Advanced Machine Learning

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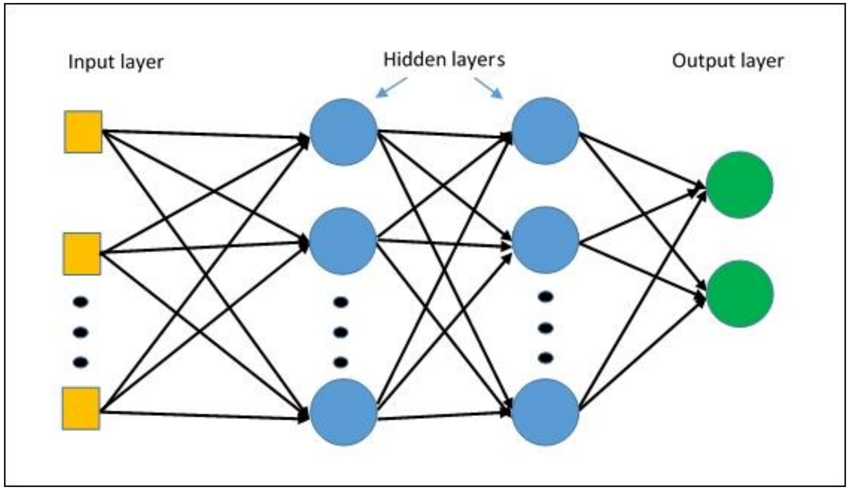
JUNIA ISEN

PowerPoint slides from **Halim Benhabiles, PhD** and **Farès BOUGOURZI, PhD**

Properties of the MLP

- Number of layers and neurons affect highly the algorithm
- More layers and neurons improve the capacity of the network but
  - Slow training speed
  - Risk of overfitting particularly with small datasets
- How to deal with these parameters?



MLP example (Multi Layer Perceptron)

Going faster with Keras - https://keras.io/

- Python Deep learning library
  - High-level neural networks API
  - Running on backend platforms

mxnet

TensorFlow

Keras

PyTorch

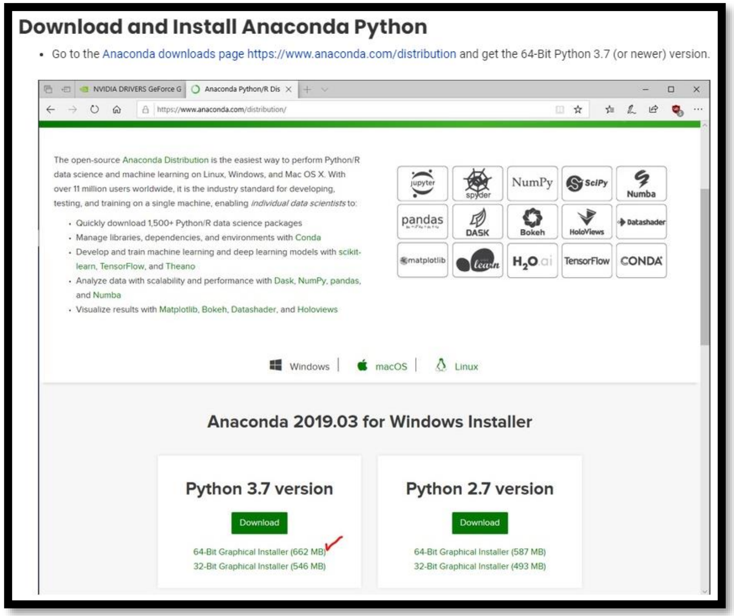
  - Fast prototyping
  - Use **CPU** or **GPU**

Installing keras and TensorFlow

How to Install TensorFlow with GPU Support on Windows 10 (Without Installing CUDA) UPDATED!

Written on April 26, 2019 by Dr Donald Kinghorn

https://www.pugetsystems.com/labs/hpc/How-to-Install-TensorFlow-with-GPU-Support-on-Windows-10-Without-Installing-CUDA-UPDATED-1419/



