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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?

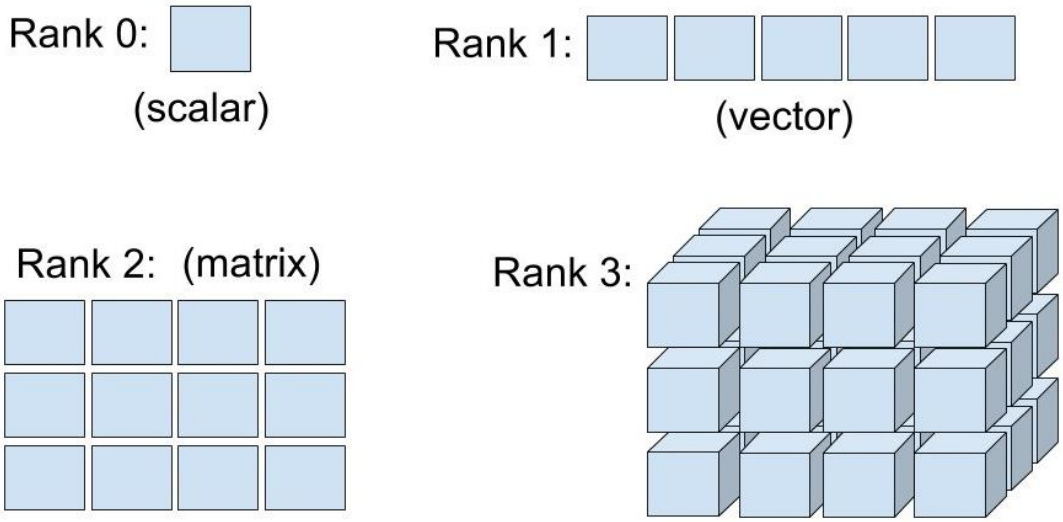
TensorFlow

WHAT IS TENSORFLOW?

Open source platform for numerical computation

Computations based on tensors

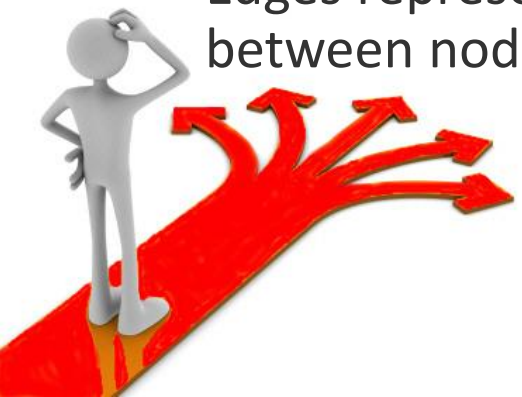
- Tensors are multi-dimensional arrays with a uniform type, backed by the accelerator memory (GPU), and are immutable

