TELECOM Paris

Une école de l'IMT

Practice in Deep Learning TP 40

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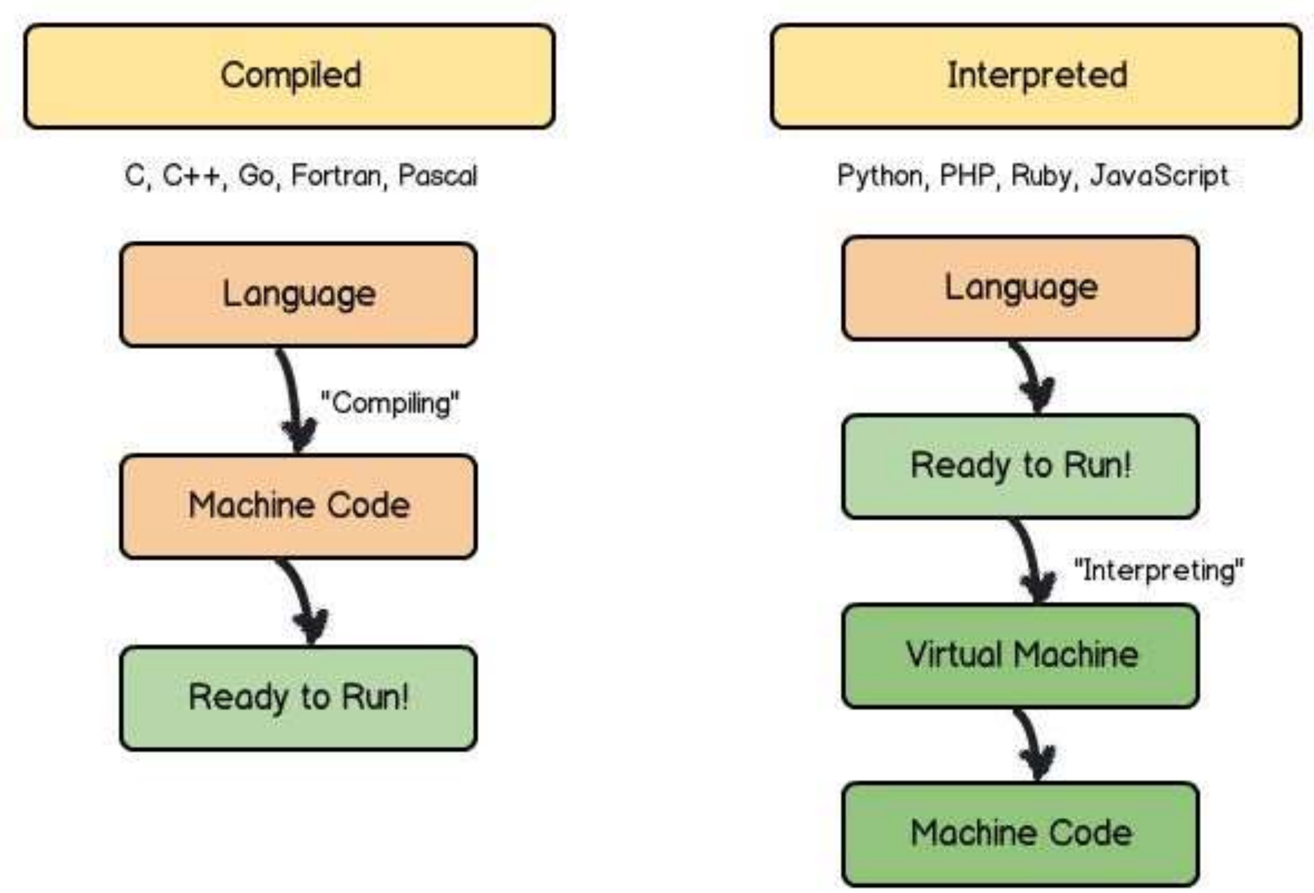
Introduction to Python

Compiled vs Interpreted Languages



Python Versions and Syntax

- **Current version 3.x (PyTorch, Keras,**

```
print ("Hello World!")
```

Old 2.x code not 100% compatible

```
print "Hello World!"
```

- **How do I know my python version /**

```
attilio@debian:~$ python --version
Python 3.5.3

attilio@debian:~$ which python
/usr/bin/python
```

Indentation

- **Python requires indentation**

```
if myIntVar == 10:
        print (”First branch taken!”)
        if myStrVar == ”Some text“
                print (”Second branch taken!”)
```

- **Indentation error example**

```
>>> if myVar == 10:
... print ("Branch taken!")
  File "<stdin>", line 2
    print ("Branch taken!")
        ^
IndentationError: expected an indented block
```

Variables Types

- **Weakly typized variables**

```
# boolean variable
>>> v=True
>>> type(v)
<type 'bool'>

# integer number
>>> v=1
>>> type(v)
<type 'int'>

# floating point number
>>> v=1.0
>>> type(v)
<type 'float'>

# text string
>>> v="Hello World!"
>>> type(v)
<type 'str'>
```

```
# defining a list
>>> list=['Rat','Cat','Dog']
>>> type(list)
<type 'list'>

# defining a list of lists
>>> matrix=[[1,2,3],[4,5,6]]
>>> type(matrix)
<type 'list'>
>>> len(matrix)
2
>>> len(matrix[0])
3

# defining a dictionary
>>> dictionary={'Rat', 10, True}
>>> type(dictionary)
<type 'dict'>
```

Variables by Reference

```
# creating list
>>> m=[1, 2, 3]

# creating second list pointer
>>> m2 = m

# modifying list via first pointer
>>> m[0][1] = -1
>>> m2
[-1, 2, 3]

# dropping first pointer
>>> del(m)
>>> type(m)
Traceback (most recent call last):
NameError: name 'm' is not defined

# list still accessible via second pointer
>>> type(m2)
<class 'list'>
```

Variables Cloning

- **See also *deepcopy()***

```
# original list
>>> list = [0, 1, 2]

# cloning the list
>>> new_list = list.copy()

# appending one element to the cloned list
>>>  new_list.append(4)

# printing new and old list
>>> print('Old List: ', list)
Old List:  [0, 1, 2]
>>> print('New List: ', new_list)
New List:  [0, 1, 2, 4]
```

Conditional Branches

- **Mind the indentation!**

```
>>> v=1
>>> if v == 0:
...     print("variable equal to 0")
... elif v == 1:
...     print("variable equal to 1")
... else:
...     print("variable value is " + str(v))
...
variable equal to 1
```

For Loops

- **The C / Java way**

```
# define a list
>>> list=['a',-1,1.0]

# getting length of list
>>> length = len(list)

# Iterating the index
>>> for i in range(length):
... print(list[i])
a
-1
1.0

# same as 'for i in range(len(list))'
```

For Loops

- **The Python way**

```
# define a list
>>> list=['a',-1,1.0]

# iterate through the list elements the python way
>>> for e in list:
...     print ("element " +str(e) + " is of type " + str(type(e)))
...
element a is of type <class 'str'>
element -1 is of type <class 'int'>
element 1.0 is of type <class 'float'>
```

While Loops

- **Also do ... while**

```
# creating counter
>>> cnt = 5

# cycling throuh
>>> while cnt > 0:
...     print (cnt)
...     cnt = cnt - 1
...
5
4
3
2
1
```

Functions

- **Positional arguments**
- **Keyword arguments**

```
>>> def f(x, y=1, z=1):
...     return x + y + z
...
>>> print(f(1, 2, 3))
6
>>> print(f(1))
3
>>> print(f(1, 2))
4
>>> print(f(1, z=3))
5
>>> print(f(1, z=3, y=2))
6
>>> print(f(z=3, 1))
  File "<stdin>", line 1
SyntaxError: positional argument follows keyword argument
```

Importing modules

- **Importing entire libraries or subcomponents**

```
>>> import numpy
>>> numpy.array([1, 2])
array([1, 2])
>>> import numpy as np
>>> np.array([1, 2])
array([1, 2])
>>> from numpy import array
>>> array([1, 2])
array([1, 2])
>>> from numpy import array as ar
>>> ar([1, 2])
array([1, 2])
```

The Anaconda Distribution

- **Problem: my OS has python 2.x, but I need 3.x**
  - Python 2.x needed by OS, have no root rights, ...
- **Solution: install Anaconda**
  - No need to be root (installed in user's home)

```
attilio@debian:~$ which python
/home/attilio/anaconda3/bin/python
```

- **Manage libraries via *conda***

  $conda search [libray name]

  $conda install [libray name]

