Saving a model to disk

To find out more on the Pima indian dataset challenge visit [Kaggle (https://www.kaggle.com/uciml/pima-indians-diabetes-database/home)](https://www.kaggle.com/uciml/pima-indians-diabetes-database/home)

This dataset is originally from the National Institute of Diabetes and Digestive and Kidney Diseases.
The objective of the dataset is to diagnostically predict whether or not a patient has diabetes, based on certain diagnostic measurements included in the dataset.
Several constraints were placed on the selection of these instances from a larger database. In particular, all patients here are females at least 21 years old of Pima Indian heritage.

In [1]:

```
import pandas as pd # for reading the csv file
import matplotlib.pyplot as plt # for plotting graphs
import numpy as np # for numerical manipulation
```

In [2]:

```
diabetes_csv = pd.read_csv("diabetes.csv") # for reading csv files
```

In [3]:

```
%pylab inline
"""
-> this is a magic function
-> this is an Ipython command, that allows graphs to be embedded in the notebook.
-> %matplotlib, %pyplot and %pylab wotk the same way only that %pylab imports all neede
d
   libraries for graphing using matplotlib
"""
```

```
Populating the interactive namespace from numpy and matplotlib
```

Out[3]:

```
'\n-> this is a magic function\n-> this is an Ipython command, that allows
graphs to be embedded in the notebook.\n-> %matplotlib, %pyplot and %pylab
wotk the same way only that %pylab imports all needed \n   libraries for g
raphing using matplotlib\n'
```

In [4]:

```
dataset = diabetes_csv # assigning the csv to the dataset variable
```

In [5]:

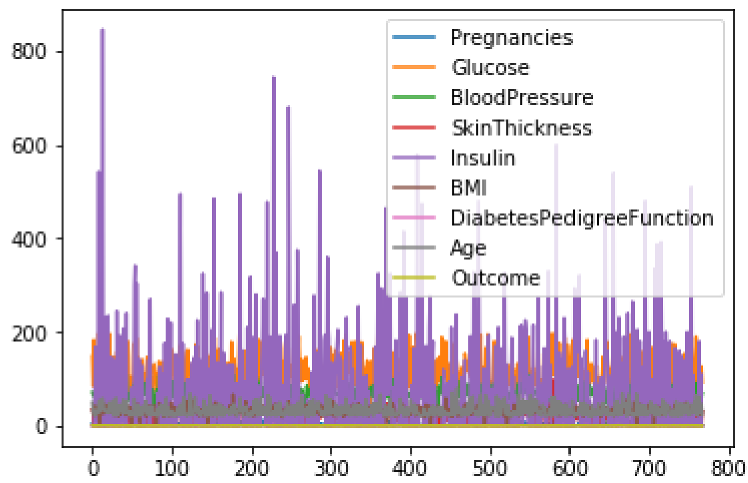
```
dataset.head() # prints the first 5 rows of our csv
```

Out[5]:

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	DiabetesPedig
0	6	148	72	35	0	33.6	0.627
1	1	85	66	29	0	26.6	0.351
2	8	183	64	0	0	23.3	0.672
3	1	89	66	23	94	28.1	0.167
4	0	137	40	35	168	43.1	2.288

In [6]:

```
dataset.plot() # this is for plotting our csv data
plt.show() # for plotting in the notebook though it can be oittmed because %pylab inlin
e
```



Fix random seed for reproducibility

In [7]:

```
# setting a random seed ensures reproducibility of the results
seed = 7
np.random.seed(seed)
```

In [8]:

```
dataset.shape # shows the number of rows and colums
```

Out[8]:

(768, 9)

In [9]:

```
dataset.dtypes # shows the data types
```

Out[9]:

```
Pregnancies                   int64
Glucose                       int64
BloodPressure                 int64
SkinThickness                 int64
Insulin                       int64
BMI                         float64
DiabetesPedigreeFunction    float64
Age                           int64
Outcome                       int64
dtype: object
```

In [10]:

```
# descriptions, change precision to 3 decimal places
pd.set_option('precision', 3)
```

In [11]:

```
pd.set_option('display.width', 200)
```

In [12]:

```
dataset.describe()
```

Out[12]:

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	Di
count	768.000	768.000	768.000	768.000	768.000	768.000	76
mean	3.845	120.895	69.105	20.536	79.799	31.993	0.
std	3.370	31.973	19.356	15.952	115.244	7.884	0.
min	0.000	0.000	0.000	0.000	0.000	0.000	0.
25%	1.000	99.000	62.000	0.000	0.000	27.300	0.
50%	3.000	117.000	72.000	23.000	30.500	32.000	0.
75%	6.000	140.250	80.000	32.000	127.250	36.600	0.
max	17.000	199.000	122.000	99.000	846.000	67.100	2.