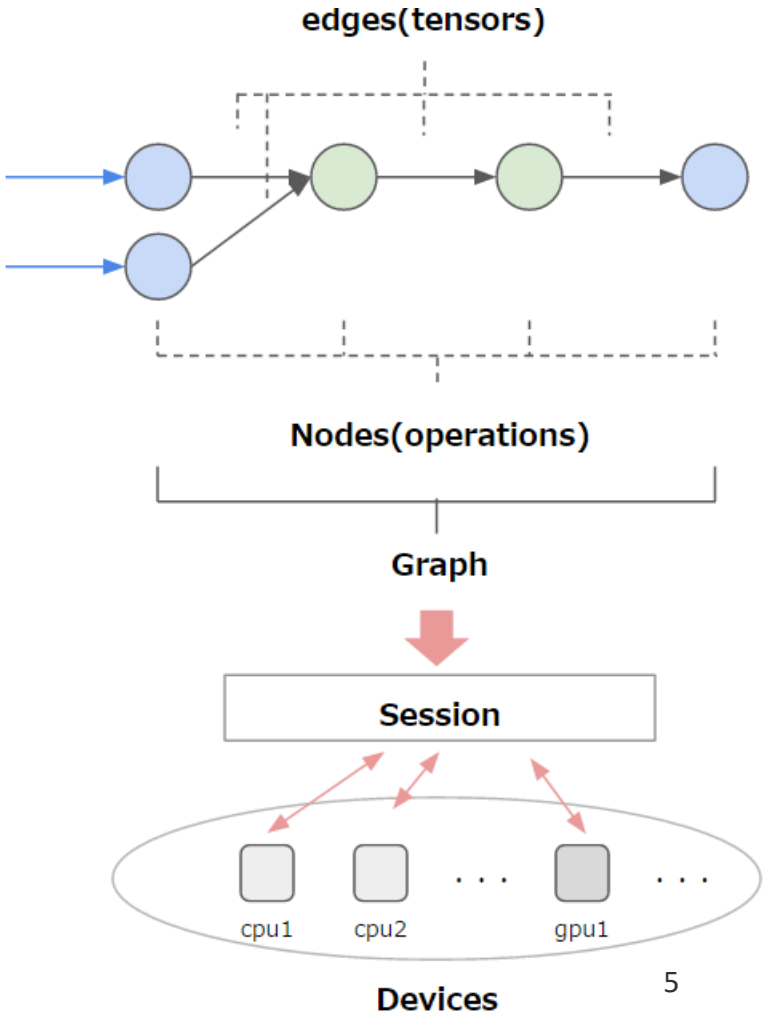


WHAT IS TENSORFLOW?

