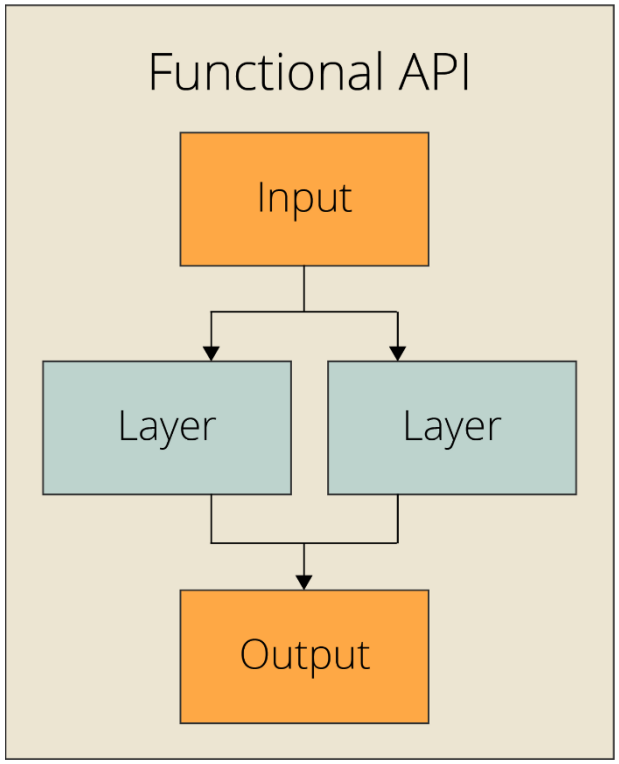

```
1 from tensorflow.keras import Sequential
2 from tensorflow.keras.layers import Flatten
3 from tensorflow.keras.layers import Dense
4
5 model = Sequential([
6   Flatten(input_shape=(28, 28)),
7   Dense(10,'relu'),
8   Dense(10, "softmax"),
9   ])
```

```
1 from tensorflow.keras import Sequential
2 from tensorflow.keras.layers import Flatten
3 from tensorflow.keras.layers import Dense
4
5 model = Sequential()
6 model.add(Flatten(input_shape=(28, 28)))
7 model.add(Dense(10, "relu"))
8 model.add(Dense(10, "softmax"))
```

WHAT IS TENSORFLOW?

Methods to build a Keras model in TensorFlow:

- Functional API

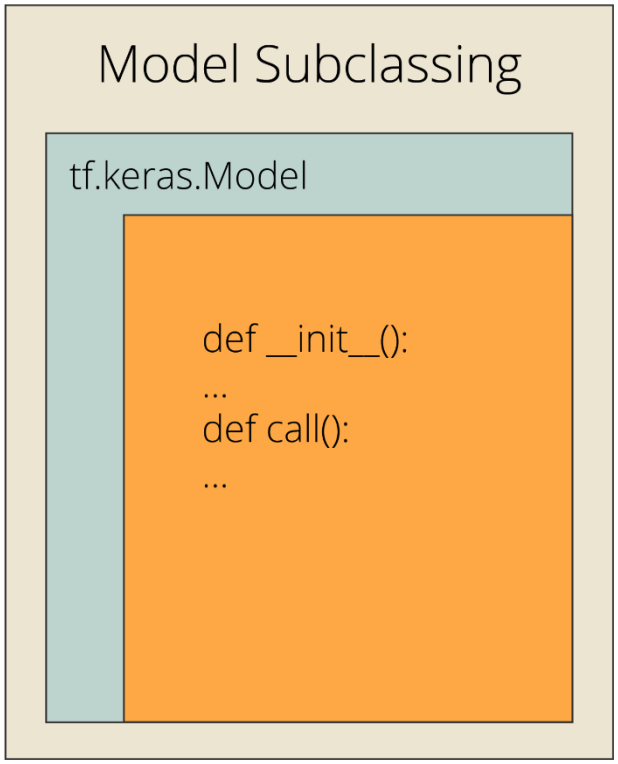



```
1 from tensorflow.keras import Model
2 from tensorflow.keras.layers import Flatten
3 from tensorflow.keras.layers import Dense
4 from tensorflow.keras.layers import Input
5
6 inputs = Input(shape=(28, 28))
7 x = Flatten()(inputs)
8 x = Dense(10, "relu")(x)
9 outputs = Dense(10, "softmax")(x)
10
11 model = Model(inputs=inputs, outputs=outputs)
```

WHAT IS TENSORFLOW?