Conda Package Manager

```
attilio@debian:~$ conda -V
conda 3.7.0

attilio@debian:~$ conda search keras
Loading channels: done
# Name                Version        Build  Channel
keras                 1.1.1         py27_0  pkgs/free
keras                 1.1.1         py34_0  pkgs/free
keras                 1.1.1         py35_0  pkgs/free
keras                 2.1.6         py27_0  pkgs/main
keras                 2.1.6         py35_0  pkgs/main
keras                 2.1.6         py36_0  pkgs/main

attilio@debian:~$ conda install [-c XYZ] keras[[=2.1.6]=py27_0]
```

Python Environments

- **Create the environment**

```
attilio@debian:~$ conda create -n yourenvname python=x.x anaconda
```

- **Activate the environment**

```
attilio@debian:~$ source activate yourenvname
```

- **Install packages in the environment**

```
attilio@debian:~$ conda install -n yourenvname [package]
```

Conda Cheat Sheet

Introduction to Keras

The Keras Language

- High level framework for machine learning
  - *High-level* w.r.t. PyTorch, TensorFlow, etc.
- Several backends available
  - We will use the TensorFlow backend (Google)

The Keras Language

- High level framework for machine learning
  - *High-level* w.r.t. PyTorch, TensorFlow, etc.
- Several backends available
  - We will use the TensorFlow backend (Google)
- Main author François Chollet
  - Google employee, former ENSTA Paristech alumn

Keras System Stack

Keras

TensorFlow

CUDDnn, CUBLAS, ...

CUDA

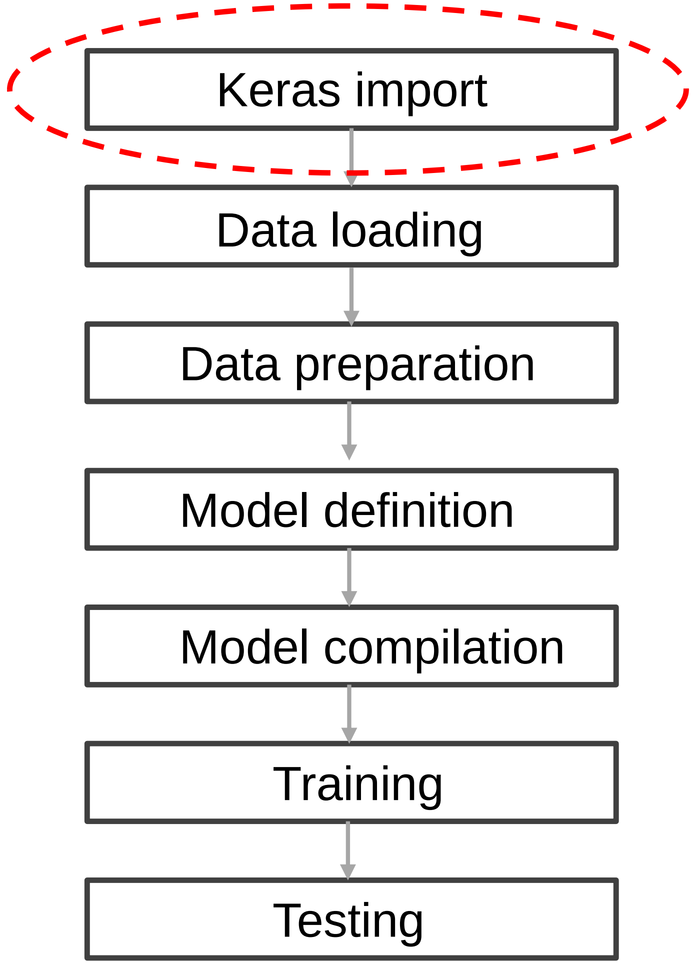
Kernel drivers

GPU

Keras

- Datasets loading
  - Popular datasets such as MNIST, etc available
  - Uses *scikit-learn* for synthetic data
- Defining network architecures
  - Non-sequential models supported
  - Pretrained deep models (AlexNet, ResNet)
- Training a network
  - Multiple optimizers available
  - One-line *fit()* function
- Visualizing data and results
  - *Relies on matplotlib* for visualization

Typical Keras Dataflow



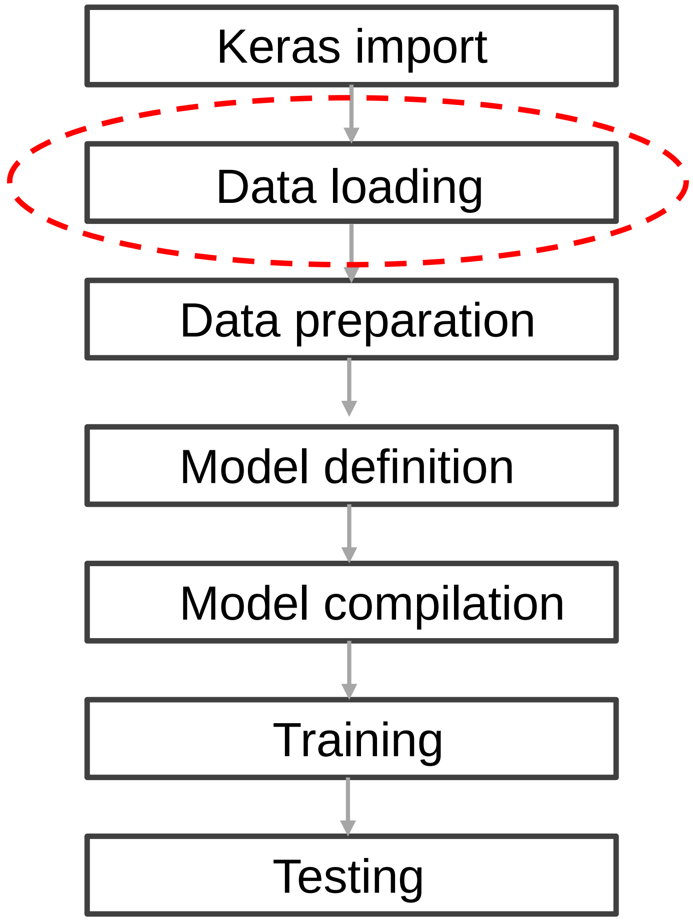
Module Import – Backend Ordering

- Make sure Keras uses the *TensorFlow* backend
- «*NHWC*» data ordering required for images
  - *N -> image index in batch*
  - *H -> image height*
  - *W -> image width*
  - *C –> image channel*

```
import keras
```

```
Using TensorFlow backend.
```

Typical Keras Dataflow



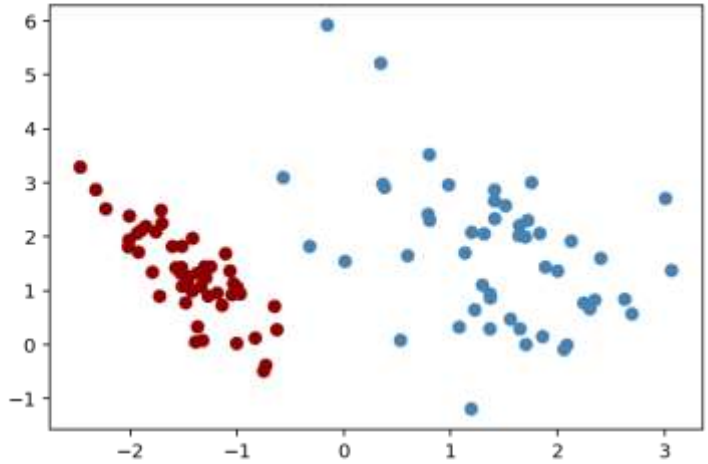
Data Generation

- Will use the *sklearn* beackend

```
from sklearn import datasets
```

- Generate two Gaussian clusters of points

```
data, labels = datasets.make_classification(
                    n_samples=100,
                    n_features=2, n_informative=2, n_redundant=0,
                    n_classes=2, n_clusters_per_class=1,
                    class_sep=1.5, flip_y=0,
                    shuffle=True)
```



Data Generation

- Will use the *sklearn* beackend

```
from sklearn import datasets, model_selection
```

- Generate two Gaussian clusters of points

```
data, labels = datasets.make_classification(
                    n_samples=100,
                    n_features=2, n_informative=2, n_redundant=0,
                    n_classes=2, n_clusters_per_class=1,
                    class_sep=1.5, flip_y=0,
                    shuffle=True)
```

- Separate 90% train and 90% test

```
train_data, test_data,
train_labels, test_labels = model_selection.train_test_split(
                            data, labels,
                            test_size = 0.1)
```