Download and Install Anaconda Python

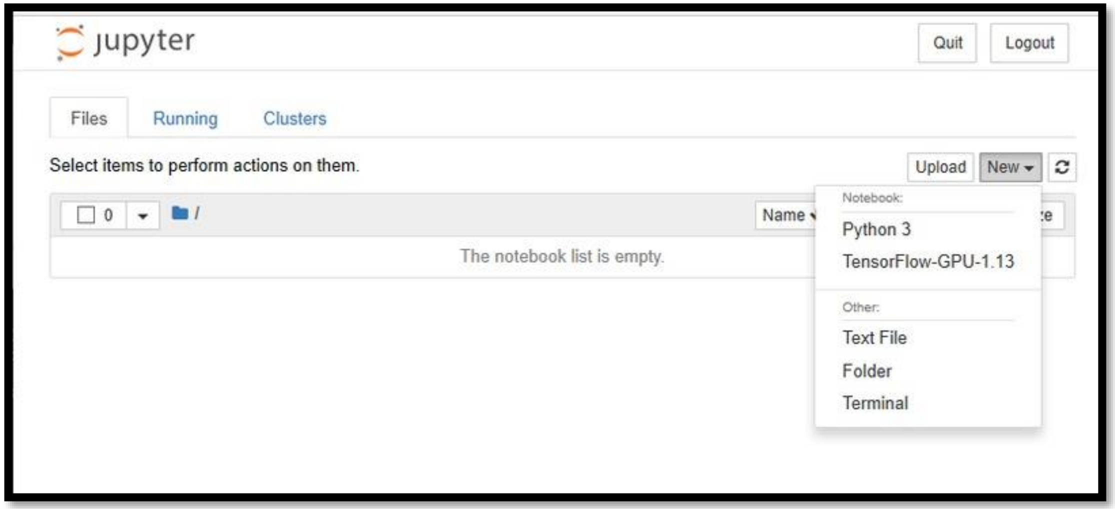
- Go to the Anaconda downloads page https://www.anaconda.com/distribution and get the 64-Bit Python 3.7 (or newer) version.

The open-source Anaconda Distribution is the easiest way to perform Python/R data science and machine learning on Linux, Windows, and Mac OS X. With over 11 million users worldwide, it is the industry standard for developing, testing, and training on a single machine, enabling *individual data scientists* to:

- Quickly download 1,500+ Python/R data science packages
- Manage libraries, dependencies, and environments with Conda
- Develop and train machine learning and deep learning models with scikit-learn, TensorFlow, and Theano
- Analyze data with scalability and performance with Dask, NumPy, pandas, and Numba
- Visualize results with Matplotlib, Bokeh, Datashader, and Holoviews

Anaconda 2019.03 for Windows Installer

Python 3.7 version	Python 2.7 version
Download	Download
64-Bit Graphical Installer (662 MB) ✓	64-Bit Graphical Installer (587 MB)
32-Bit Graphical Installer (546 MB)	32-Bit Graphical Installer (493 MB)



Select items to perform actions on them.

The notebook list is empty.

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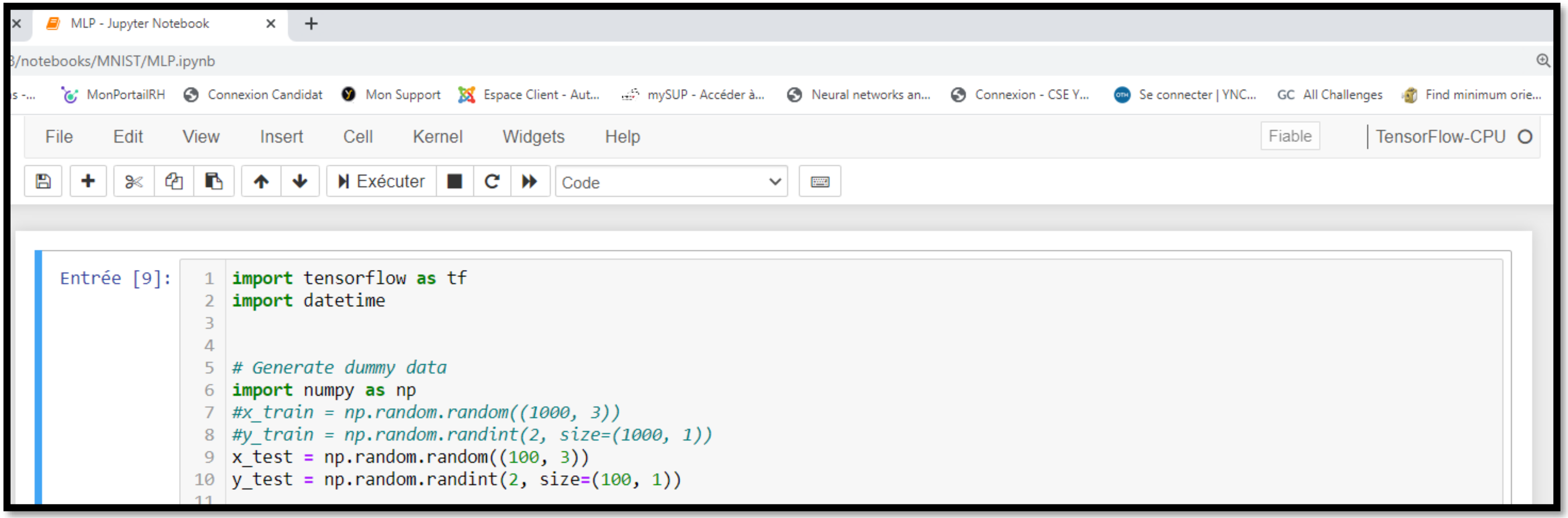


Entrée [9]:

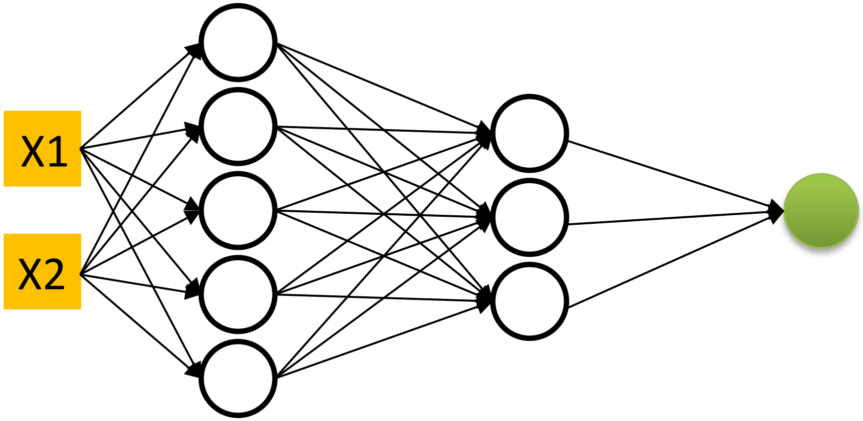
```python
import tensorflow as tf
import datetime


# Generate dummy data
import numpy as np
#x_train = np.random.random((1000, 3))
#y_train = np.random.randint(2, size=(1000, 1))
x_test = np.random.random((100, 3))
y_test = np.random.randint(2, size=(100, 1))
```

Getting started with Keras – TensorFlow core

- Designing the architecture of your MLP model to solve XOR, OR, AND functions

MLP example (input: 2 units, hidden layers: 2 (5 units, 3 units), output: 1 unit)

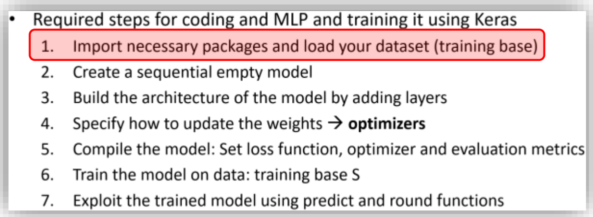


Getting started with Keras – TensorFlow core

- Required steps for coding and training MLP using Keras
  1. Import necessary packages and load your dataset (training base)
  2. Create a sequential empty model
  3. Build the architecture of the model by adding layers
  4. Specify how to update the weights → **optimizers**
  5. Compile the model: Set loss function, optimizer and evaluation metrics
  6. Train the model on data: training base S
  7. Exploit the trained model using predict and round functions

Getting started with Keras – TensorFlow core

- Import necessary packages and load your dataset



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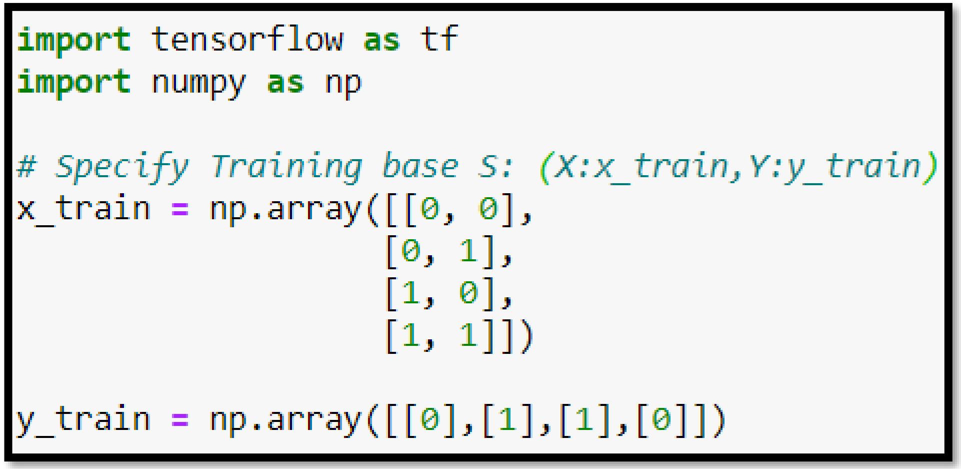

```
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import numpy as np

# Specify Training base S: (X:x_train,Y:y_train)
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                    [1, 1]])

y_train = np.array([[0],[1],[1],[0]])
```
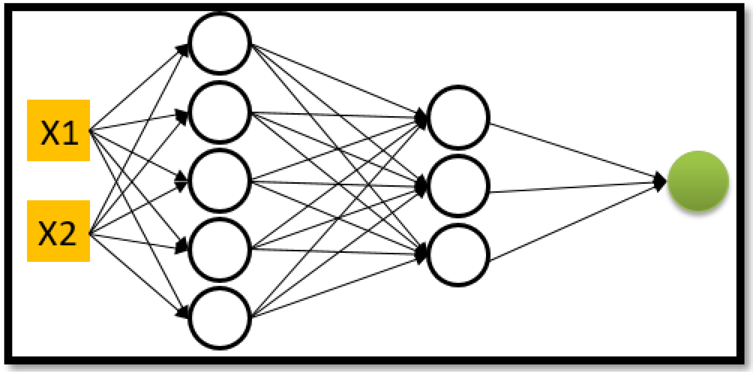
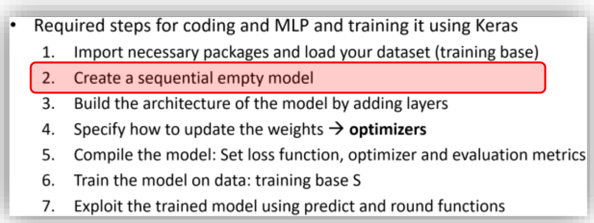