Methods to build a Keras model in TensorFlow:

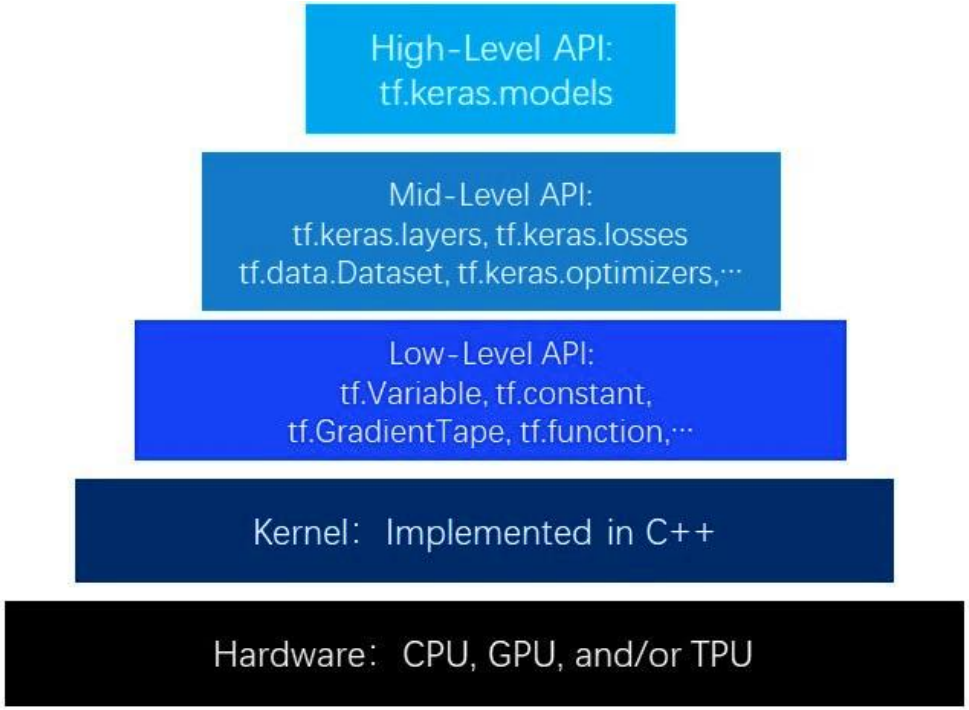
- Model Subclassing




```python
from tensorflow.keras import Model
from tensorflow.keras.layers import Flatten
from tensorflow.keras.layers import Dense

class CustomModel(Model):

  def __init__(self, **kwargs):
    super(CustomModel, self).__init__(**kwargs)
    self.layer_1 = Flatten()
    self.layer_2 = Dense(10, "relu")
    self.layer_3 = Dense(10, "softmax")

  def call(self, inputs):
    x = self.layer_1(inputs)
    x = self.layer_2(x)
    x = self.layer_3(x)
    return x

model = CustomModel()
```

WHAT IS TENSORFLOW?