Data Generation - Visualization

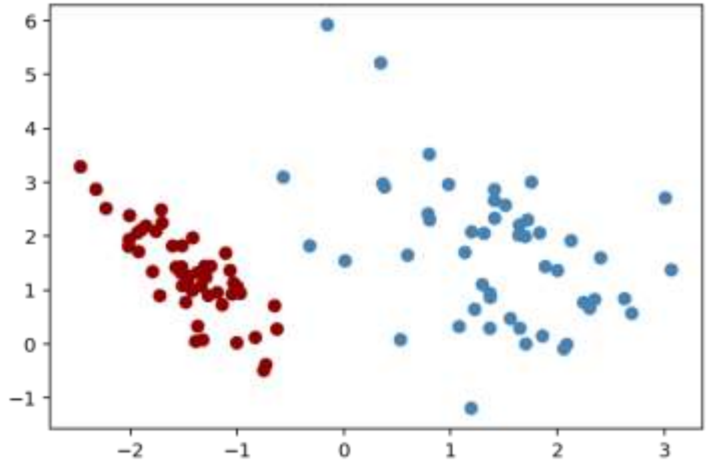
- Matlab-like plotting library

```
import matplotlib.pyplot as plt
```

- Plot the data

```
colors = ['steelblue' if label == 1 else 'darkred' for label in
labels]
plt.scatter(X[:,0], X[:,1], color=colors)
plt.show()

Y.shape, X.shape
((100,), (100, 2))
```



Dataset Loading - MNIST

- Keras has some popular datasets pre-packaged

```
from keras.datasets import mnist
```

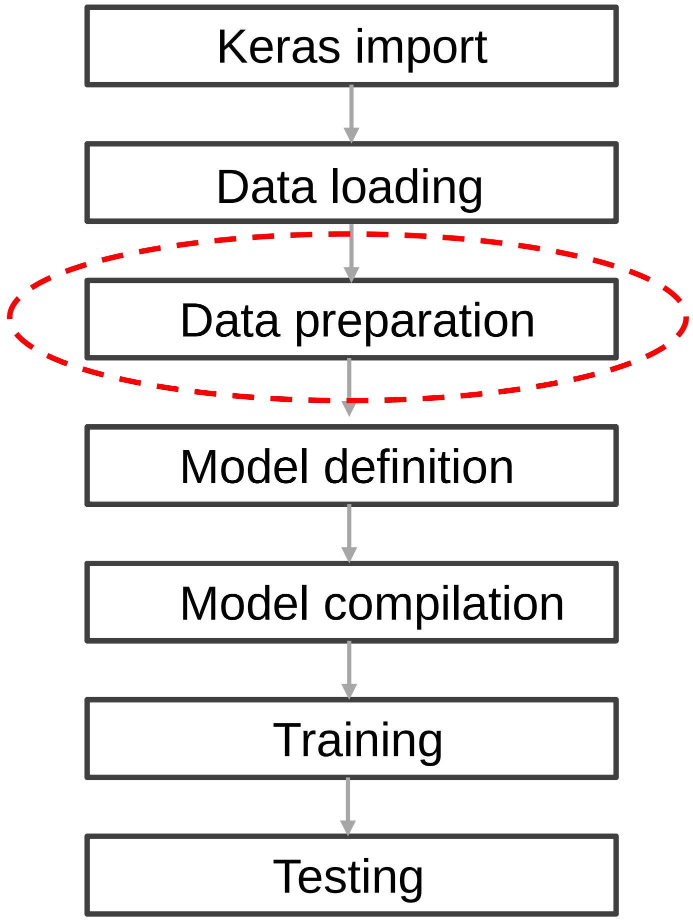
- Load images and labels into memory

```
(x_train, y_train), (x_test, y_test) = mnist.load_data()

print(y_train.shape)
(60000,)
print(x_train.shape)
(60000, 28, 28)
```

- Train samples are a `numpy.ndarray` of `int8`
- N = 60000 samples
  - W x H = 28 x 28 px. samples grayscale

Typical Keras Dataflow



Data Preparation - Images

- Load images and labels into memory

```
(x_train, y_train), (x_test, y_test) = mnist.load_data()

print(x_train.shape)
(60000, 28, 28)
```

- Samples are in (N,W,H) ordering
  - The TF backend requires (N,W,H,C) ordering
- Samples are 256-grayscale `int8` arrays
  - Neural networks require `float` in input
- Samples are in 0-255 interval
  - Normalization desirable

Data Preparation - Images

- Let us exploit numpy builtins!
- Reshape the samples to NWHC order

```
x_train = numpy.reshape(x_train, newshape, order='C')
```

Data Preparation - Images

- Let us exploit numpy builtins!
- Reshape the samples to NWHC order

```
x_train = numpy.reshape(x_train, newshape, order='C')
```

- Recast the samples from `int8` to `float`

```
x_train = x_train.astype('float_32')
```

Data Preparation - Images

- Let us exploit numpy builtins!
- Reshape the samples to NWHC order

```
x_train = numpy.reshape(x_train, newshape, order='C')
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Data Preparation - Images

- Let us exploit numpy builtins!
- Reshape the samples to NWHC order

```
x_train = numpy.reshape(x_train, newshape, order='C')
```

- Recast the samples from `int8` to `float`

```
x_train = x_train.astype('float_32')
```

- Normalize to have zero-mean (and unit-std)

```
           (x_train - x_train.mean())
x_train = --------------------------
                 x_train.std()
```

Data Preparation - Images

- Let us exploit numpy builtins!
- Reshape the samples to NWHC order

```
x_train = numpy.reshape(x_train, newshape, order='C')
```

- Recast the samples from `int8` to `float`

```
x_train = x_train.astype('float_32')
```

- Normalize to have zero-mean (and unit-std)

```
           (x_train - x_train.mean())
x_train = --------------------------
                 x_train.std()
```

- What you do on train samples, do it also on test samples
  - Yet on train statistics!

Data Preparation - Images

- Labels (classes) are encoded as integers [0-9]

```
(x_train, y_train), (x_test, y_test) = mnist.load_data()

print(y_train.shape)
(60000,)
```

- One-hot encoding required (multiclass problem)
  - Use `to_categorical()`

```
from keras.utils import to_categorical
y_train_oh = to_categorical(y_train)

print(y_train_oh.shape)
(60000, 10, 2)

print(train_labels.shape)
[[1. 0.] [1. 0.] [1. 0.] [1. 0.] [1. 0.] [0. 1.] [1. 0.] [1. 0.] [1. 0.] [1. 0.]]
```

Data Loading - Generating Data

- Transform your labels to *one-hot* encoding first

```
from keras.utils.np_utils import to_categorical

data, labels = datasets.make_classification(
                    n_samples=5, n_features=2, n_classes=2, [...])

labels_oh = to_categorical(labels)
```

```
print(data)
array([[ 3.34195848, -2.02906319],
       [ 0.12096805,  2.27640523],
       [ 2.02600963, -0.62195723],
       [ 1.91840064, -2.19699255],
       [ 3.47918424, -0.43343625]])
```

```
print(labels)
array([0,
       1,
       0,
       0,
       1])
```

```
print(labels_oh)
array([[1, 0],
       [0, 1],
       [1, 0],
       [1, 0],
       [0, 1]])
```

Data Preparation - Augmentation

- Import ImageDataGenerator

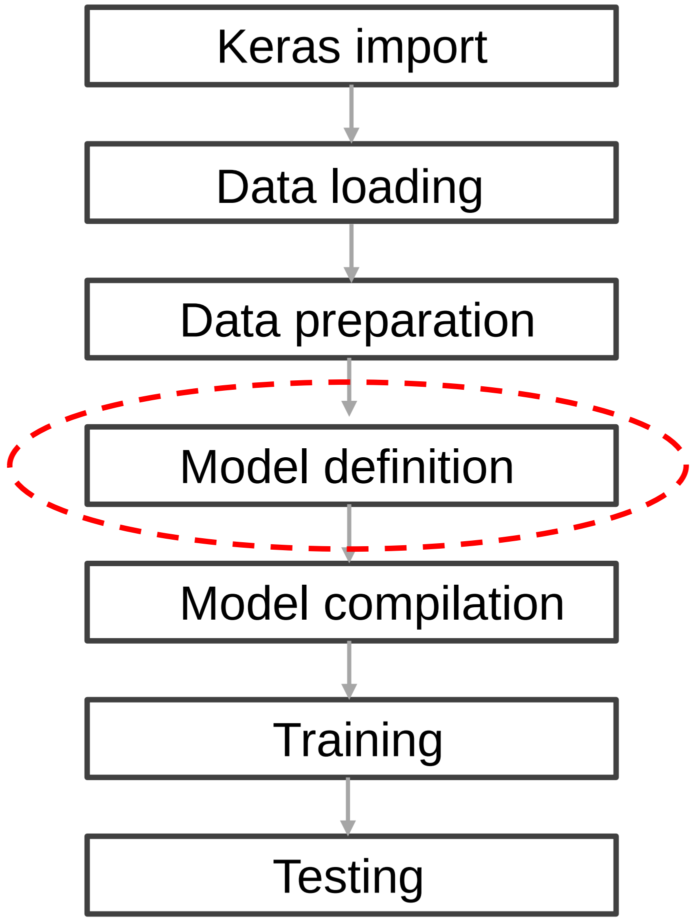
```
from tf.keras.preprocessing.image import ImageDataGenerator
```

- Create proper ImageDataGenerator instance