Getting started with Keras – TensorFlow core



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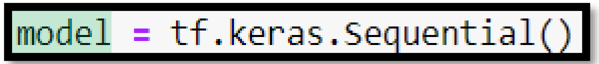
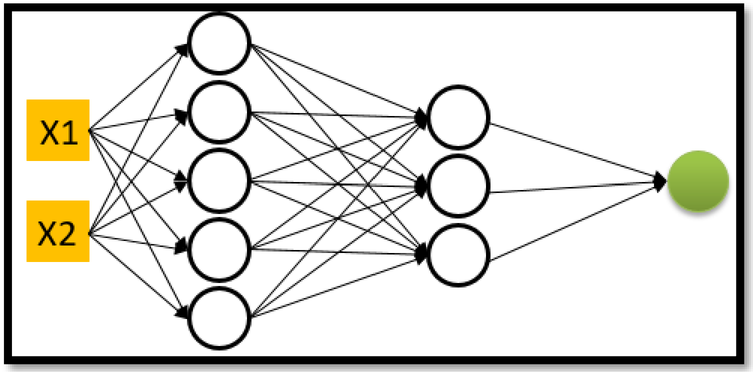
- Create a sequential model (neural network architecture)

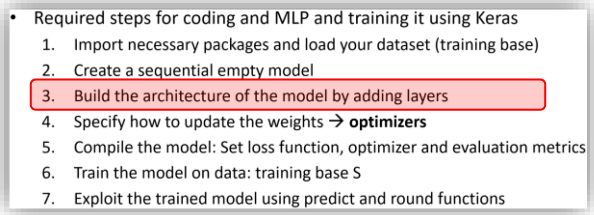


```
model = tf.keras.Sequential()
```

At this stage of the code, the model is empty



Getting started with Keras – TensorFlow core



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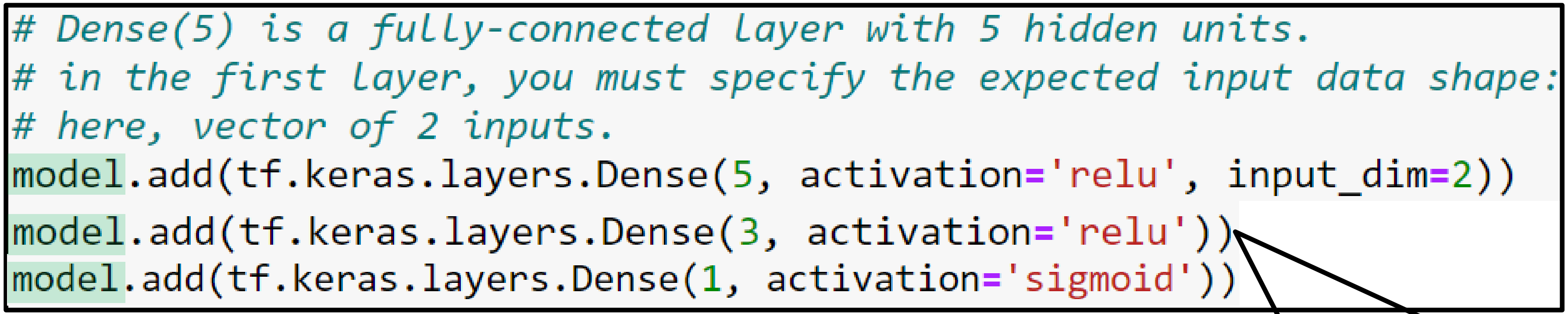
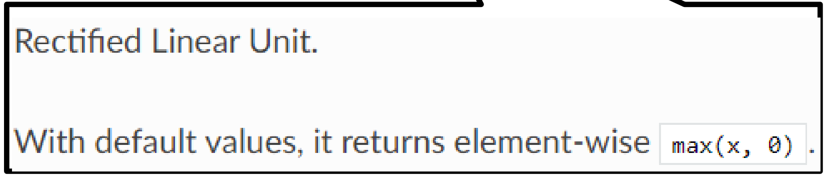
- Building the architecture of our model by adding layers



```
# Dense(5) is a fully-connected layer with 5 hidden units.
# in the first layer, you must specify the expected input data shape:
# here, vector of 2 inputs.
model.add(tf.keras.layers.Dense(5, activation='relu', input_dim=2))
model.add(tf.keras.layers.Dense(3, activation='relu'))
model.add(tf.keras.layers.Dense(1, activation='sigmoid'))
```

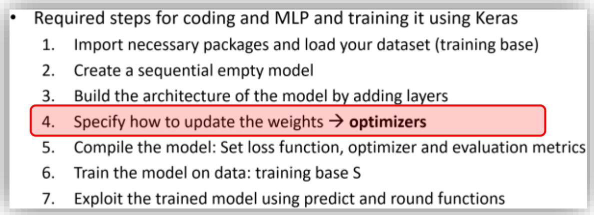


Rectified Linear Unit.