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

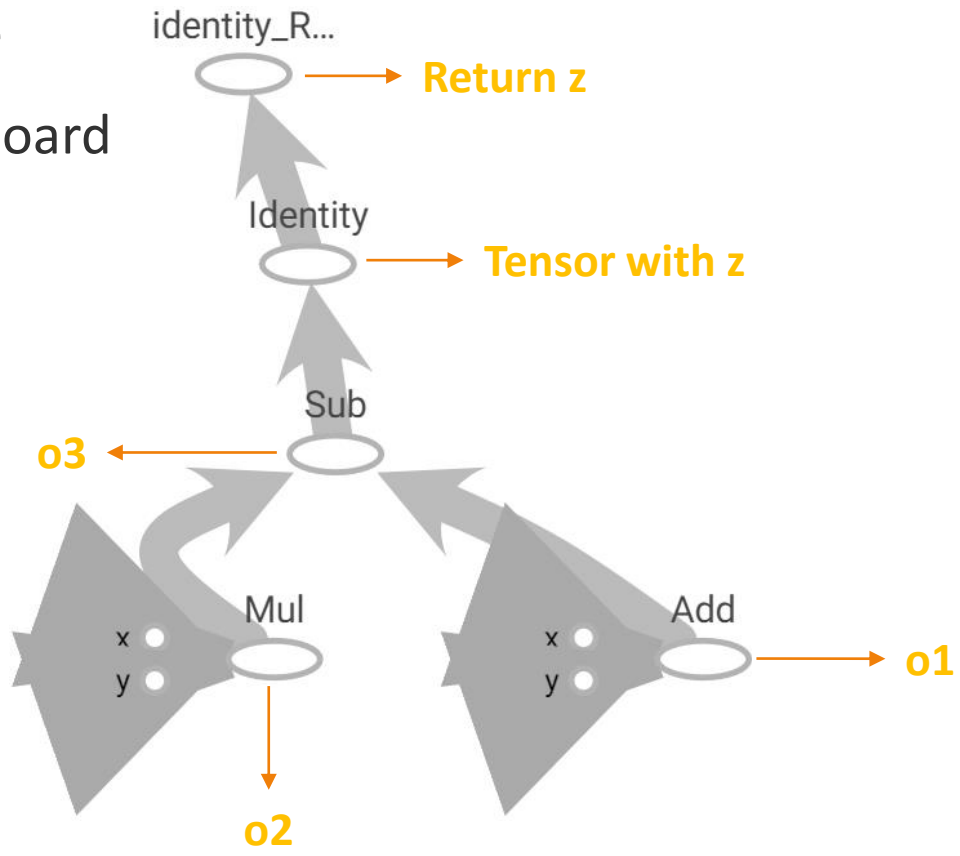
- Check TensorBoard

```
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



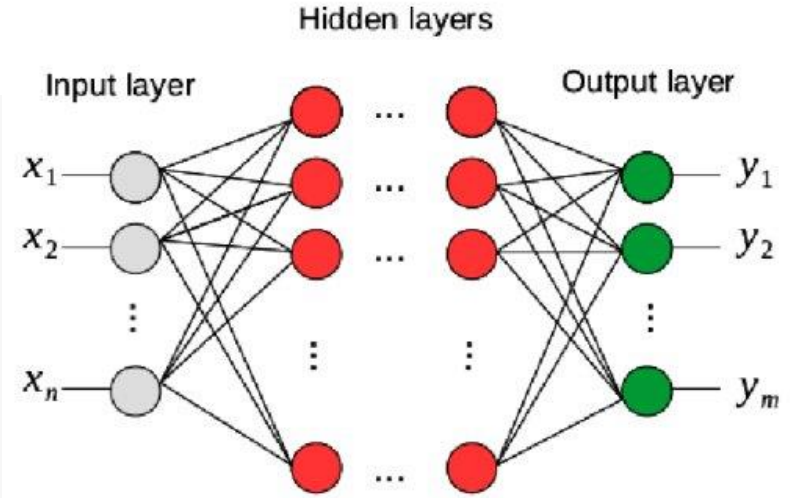
WHAT IS TENSORFLOW?

Tensors flow trough the graph,

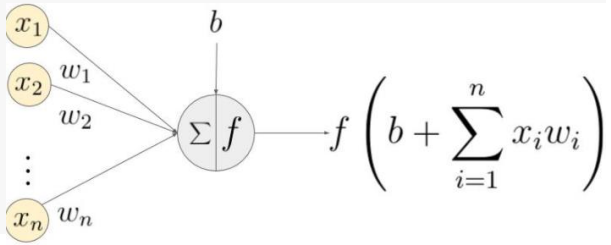
thus the name TensorFlow