```
myDatagen = ImageDataGenerator(
    rotation_range=0,
    width_shift_range=0.1,
    height_shift_range=0.1,
    horizontal_flip=True,
    vertical_flip=False
)
```

- Can optionally normalize data for you
  - Must fit generator to your data if normalization used!
- Further steps required during training
  - Detailed later

Typical Keras Dataflow



Model definition – Binary Classifier

- Import keras modules

```
from keras.models import Sequential
from keras.layers import Input, Dense, Activation
```

- Use the *sequential* API

```
model = Sequential()
```

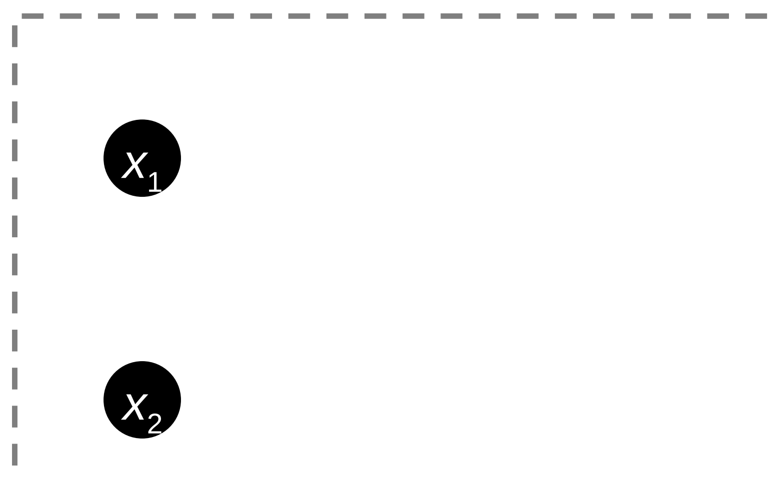
Model definition – Binary Classifier

- Import keras modules

```
from keras.models import Sequential
from keras.layers import Input, Dense, Activation
```

- Use the *sequential* API

```
model = Sequential()
model.add(Input(shape=(2,)))
```



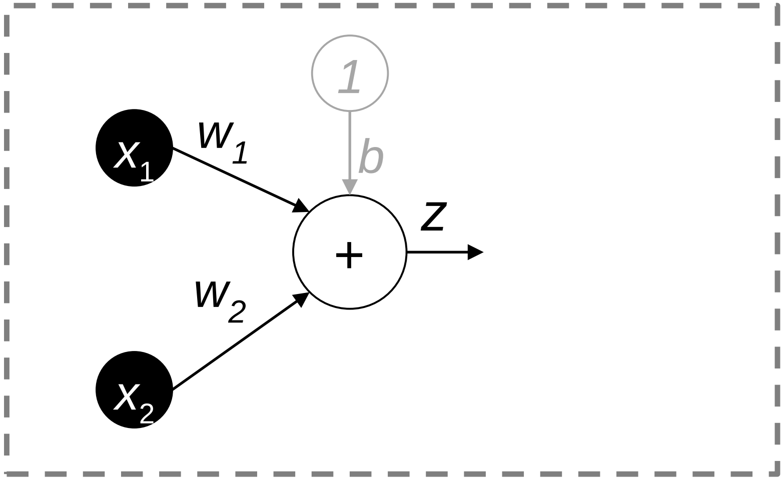
Model definition – Binary Classifier

- Import keras modules

```
from keras.models import Sequential
from keras.layers import Input, Dense, Activation
```

- Use the *sequential* API

```
model = Sequential()
model.add(Input(shape=(2,)))
model.add(Dense(units=1))
```



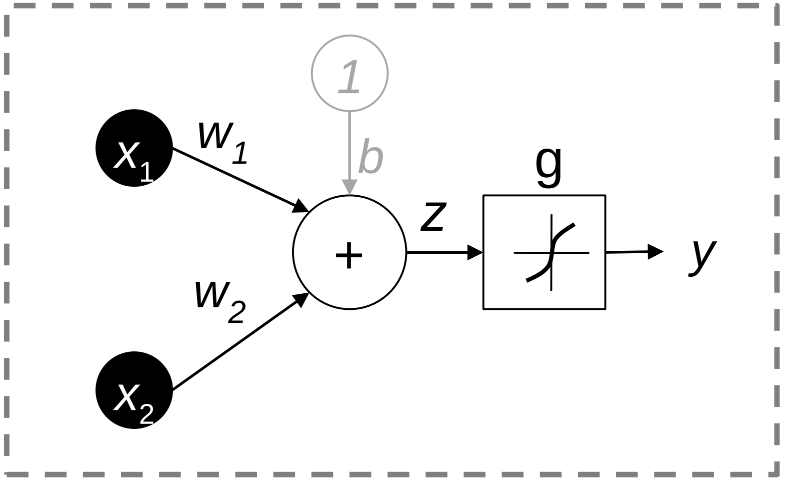
Model definition – Binary Classifier

- Import keras modules

```
from keras.models import Sequential
from keras.layers import Input, Dense, Activation
```

- Use the *sequential* API

```
model = Sequential()
model.add(Input(shape=(2,)))
model.add(Dense(units=1))
model.add(Activation('sigmoid'))
```



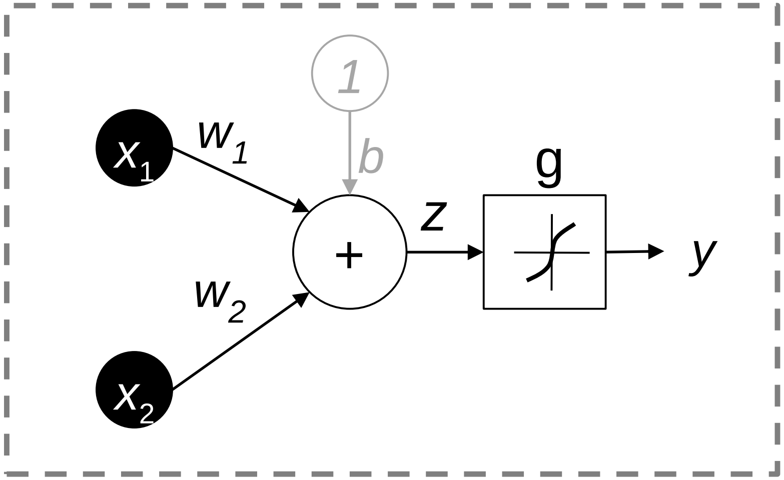
Model definition – Binary Classifier

- Import keras modules

```
from keras.models import Sequential
from keras.layers import Input, Dense, Activation
```

- Use the *sequential* API

```
model = Sequential()
model.add(Input(shape=(2,)))
model.add(Dense(units=1,
                activation='sigmoid'))
```



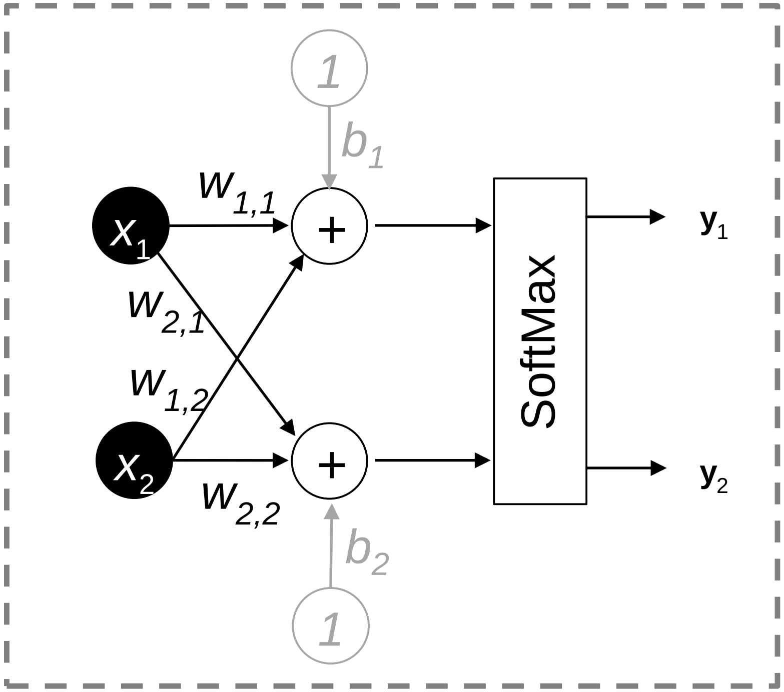
Model definition – Multiclass Classifier

- Import keras modules