With default values, it returns element-wise `max(x, 0)`.

Getting started with Keras – TensorFlow core

- Specifying how to update the weights
  → **optimizers**



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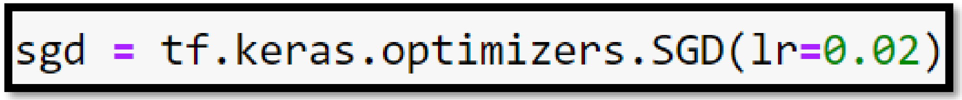
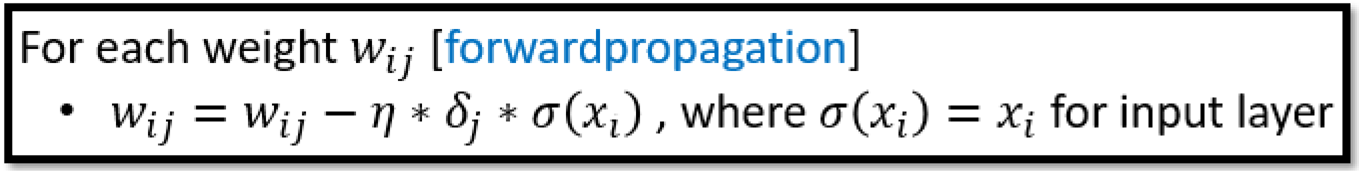
we want to use stochastic gradient descent with learning rate = 0.02



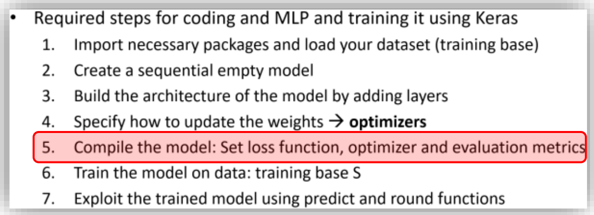
```
sgd = tf.keras.optimizers.SGD(lr=0.02)
```



For each weight w_{ij} [forwardpropagation]

- $w_{ij} = w_{ij} - \eta * \delta_j * \sigma(x_i)$, where $\sigma(x_i) = x_i$ for input layer

Getting started with Keras – TensorFlow core



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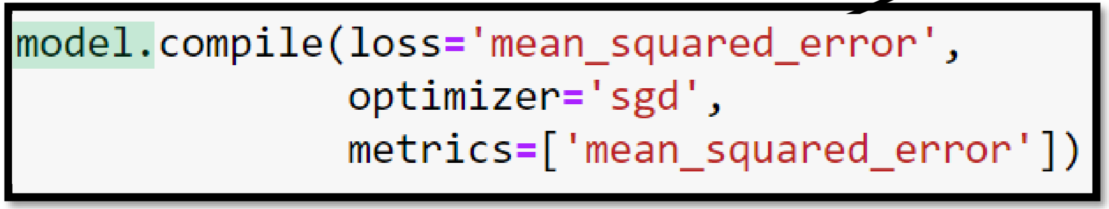
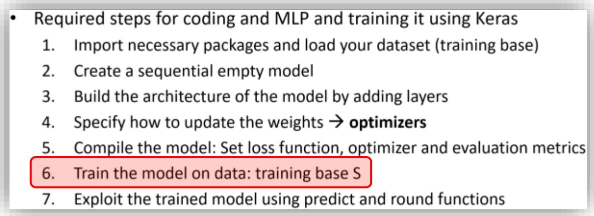
- Compile the model: Set loss function, optimizer and evaluation metrics

$$\text{MSE}(w) = \frac{1}{n}\sum_{(X,c)\ in\ S}(c - o)^2$$



```
model.compile(loss='mean_squared_error',
              optimizer='sgd',
              metrics=['mean_squared_error'])
```