Keras was defined as the standard high-level API of TensorFlow 2

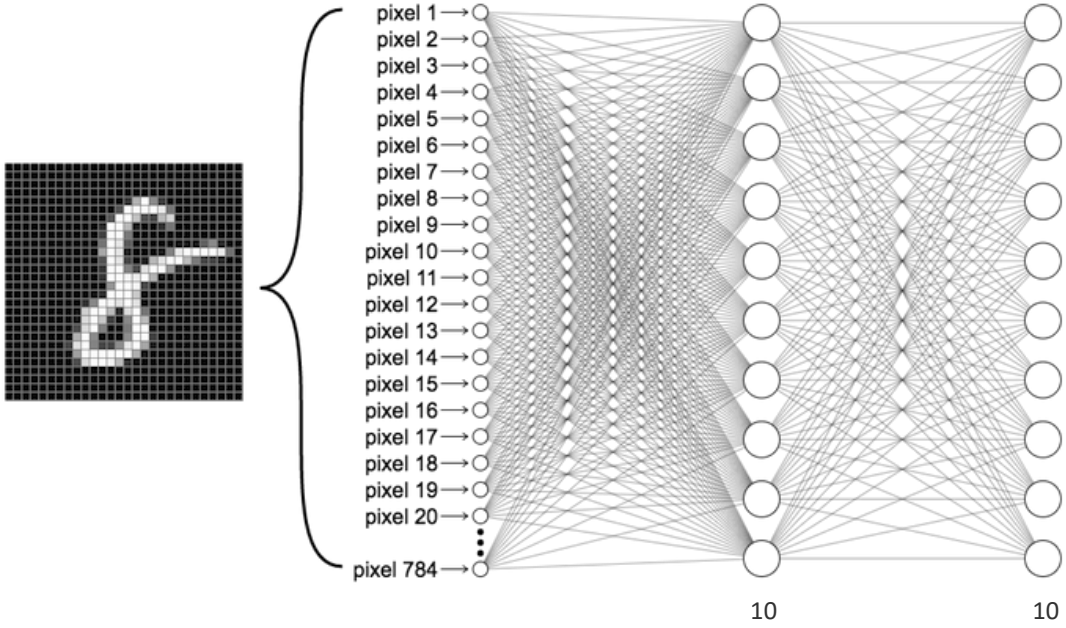


PRACTICAL EXAMPLE

PRACTICAL EXAMPLE

FFNN Colab example: FFNN – MNIST

- Handwritten dataset
- 70000 images
- All are 28x28
- 784 pixels in total



WHY TENSORFLOW

WHY TENSORFLOW

Key advantages:

- Allow the visualization of the computational graphs (nor possible in Scikit learn)
- Can be used from beginners (with simple to use interfaces) to researchers (with the high customization capabilities)
- Probably the easiest to use for deep learning
- Great portability (deploy on multiple devices)
- Easy to train in GPU and TPU
- Open-source backed by a large community (all the way from software engineers to data scientist)

WHAT IS TENSORFLOW?

Software	Open source	Written in	Interface	CUDA support	Pretrained models	Recurrent nets	Convolutional nets	Actively developed
Caffe	Yes	C++	Python, MATLAB, C++	Yes	Yes	Yes	Yes	No
Chainer	Yes	Python	Python	Yes	Yes	Yes	Yes	No
Deeplearning4j	Yes	C++, Java	Java, Scala, Clojure, Python (Keras), Kotlin	Yes	Yes	Yes	Yes	Yes
Flux	Yes	Julia	Julia	Yes	Yes	Yes	Yes	Yes
Keras	**Yes**	**Python**	**Python, R**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
MATLAB + Deep Learning Toolbox	No	C, C++, Java, MATLAB	MATLAB	Yes	Yes	Yes	Yes	Yes
Microsoft Cognitive Toolkit (CNTK)	Yes	C++	Python (Keras), C++, Command line	Yes	Yes	Yes	Yes	No
Apache MXNet	Yes	C++	C++, Python, Julia, Matlab, JavaScript	Yes	Yes	Yes	Yes	Yes
PlaidML	Yes	Python, C++, OpenCL	Python, C++	No	Yes	Yes	Yes	Yes
PyTorch	**Yes**	**Python, C, C++, CUDA**	**Python, C++, Julia**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Seq2SeqSharp	Yes	C#, C, C++, CUDA	C#	Yes	Yes	Yes	No	Yes
TensorFlow	**Yes**	**C++, Python, CUDA**	**Python, C/C++, Java, Go, JavaScript**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Theano	Yes	Python	Python	Yes	With Lasagne	Yes	Yes	No
Wolfram Mathematica	No	C++, Wolfram Language, CUDA	Wolfram Language	Yes	Yes	Yes	Yes	Yes

SOURCES

SOURCES

- http://clipart-library.com/
- https://medium.com/@schartz/the-shape-of-tensor-bab75001d7bc
- https://lyhue1991.github.io/eat_tensorflow2_in_30_days/english/Chapter3/
- https://zitaoshen.rbind.io/project/machine_learning/how-to-build-your-own-neural-net-from-the-scrach/
- https://en.wikipedia.org/w/index.php?title=Comparison_of_deep-learning_software&action=edit&section=1
- https://www.researchgate.net/publication/319901002_NeuRoute_Predictive_Dynamic_Routing_for_Software-Defined_Networks/figures
- https://abhigoku10.medium.com/activation-functions-and-its-types-in-artifical-neural-network-14511f3080a8