```
from keras.models import Sequential
from keras.layers import Input, Dense, Activation
```

- Use the *sequential* API

```
model = Sequential()
model.add(Input(shape=(2,)))
model.add(Dense(units=2,
          activation='softmax'))
```



Model definition – Convolutional Layers

- Import keras modules

```
from keras.models import Conv2D, MaxPooling2D
```

- Convolutional layer with sigmoid activation and MaxPooling

```
model = Sequential()
model.add(Input(w,h,c))
model.add(Conv2D(filters=6,
                 kernel_size=(5,5),
                 padding=‘same',
                 data_format='channels_last‘))
model.add(Activation(‘sigmoid'))
Model.add(MaxPooling2D(pool_size=2)
```

- Serialize the feature maps into feature vectors

```
model.add(Flatten())
```

Model definition - Regularizers

- Implemented as layer parameters

```
from keras import regularizers
```

- L1 and L2 norm regularizers commonly used
- Apply individually to each layer

```
model = Sequential()

model.add(Dense(1000,
                kernel_regularizer=regularizers.l2(0.01),
                bias_regularizer=regularizers.l2(0.01)))

model.add(Activation(...)
model.add(Dense(10, ...))
model.add(Activation('softmax'))
```

Model definition - Dropout

- Implemented as a layer

```
from keras.models import Dropout
keras.layers.Dropout(rate, noise_shape=None, seed=None)
```

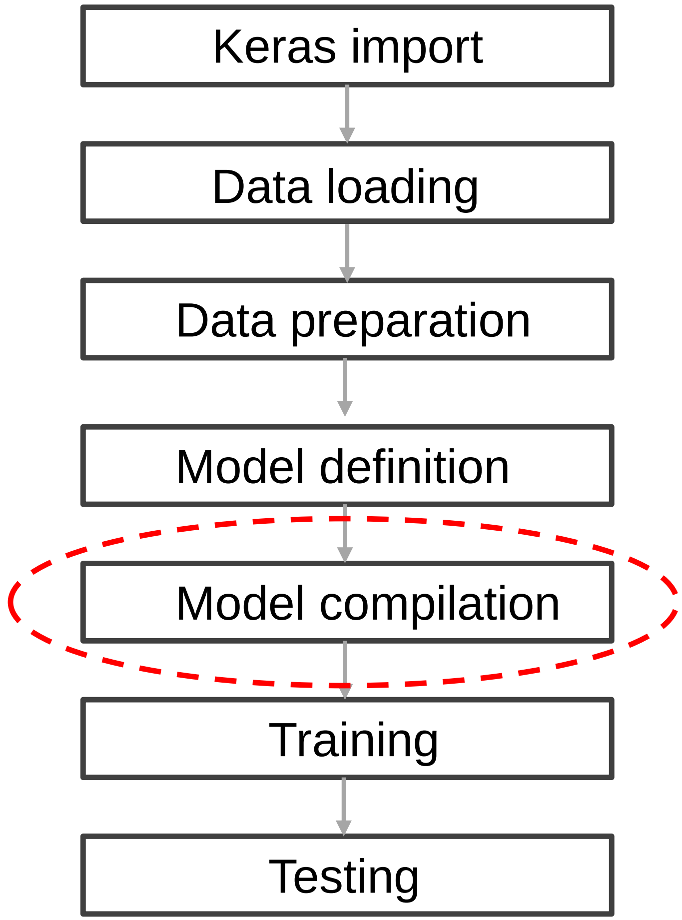
- Usually useful before most parametrized layer

```
model = Sequential()
model.add(Input(...))
model.add(Conv2D(...))
model.add(Activation(...))
model.add(MaxPooling2D(...)
model.add(Flatten())

model.add(Dropout(rate = 0.5)

model.add(Dense(1000))
model.add(Activation(...)
model.add(Dense(10, ...))
model.add(Activation('softmax'))
```

Typical Keras Dataflow



Model compilation – Binary Classifier

- Define an optimizer

```
myOpt = tf.keras.optimizers.SGD(learning_rate=0,01, decay=10e-6)
```

- Define loss (and performance) metric

```
model.compile(optimizer=myOpt, loss='binary_crossentropy',
              metrics=['accuracy'])
```

- **After** compiling the model, visualize it

```
model.summary()

_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense_1 (Dense)              (None, 1)                 3
=================================================================
Total params: 3
_________________________________________________________________
```

Model compilation – Multiclass Classifier

- Define an optimizer

```
myOpt = tf.keras.optimizers.SGD(learning_rate=0,01, decay=10e-6)
```

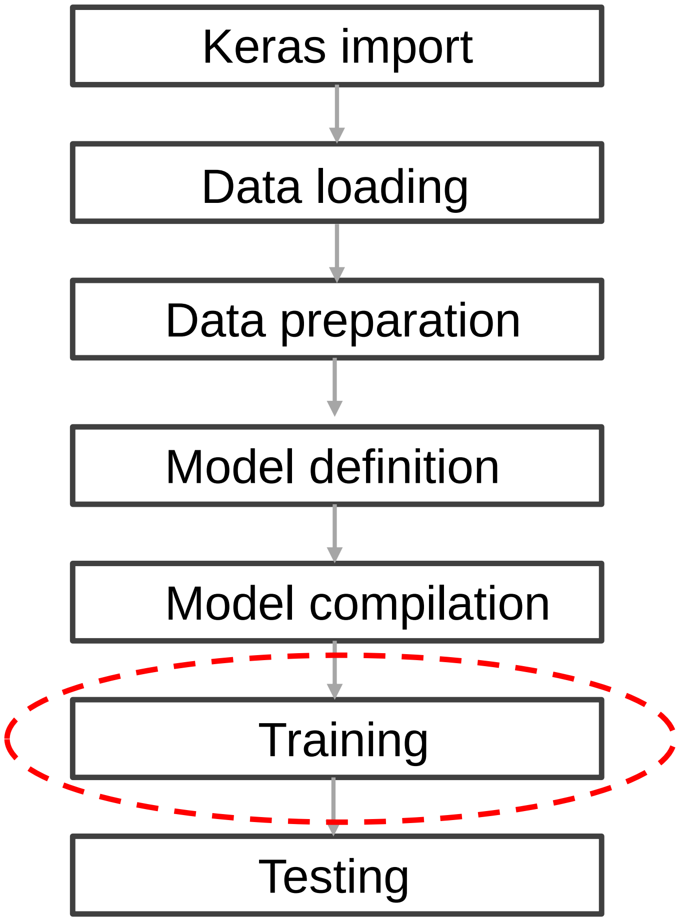
- Define loss (and performance) metric

```
model.compile(optimizer=myOpt, loss='categorical_crossentropy',[…])
```

- **After** compiling the model, visualize it

```
model.summary()
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense_1 (Dense)              (None, 2)                 6
=================================================================
Total params: 6
_________________________________________________________________
```

Typical Keras Dataflow



Training

- High-level fit() function

```
history = model.fit(x=train_data[firstSample:lastSample],
                    y=train_labels[firstSample:lastSample],
                    validation_data=(test_data, test_labels),
                    epochs=10,
                    batch_size=32,
                    shuffle=True,
                    verbose=0|1|2)
```

- Set verbose=1 to visualize this output

```
Epoch 1/100
100/100 [==============================] - 0s 2ms/step - loss: 0.9530 - acc: 0.5500
Epoch 2/100
100/100 [==============================] - 0s 94us/step - loss: 0.6889 - acc: 0.5700

                                             ...
Epoch 99/100
100/100 [==============================] - 0s 70us/step - loss: 0.0371 - acc: 1.0000
Epoch 100/100
100/100 [==============================] - 0s 67us/step - loss: 0.0369 - acc: 1.0000
```

- Train/Validation loss/accuracy logged in history

Training with data generators – fit_generator()

- High-level fit_generator() function