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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    data = tf.convert_to_tensor(X, dtype=tf.float32)
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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?

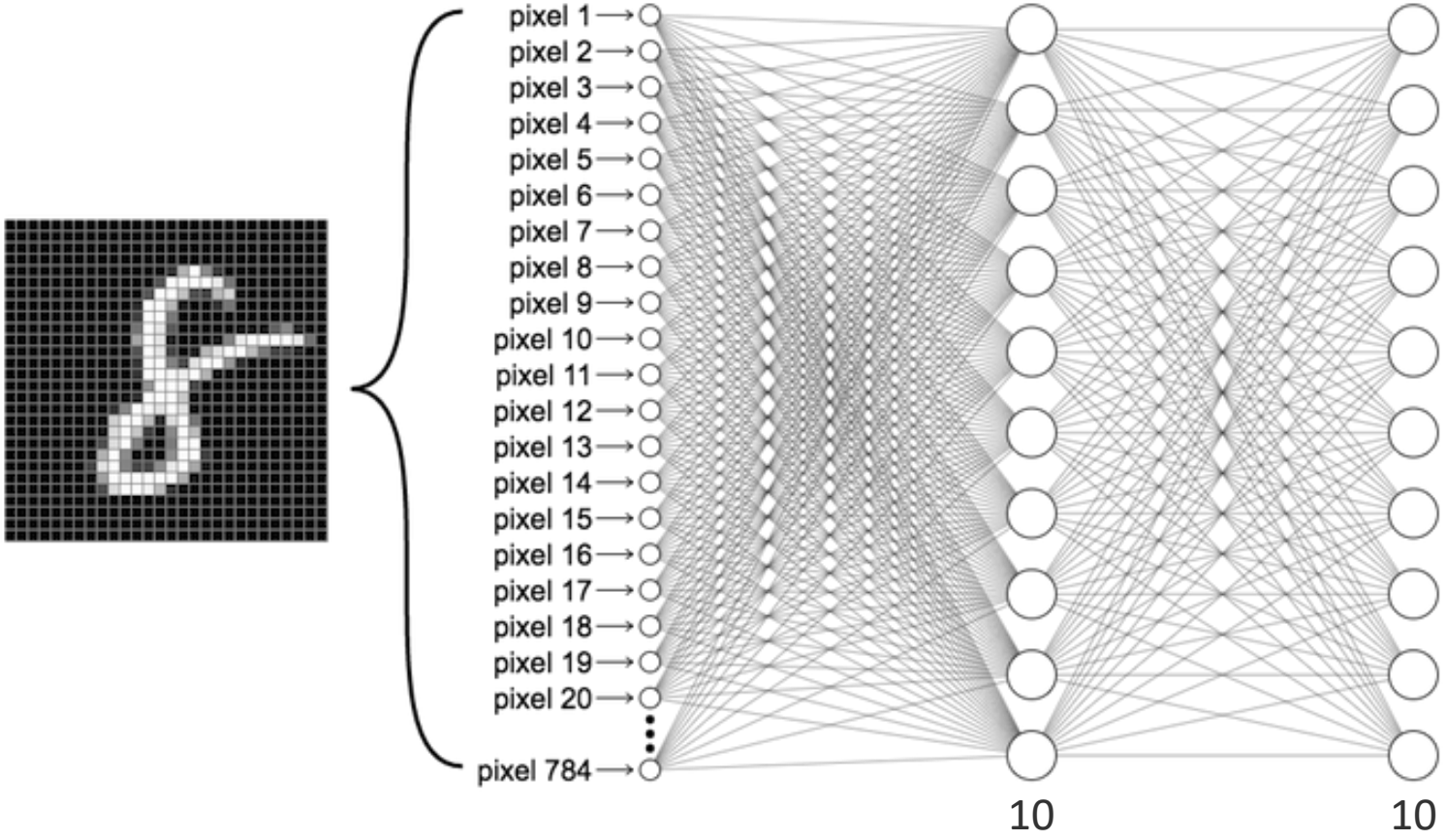
WHAT IS TENSORFLOW?

Use Keras API:

“API designed for human beings, not machines”

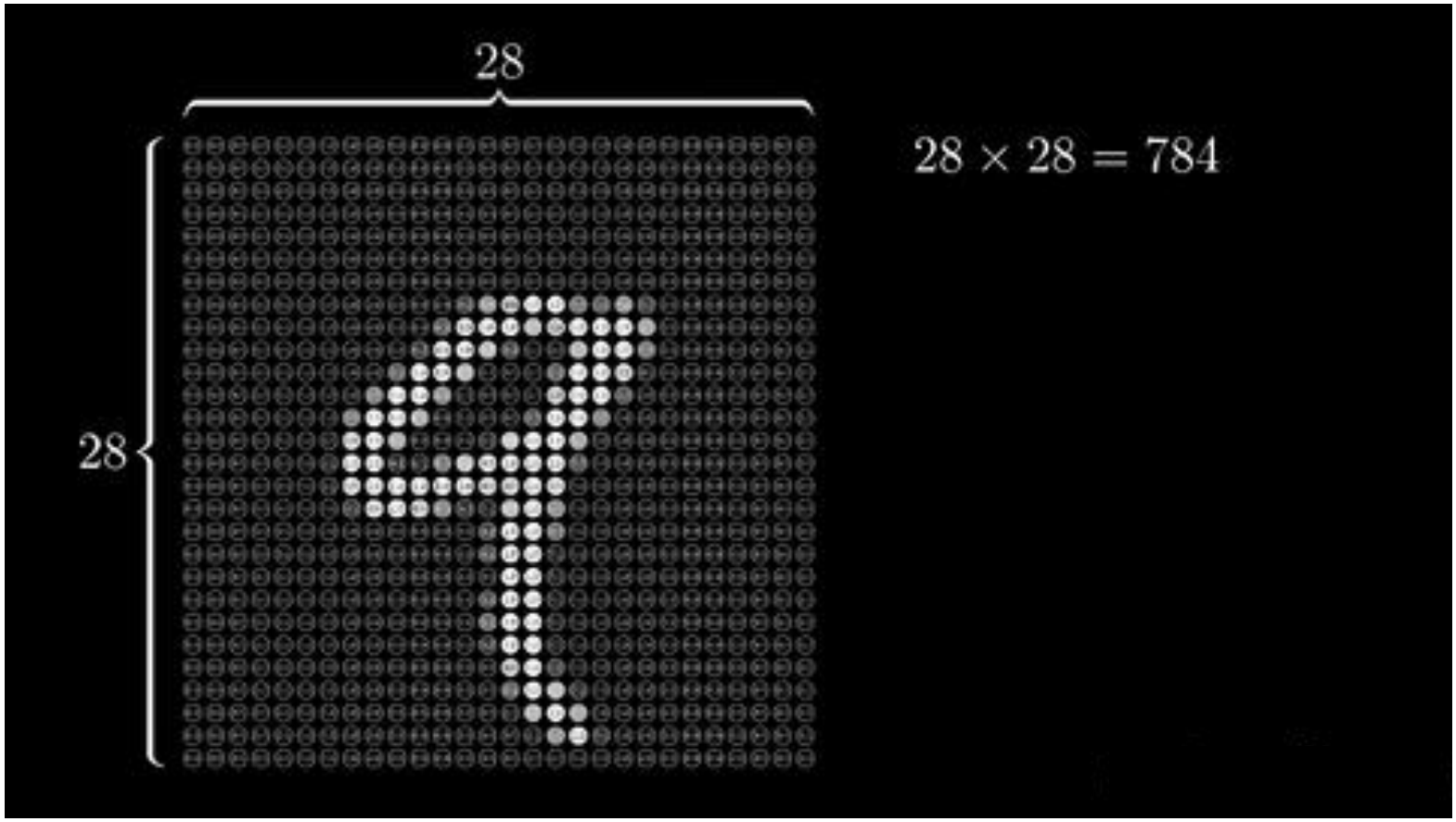
WHAT IS TENSORFLOW?

Methods to build a Keras model in TensorFlow:



WHAT IS TENSORFLOW?

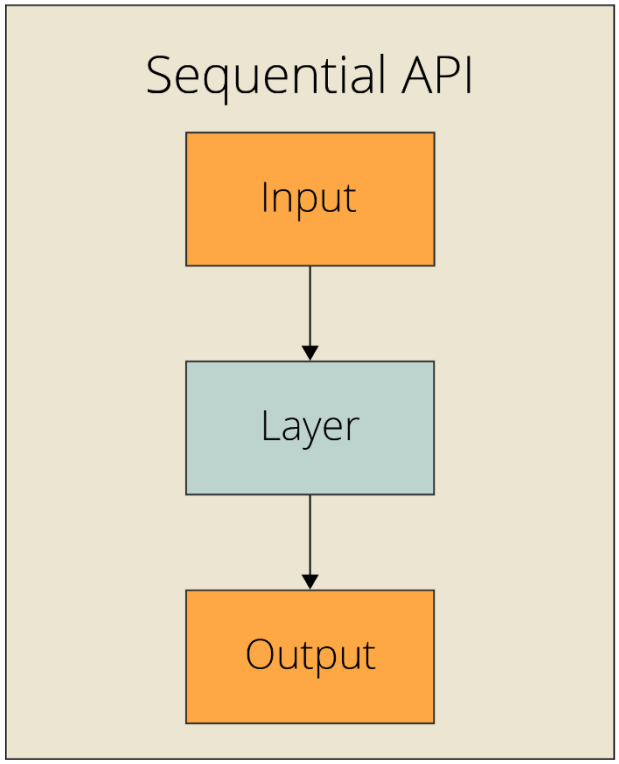
Methods to build a Keras model in TensorFlow:



WHAT IS TENSORFLOW?

Methods to build a Keras model in TensorFlow:

- Sequential API