Getting started with Keras – TensorFlow core



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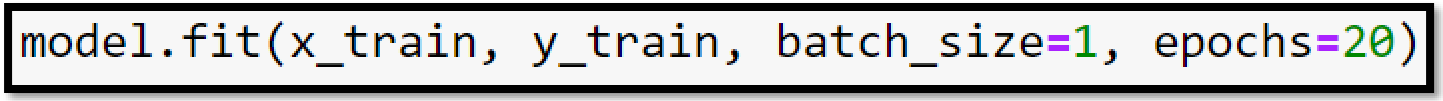
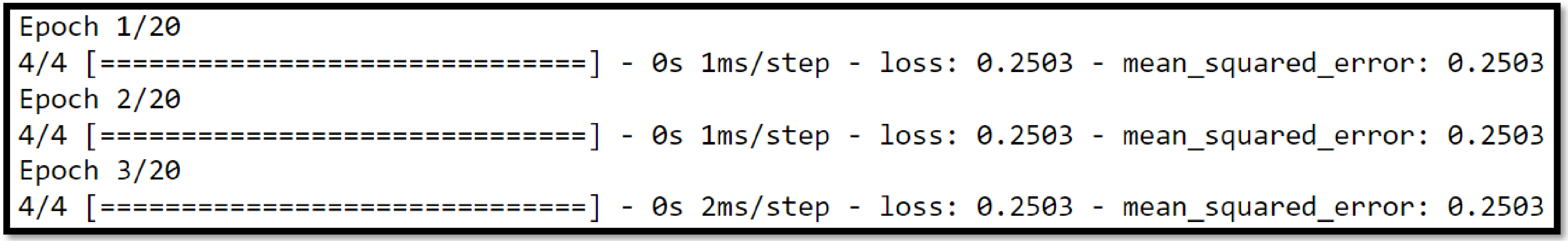
- Train the model on data: training base S

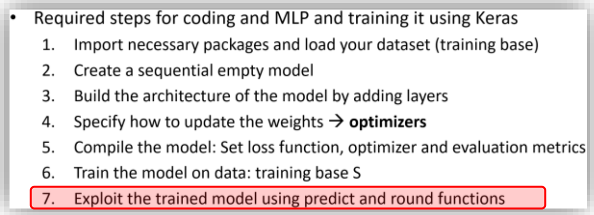


```
model.fit(x_train, y_train, batch_size=1, epochs=20)
```



```
Epoch 1/20
4/4 [==============================] - 0s 1ms/step - loss: 0.2503 - mean_squared_error: 0.2503
Epoch 2/20
4/4 [==============================] - 0s 1ms/step - loss: 0.2503 - mean_squared_error: 0.2503
Epoch 3/20
4/4 [==============================] - 0s 2ms/step - loss: 0.2503 - mean_squared_error: 0.2503
```

Getting started with Keras – TensorFlow core



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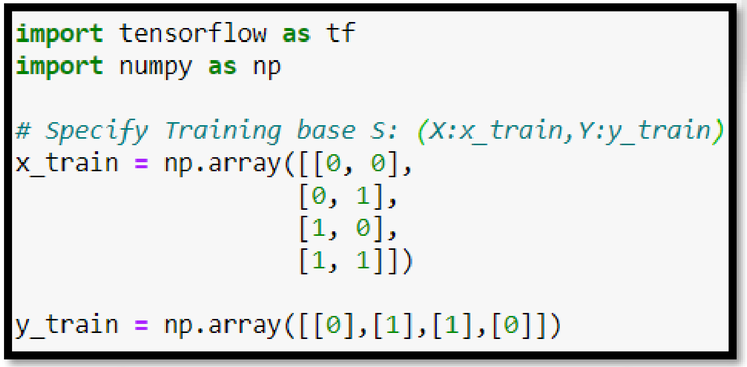
- Use predict and round functions of your model



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# Specify Training base S: (X:x_train,Y:y_train)
x_train = np.array([[0, 0],
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y_train = np.array([[0],[1],[1],[0]])
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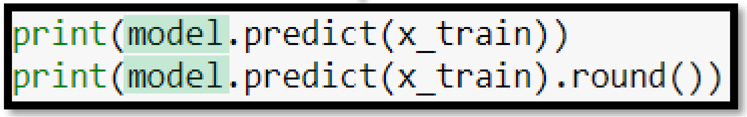
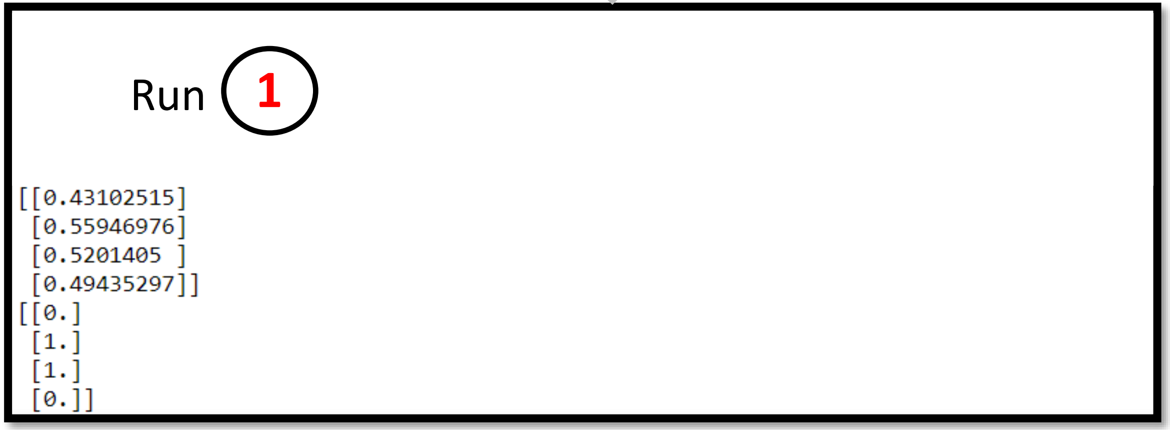