```
history = model.fit_generator(
        myDatagen.flow(train_data, train_labels, batch_size=32),
        steps_per_epoch = train_images.shape[0] / 32,
        validation_data=(test_data, test_labels),
        epochs=10,
        shuffle=True,
        verbose=1,
        workers=1
)
```

- Requires setting up a DataGenerator
  - required if you have a custom dataset
- Also validation_data could be augmented in principle
  - Typically only train data augmented

Training with data generators – train_on_batch()

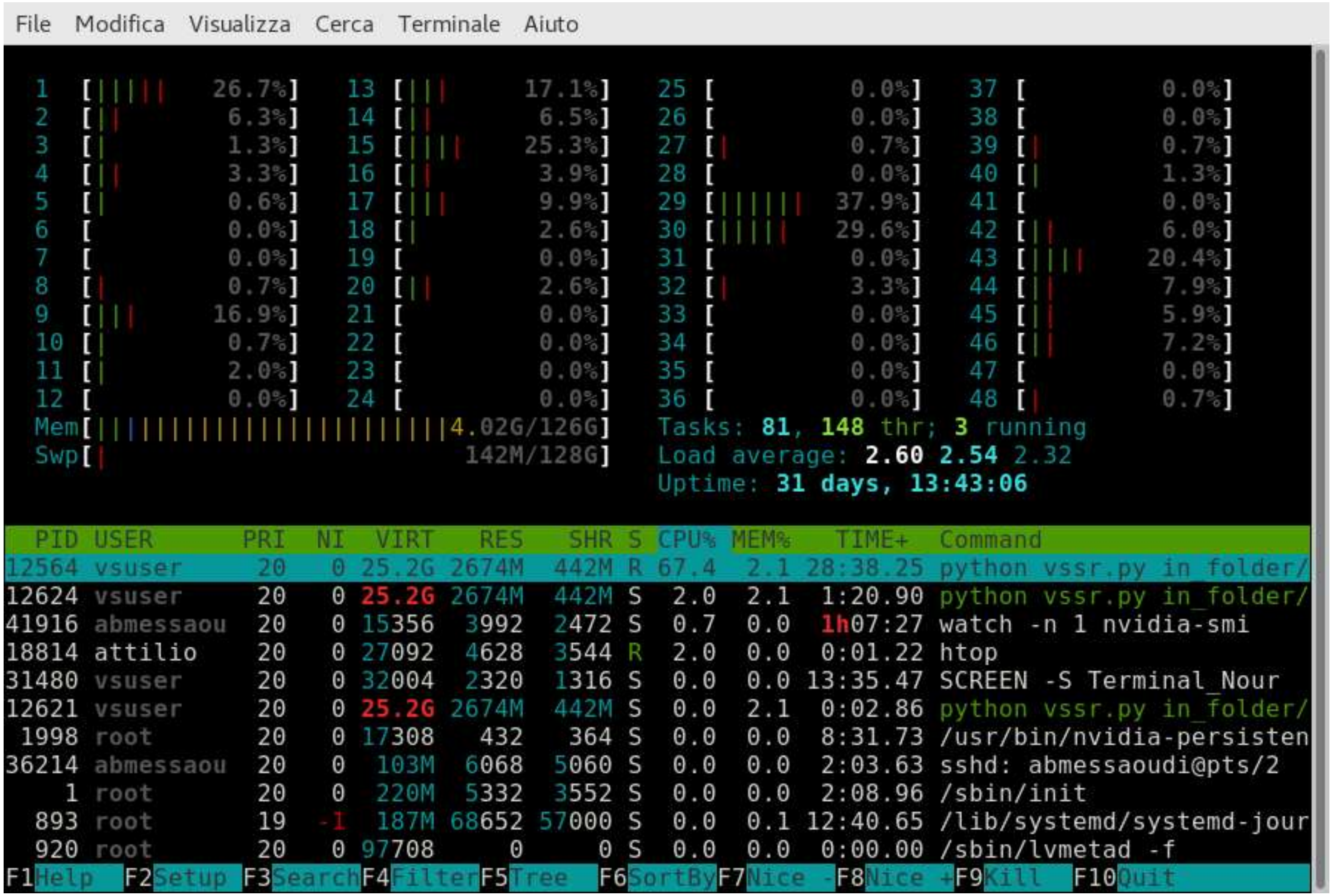
- Manually iterate over train/test batches

```
for e in range(numEpochs):
    # Loop over training samples in batches of 32 samples
    trainLoss = 0; trainBatches = 0
    for X_batch, Y_batch in
    datagenTrain.flow(train_data, train_labels, batch_size=32):
        trainLoss += model.train_on_batch(X_batch, Y_batch)
        trainBatches += 1
        if trainBatches >= len(X_train) / 32:
            break
    # Loop over testing samples in batches of 32 samples
    testLoss = 0; testBatches = 0
    for X_batch, Y_batch in
    datagenTest.flow(test_data, test_labels, batch_size=32):
        testLoss += model.test_on_batch(X_batch, Y_batch)
        testBatches += 1
        if testBatches >= len(X_test) / batchSize:
            break

    print ('Epoch' + str(e) +
         ' trainLoss ' +  str(trainLoss/trainBatches) +
         ' testLoss ' + str(testLoss/testBatches) )
```

Training - Monitoring

- Monitor the CPU usage via `htop`



Training - Monitoring

- Monitor the GPU usage via `nvidia-smi`

File Modifica Visualizza Cerca Terminale Aiuto

```
Every 1.0s: nvidia-smi                                   sun: Mon May 27 23:10:20 2019

Mon May 27 23:10:20 2019
+-----------------------------------------------------------------------------+
| NVIDIA-SMI 410.79       Driver Version: 410.79       CUDA Version: 10.0     |
|-------------------------------+----------------------+----------------------+
| GPU  Name        Persistence-M| Bus-Id        Disp.A | Volatile Uncorr. ECC |
| Fan  Temp  Perf  Pwr:Usage/Cap|         Memory-Usage | GPU-Util  Compute M. |
|===============================+======================+======================|
|   0  GeForce RTX 208...  On   | 00000000:18:00.0 Off |                  N/A |
| 28%   27C    P8    14W / 175W |     10MiB / 10989MiB |      0%      Default |
+-------------------------------+----------------------+----------------------+
|   1  GeForce RTX 208...  On   | 00000000:3B:00.0 Off |                  N/A |
| 28%   28C    P8    18W / 175W |     10MiB / 10989MiB |      0%      Default |
+-------------------------------+----------------------+----------------------+
|   2  GeForce RTX 208...  On   | 00000000:86:00.0 Off |                  N/A |
| 39%   66C    P2   169W / 175W |   2771MiB / 10989MiB |     87%      Default |
+-------------------------------+----------------------+----------------------+
|   3  GeForce RTX 208...  On   | 00000000:AF:00.0 Off |                  N/A |
| 28%   33C    P8     8W / 175W |     10MiB / 10989MiB |      0%      Default |
+-------------------------------+----------------------+----------------------+

+-----------------------------------------------------------------------------+
| Processes:                                                       GPU Memory |
|  GPU       PID   Type   Process name                             Usage      |
|=============================================================================|
|    2     12564      C   python                                      2761MiB |
+-----------------------------------------------------------------------------+
```

Training - Analysis

- Using matplotlib again

```
import matplotlib.pyplot as plt
```

- Plot the loss grpah

```
plt.figure()
plt.subplot(211)
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.ylabel('Loss')
plt.xlim(left=1, right=10)
plt.legend(['Train','Test'], loc='upper right')
plt.show()