```
from tensorflow.keras import Sequential
from tensorflow.keras.layers import Flatten
from tensorflow.keras.layers import Dense

model = Sequential([
  Flatten(input_shape=(28, 28)),
  Dense(10,'relu'),
  Dense(10, "softmax"),
  ])
```

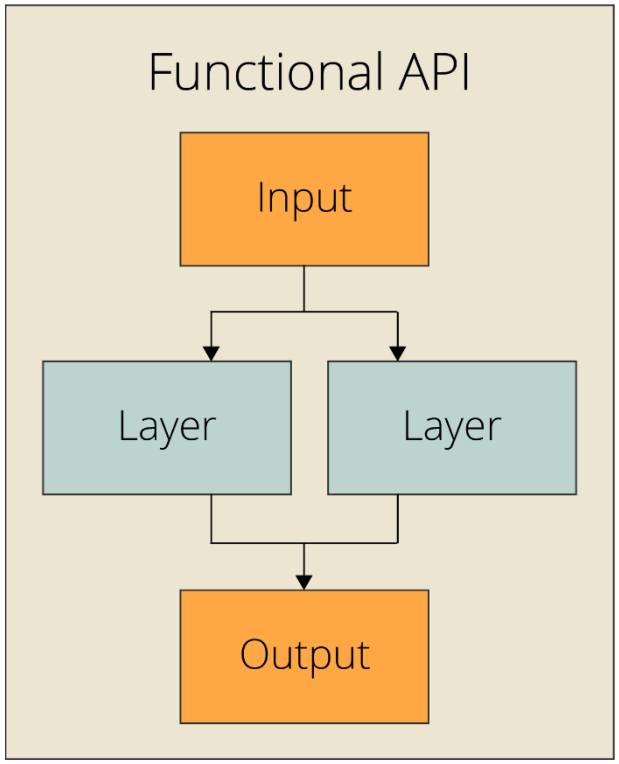
```
from tensorflow.keras import Sequential
from tensorflow.keras.layers import Flatten
from tensorflow.keras.layers import Dense

model = Sequential()
model.add(Flatten(input_shape=(28, 28)))
model.add(Dense(10, "relu"))
model.add(Dense(10, "softmax"))
```

WHAT IS TENSORFLOW?

Methods to build a Keras model in TensorFlow:

- Functional API

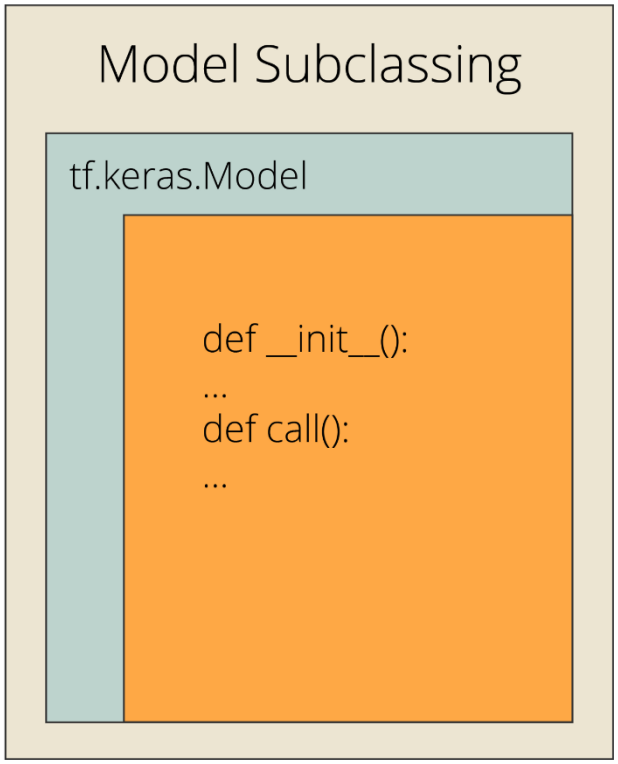



```
1 from tensorflow.keras import Model
2 from tensorflow.keras.layers import Flatten
3 from tensorflow.keras.layers import Dense
4 from tensorflow.keras.layers import Input
5
6 inputs = Input(shape=(28, 28))
7 x = Flatten()(inputs)
8 x = Dense(10, "relu")(x)
9 outputs = Dense(10, "softmax")(x)
10
11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

WHAT IS TENSORFLOW?