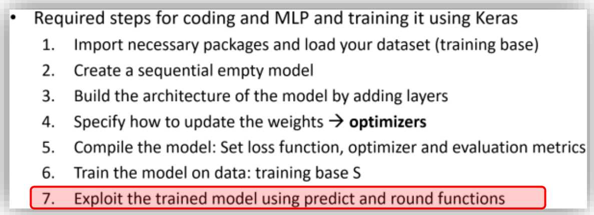
```python
print(model.predict(x_train))
print(model.predict(x_train).round())
```



Run 1

```
[[0.43102515]
 [0.55946976]
 [0.5201405 ]
 [0.49435297]]
[[0.]
 [1.]
 [1.]
 [0.]]
```

Getting started with Keras – TensorFlow core



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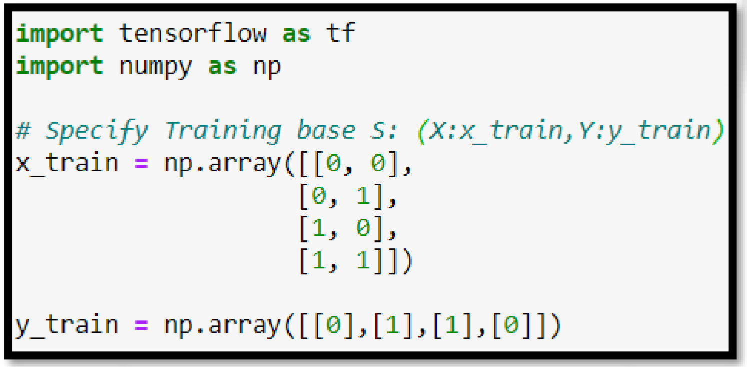

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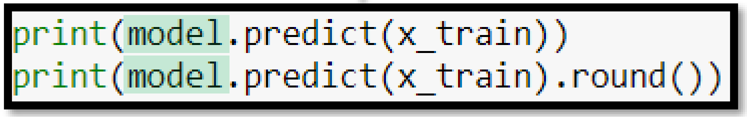

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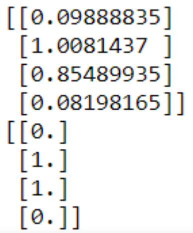
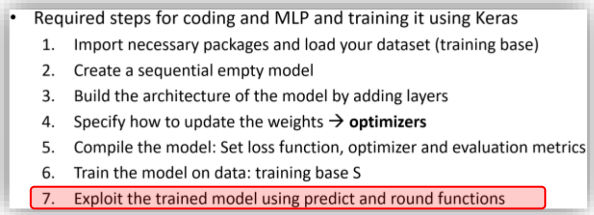
```

Run 2



```
[[0.09888835]
 [1.0081437 ]
 [0.85489935]
 [0.08198165]]
[[0.]
 [1.]
 [1.]
 [0.]]
```

Getting started with Keras – TensorFlow core



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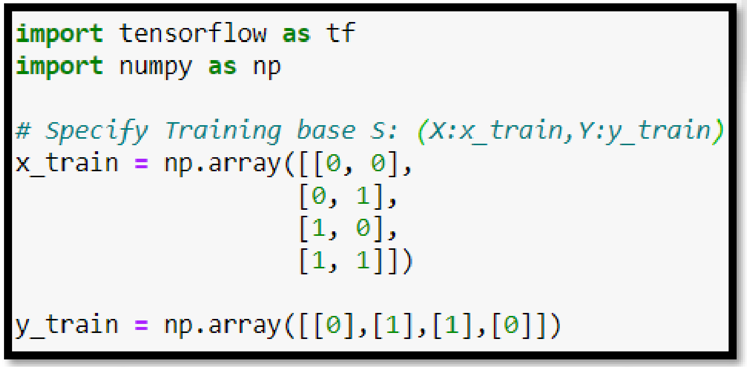

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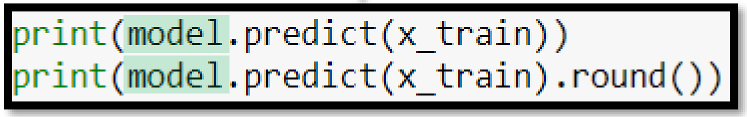
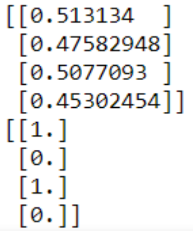