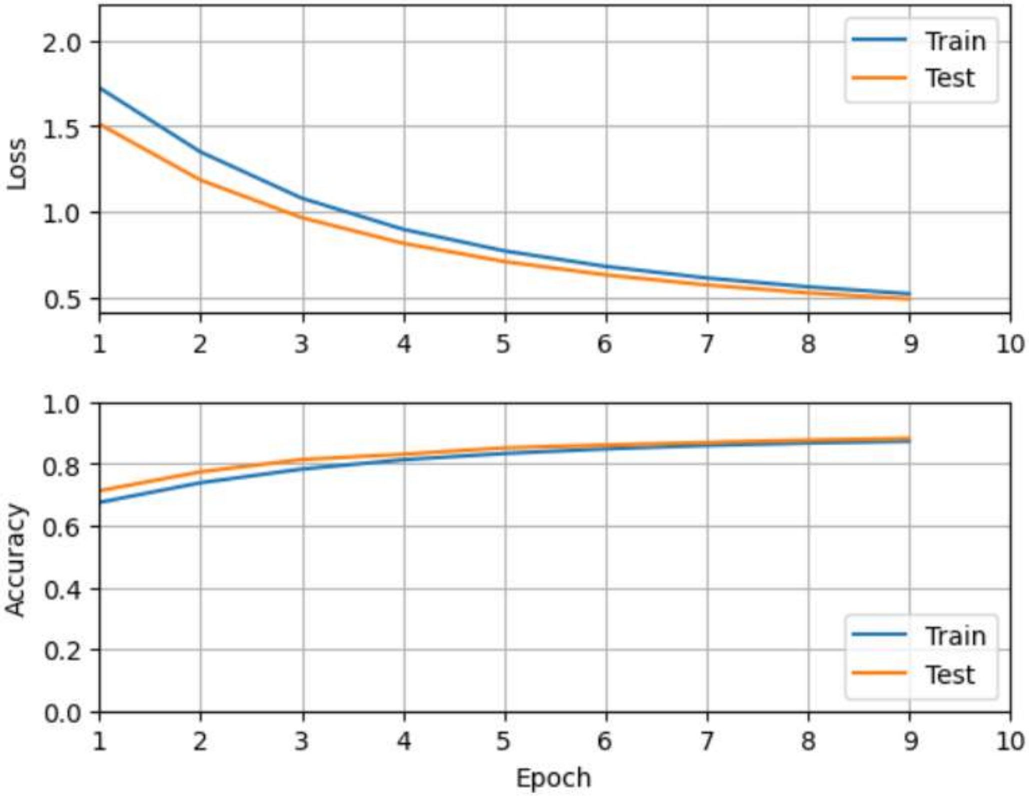
plt.subplot(212)
plt.grid(visible=True)
plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.ylabel('Accuracy')
plt.xlim(left=1, right=10); plt.ylim(top=1, bottom=0)
plt.xlabel('Epoch')
plt.legend(['Train', 'Test'], loc='lower right')
plt.show()
```

Training - Analysis

- Using matplotlib again

```
import matplotlib.pyplot as plt
```

- Plot the loss grpah



Training – Confusion Matrix

- Another courtesy of sklearn

```
from sklearn.metrics import confusion_matrix
```

- Which class is likely confused with which

```
predictions = model.predict(test_images)
matrix = confusion_matrix(test_labels.argmax(axis=1),
predictions.argmax(axis=1))
print (matrix)
```

```
[[ 950    0    1    5    1    7    8    1    5    2]
 [   0 1109    2    4    0    2    3    0   15    0]
 [   7    3  943   17   18    2   11   12   12    7]
 [   3    3   14  927    1   22    2   10   22    6]
 [   1    3    4    1  891    0   35    0    4   43]
 [  12    5    5   54   14  733   16    6   34   13]
 [  14    4    1    2   15    5  913    0    4    0]
 [   1   19   38    7    7    1    0  918    4   33]
 [  11    0    5   41   11   20   11    8  853   14]
 [   7    7    9    7   30    7    2   23   13  904]]
```

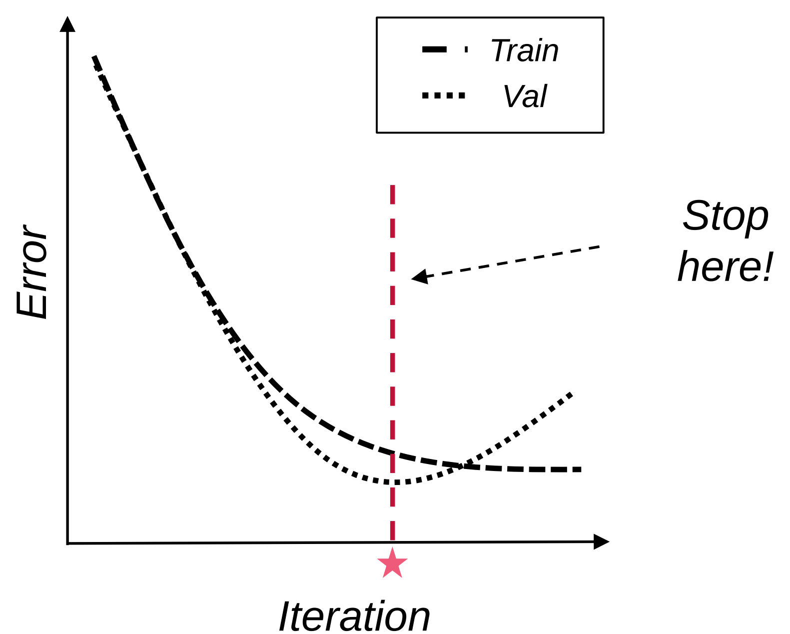
Training – Early Stop

- Useful functions for a variety of purposes

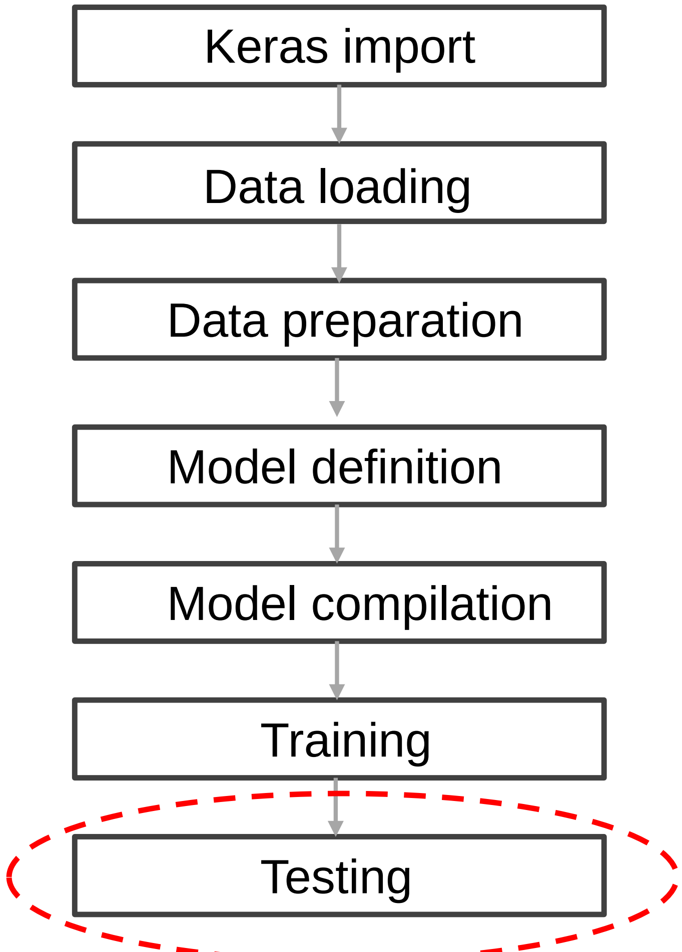
```
from keras.callbacks import EarlyStopping
```

- Ends training when validation loss stops decreasing

```
early_stopping = EarlyStopping(monitor='val_loss', patience=2)
model.fit([...], callbacks=[early_stopping])
```



Typical Keras Dataflow



Testing

- Left-out samples

```
score = model.evaluate(
          data_test[firstSample:lastSample],
          labels_test[firstSample:lastSample]
          )
```

Model Saving / Loading

- Let us save the trained model (topology + params)

```
import os
model_name = ‘trained_model.h5‘
model.save(model_path)
print('Saved trained model at ‘ + os.getcwd() + ‘/’ + model_path)
del(model)
```

- And let us load the trained model later on