Methods to build a Keras model in TensorFlow:

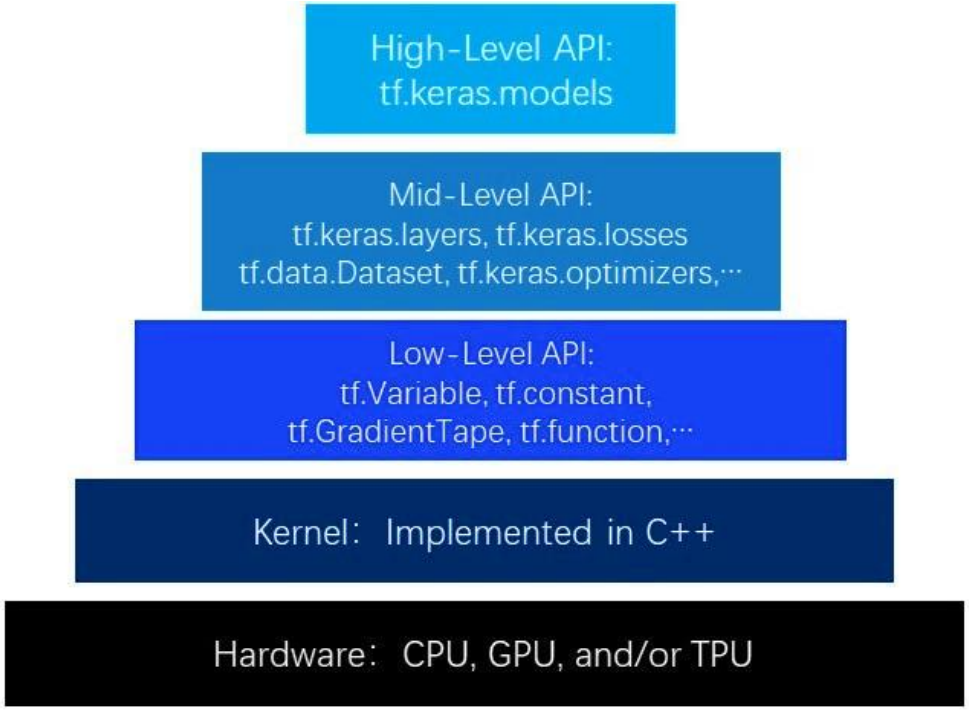
- Model Subclassing




```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

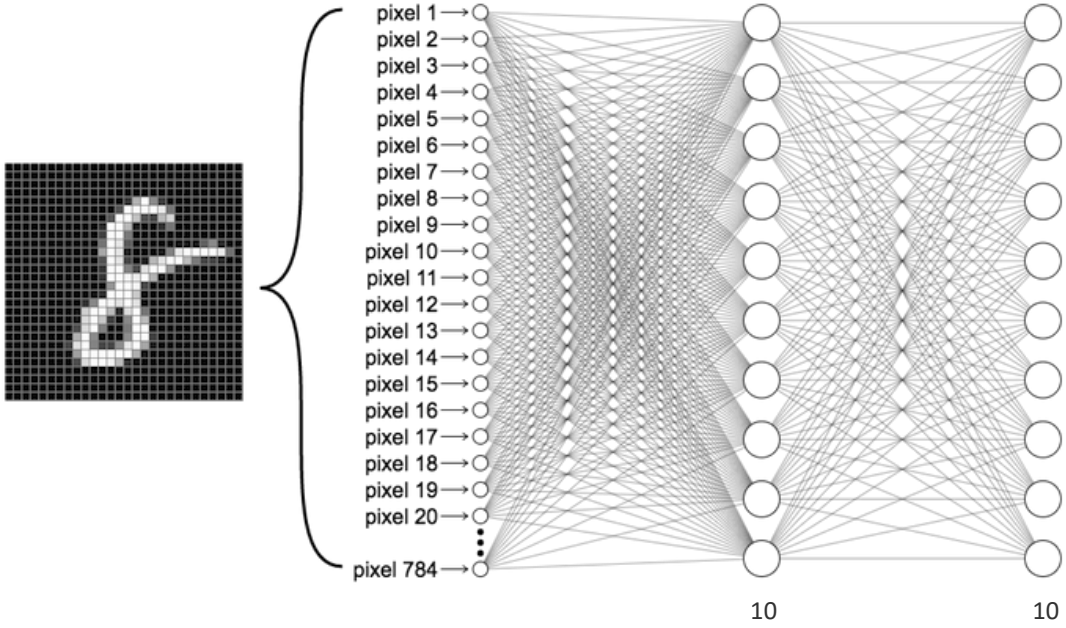


PRACTICAL EXAMPLE

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