```
print(model.predict(x_train))
print(model.predict(x_train).round())
```

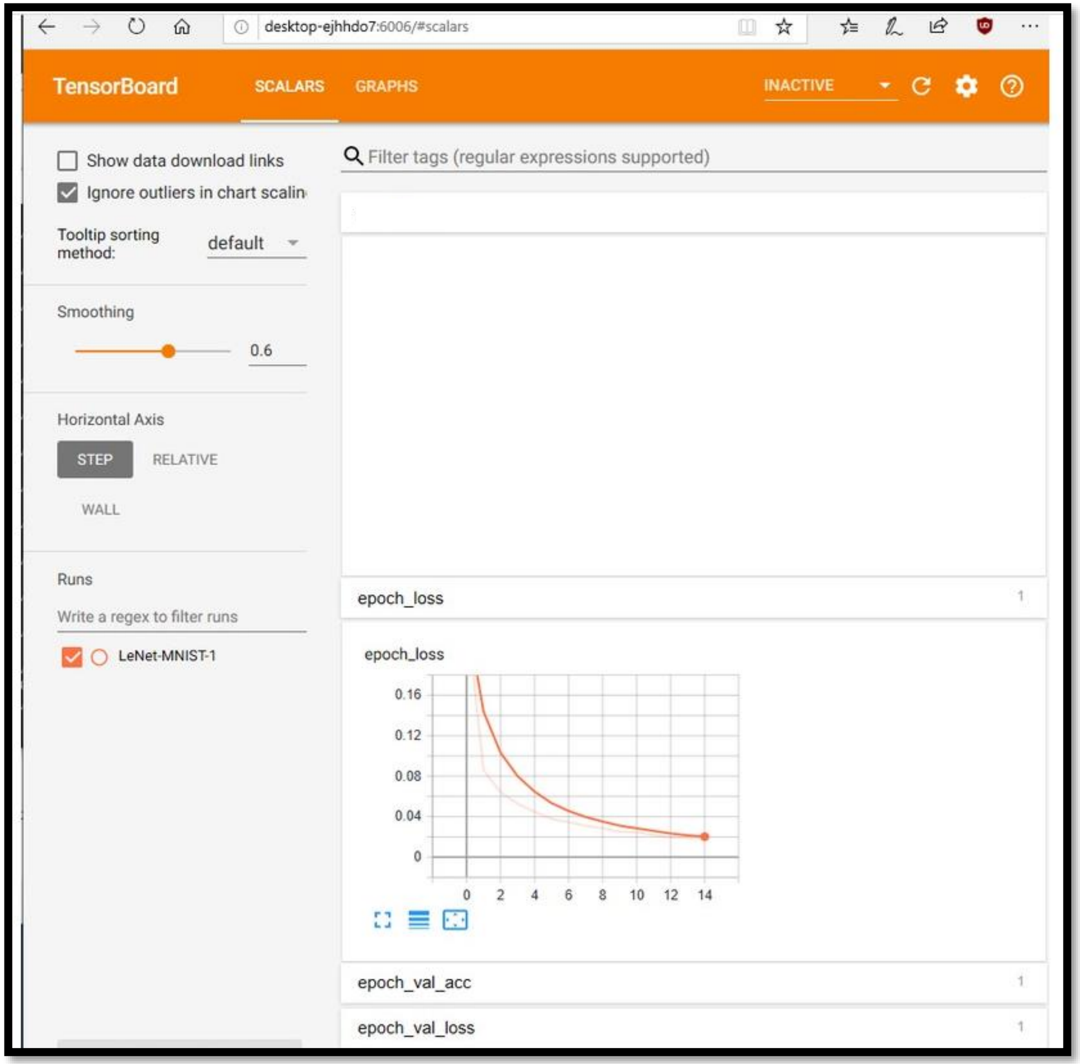
Run 3



```
[[0.513134  ]
 [0.47582948]
 [0.5077093 ]
 [0.45302454]]
[[1.]
 [0.]
 [1.]
 [0.]]
```

Getting started with Keras – TensorFlow core

- Use Tensorboard to display loss curves over epochs



☐ Show data download links

☑ Ignore outliers in chart scalin

Tooltip sorting method: default

Smoothing 0.6

Horizontal Axis: STEP RELATIVE WALL

Runs

Write a regex to filter runs

☑ ○ LeNet-MNIST-1

Filter tags (regular expressions supported)

epoch_loss 1

epoch_loss

epoch_val_acc 1

epoch_val_loss 1

Lab session Keras – TensorFlow core

- Using Keras and Tensorflow backend
  - Build your MLP to solve logic functions
  - Set several architectures (depth, and hidden layer size) and test them by
    - Selecting activation functions studied in the course (sigmoid and pureline function)
    - Starting several runs
    - Plotting for each run the curves showing the evolution of your loss function and your accuracy metric – use TensorBoard
- **Look for the function that permit to output the weights of your best model and display the weights**