```
from keras.models import load_model
model = load_model( ‘trained_model.h5‘)
```

- Save/load only the parameters

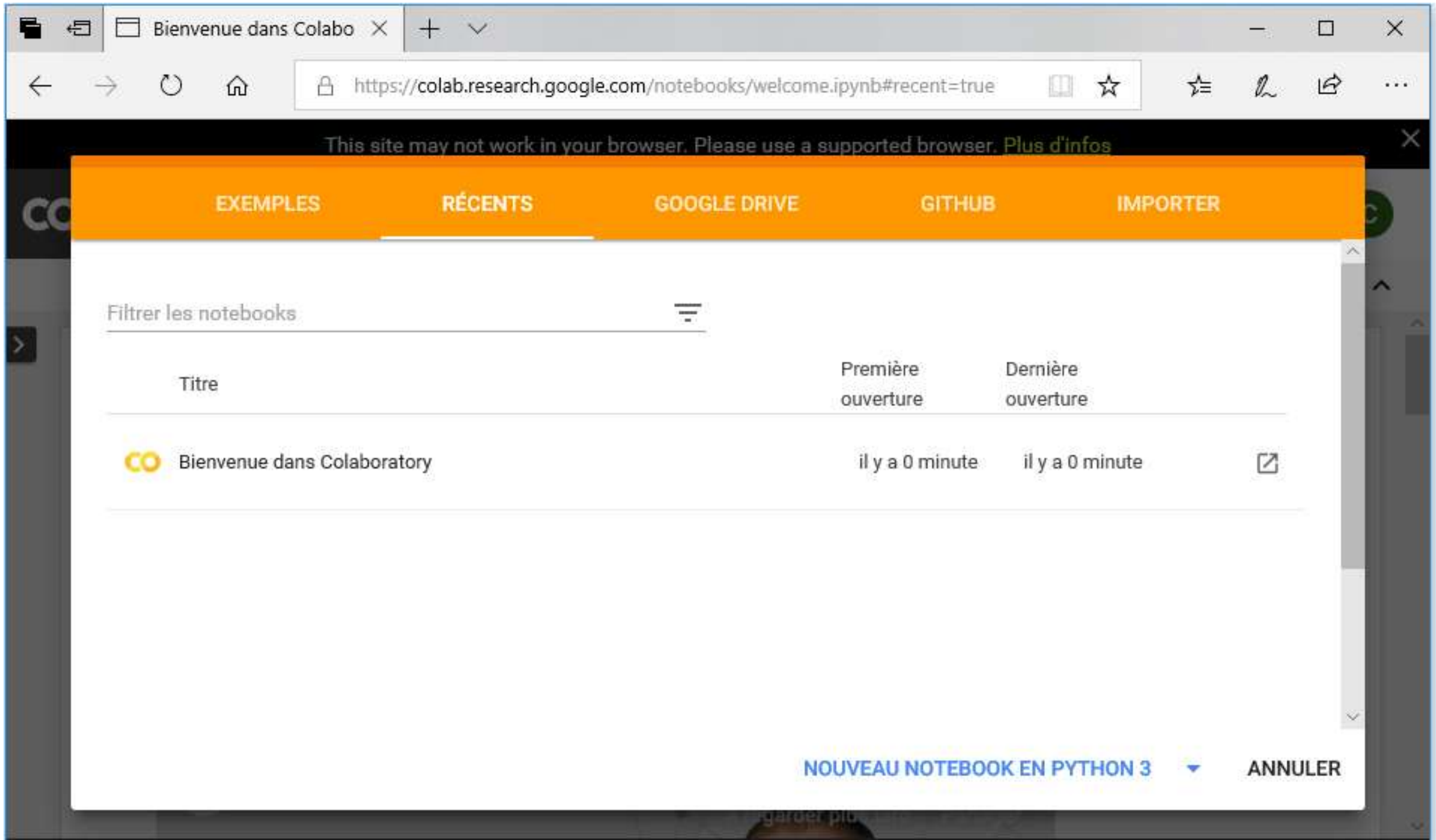
```
model.save_weights('my_model_weights.h5')

[...]

model.load_weights('my_model_weights.h5', by_name=True)
```

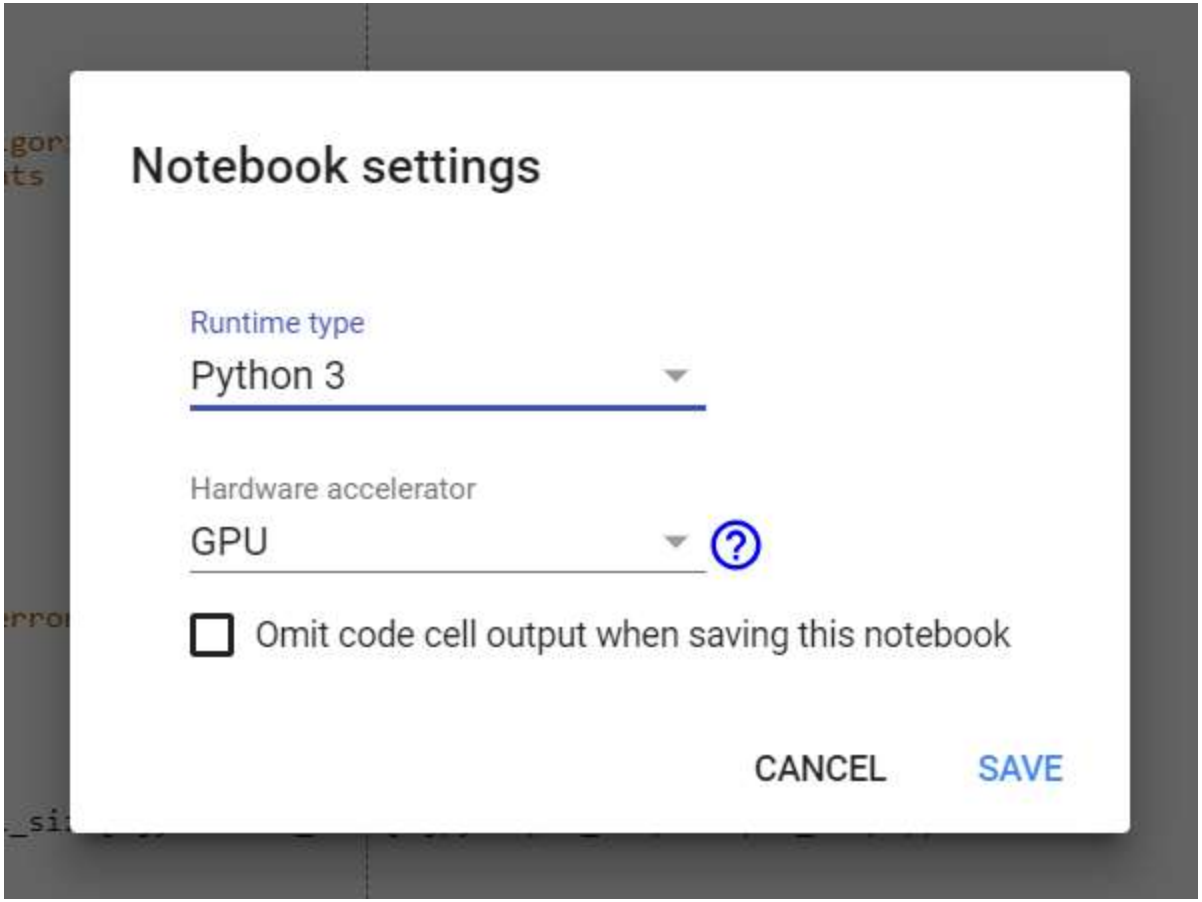
Google Colab

- Jupiter-like development environment



Google Colab

- If available, select a GPU-enabled VM («*runtime*»)
  - *Menu - Runtime – Change runtime type - GPU*



Colab Diagnostics

- Check which GPU you have available
  - «!» means system-level command (*bash*)

```
[ ]  !nvidia-smi
```

```
Wed Nov 21 13:29:39 2018
+-----------------------------------------------------------------------------+
| NVIDIA-SMI 396.44                 Driver Version: 396.44                    |
|-------------------------------+----------------------+----------------------+
| GPU  Name        Persistence-M| Bus-Id        Disp.A | Volatile Uncorr. ECC |
| Fan  Temp  Perf  Pwr:Usage/Cap|         Memory-Usage | GPU-Util  Compute M. |
|===============================+======================+======================|
|   0  Tesla K80           Off  | 00000000:00:04.0 Off |                    0 |
| N/A   35C    P0    68W / 149W |    649MiB / 11441MiB |      0%      Default |
+-------------------------------+----------------------+----------------------+

+-----------------------------------------------------------------------------+
| Processes:                                                       GPU Memory |
|  GPU       PID   Type   Process name                             Usage      |
|=============================================================================|
+-----------------------------------------------------------------------------+
```

Colab Diagnostics

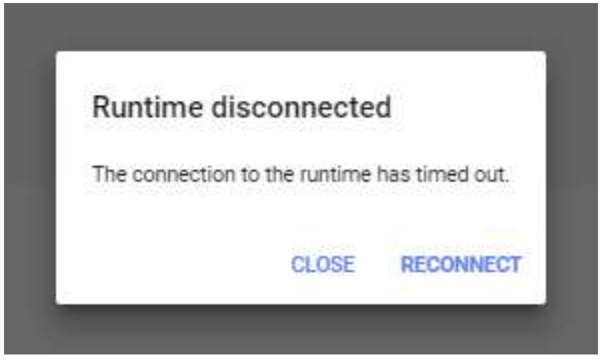
- Make sure Keras uses the *TensorFlow* backend
  - *«NHWC» data ordering required*

```
import keras
```

```
Using TensorFlow backend.
```

Preliminaries

- Do not let the terminal inactive to avoid disconnection
  - Loss of all session variables and data on filesystem



Exercises

1. Generate two linearly separable classes of points and train a simple sigmoid classifier
2. Generate two non linearly separable classes of points and find the simplest FCN capable to separate them

```
data, labels = datasets.make_moons(n_samples=1000, noise=0.05, random_state=0)
```

3. Find the projection of the input data to a linearly separable space using the above trained architecture