In [13]:

```
# class distribution
dataset.groupby('Outcome').size() # lets you know how many values are assigned for each
 variable 0 or 1
```

Out[13]:

```
Outcome
0    500
1    268
dtype: int64
```

In [14]:

```
# correlation
dataset.corr(method='pearson')
```

Out[14]:

	Pregnancies	Glucose	BloodPressure	SkinThickness
Pregnancies	1.000	0.129	0.141	-0.082
Glucose	0.129	1.000	0.153	0.057
BloodPressure	0.141	0.153	1.000	0.207
SkinThickness	-0.082	0.057	0.207	1.000
Insulin	-0.074	0.331	0.089	0.437
BMI	0.018	0.221	0.282	0.393
DiabetesPedigreeFunction	-0.034	0.137	0.041	0.184
Age	0.544	0.264	0.240	-0.114
Outcome	0.222	0.467	0.065	0.075

In [15]:

```
dataset.head(10)
```

Out[15]:

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	DiabetesPedi
0	6	148	72	35	0	33.6	0.627
1	1	85	66	29	0	26.6	0.351
2	8	183	64	0	0	23.3	0.672
3	1	89	66	23	94	28.1	0.167
4	0	137	40	35	168	43.1	2.288
5	5	116	74	0	0	25.6	0.201
6	3	78	50	32	88	31.0	0.248
7	10	115	0	0	0	35.3	0.134
8	2	197	70	45	543	30.5	0.158
9	8	125	96	0	0	0.0	0.232

Split into input (X) and output (Y) variables

In [16]:

```
# Prepare Data
array = dataset.values
X = array[:,0:8]
Y = array[:,8]
# spliting helps us map on our training set (X) to your target out come (Y)
```

Create DNN Model

In [17]:

```
import tensorflow as tf # importing tensorflow
from tensorflow import keras # importing keras from the tensorflow library to run any K
eras-compatible code
```

The `tf.keras` version in the latest TensorFlow release might not be the same as the latest keras version from PyPI (pip installation)

In [18]:

```
from keras.models import Sequential
from keras.layers import Dense
from keras.callbacks import ModelCheckpoint, EarlyStopping
from keras.models import model_from_json
import os
```

```
Using TensorFlow backend.
```

Explaining the imports

`from keras.models import Sequential`
In Keras, you assemble layers to build models. A model is (usually) a graph of layers.
The most common type of model is a stack of layers: the tf.keras.Sequential model.

`from keras.layers import Dense`
Just your regular densely-connected NN layer

`from keras.callbacks import ModelCheckpoint, EarlyStopping`
Callbacks are essentially a set of functions to be applied at different stages of the training procedure.
`ModelCheckpoint`- Save the model after every epoch.
`EarlyStopping`- Stop training when a monitored quantity has stopped improving.

`from keras.models import model_from_json`
to save a Keras model into a single HDF5 file which will contain:

```
-the architecture of the model, allowing to re-create the model
-the weights of the model
-the training configuration (loss, optimizer)
-the state of the optimizer, allowing to resume training exactly where you left
 off.
```

In [19]:

```
model = Sequential()

model.add(Dense(1024, input_dim=8, kernel_initializer='uniform', activation='relu'))

model.add(Dense(1024, kernel_initializer='uniform', activation='relu'))

model.add(Dense(1024, kernel_initializer='uniform', activation='relu'))

model.add(Dense(512, kernel_initializer='uniform', activation='relu'))

model.add(Dense(1, kernel_initializer='uniform', activation='sigmoid'))
```

Print the model sumarry

In [20]:

```
print(model.summary())
```

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
dense_1 (Dense)              (None, 1024)              9216      
_________________________________________________________________
dense_2 (Dense)              (None, 1024)              1049600   
_________________________________________________________________
dense_3 (Dense)              (None, 1024)              1049600   
_________________________________________________________________
dense_4 (Dense)              (None, 512)               524800    
_________________________________________________________________
dense_5 (Dense)              (None, 1)                 513       
=================================================================
Total params: 2,633,729
Trainable params: 2,633,729
Non-trainable params: 0
_________________________________________________________________
None
```

In [21]:

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

```
Wall time: 48 ms
```

In [22]:

```
# Save the model according to the conditions
checkpoint = ModelCheckpoint(filepath="diabetes.h5", monitor='acc', verbose=1, save_bes
t_only=True, save_weights_only=False, mode='auto', period=1)
"""
Save the model after every epoch.
monitor: quantity to monitor... either val_acc or val_loss
verbose: verbosity mode, 0 or 1.
save_best_only: if save_best_only=True, the latest best model according to the quantity
 monitored will not be overwritten.
mode: one of {auto, min, max}
    --> auto - will infer from the quantity to monitor
    --> min - is only used  when the monitor = 'val_loss'
    --> max - is only used when monitor = 'val_acc'
save_weights_only: if True, then only the model's weights will be saved
                   else, else the full model is saved
period: Interval (number of epochs) between checkpoints.
"""
model.save("diabetes.h5")

#early stopping in the event there is no improvement in val_acc
early = EarlyStopping(monitor='acc', min_delta=0, patience=10, verbose=1, mode='auto')
# patience is the number of epochs to stop if there no improvement
"""
Stop training when a monitored quantity has stopped improving.

monitor: quantity to be monitored.
min_delta: minimum change in the monitored quantity to qualify as an improvement,
           i.e. an absolute change of less than min_delta, will count as no improvemen
t.
patience: number of epochs with no improvement after which training will be stopped.
verbose: verbosity mode.
mode: one of {auto, min, max}.
    In min mode, training will stop when the quantity monitored has stopped decreasing;

    in max mode it will stop when the quantity monitored has stopped increasing;
    in auto mode, the direction is automatically inferred from the name of the monitore
d quantity.
"""
```

Out[22]:

```
'\nStop training when a monitored quantity has stopped improving.\n\nmonit
or: quantity to be monitored.\nmin_delta: minimum change in the monitored
quantity to qualify as an improvement,\n           i.e. an absolute change
of less than min_delta, will count as no improvement.\npatience: number of
epochs with no improvement after which training will be stopped.\nverbose:
verbosity mode.\nmode: one of {auto, min, max}. \n    In min mode, trainin
g will stop when the quantity monitored has stopped decreasing; \n    in m
ax mode it will stop when the quantity monitored has stopped increasing;
\n    in auto mode, the direction is automatically inferred from the name
of the monitored quantity.\n'
```

Fit the model

In [23]:

```
%%time
model.fit(X, Y, epochs=250, batch_size=10, callbacks = [checkpoint, early])
```

```
Epoch 1/250
768/768 [==============================] - 6s 7ms/step - loss: 5.6220 - ac
c: 0.6406

Epoch 00001: acc improved from -inf to 0.64063, saving model to diabetes.h
5
Epoch 2/250
768/768 [==============================] - 7s 9ms/step - loss: 5.6245 - ac
c: 0.6510

Epoch 00002: acc improved from 0.64063 to 0.65104, saving model to diabete
s.h5
Epoch 3/250
768/768 [==============================] - 5s 7ms/step - loss: 5.6245 - ac
c: 0.6510

Epoch 00003: acc did not improve from 0.65104
Epoch 4/250
768/768 [==============================] - 5s 7ms/step - loss: 5.6245 - ac
c: 0.6510

Epoch 00004: acc did not improve from 0.65104
Epoch 5/250
768/768 [==============================] - 5s 7ms/step - loss: 5.6245 - ac
c: 0.6510

Epoch 00005: acc did not improve from 0.65104
Epoch 6/250
768/768 [==============================] - 5s 7ms/step - loss: 5.6245 - ac
c: 0.6510

Epoch 00006: acc improved from 0.65104 to 0.65104, saving model to diabete
s.h5
Epoch 7/250
768/768 [==============================] - 5s 7ms/step - loss: 5.6245 - ac
c: 0.6510

Epoch 00007: acc improved from 0.65104 to 0.65104, saving model to diabete
s.h5
Epoch 8/250
768/768 [==============================] - 5s 7ms/step - loss: 5.6245 - ac
c: 0.6510

Epoch 00008: acc improved from 0.65104 to 0.65104, saving model to diabete
s.h5
Epoch 9/250
768/768 [==============================] - 5s 7ms/step - loss: 5.6245 - ac
c: 0.6510

Epoch 00009: acc did not improve from 0.65104
Epoch 10/250
768/768 [==============================] - 5s 7ms/step - loss: 5.6245 - ac
c: 0.6510

Epoch 00010: acc did not improve from 0.65104
Epoch 11/250
768/768 [==============================] - 5s 7ms/step - loss: 5.6245 - ac
c: 0.6510

Epoch 00011: acc did not improve from 0.65104
Epoch 12/250
```

```
768/768 [==============================] - 5s 7ms/step - loss: 5.6245 - ac
c: 0.6510

Epoch 00012: acc did not improve from 0.65104
Epoch 13/250
768/768 [==============================] - 5s 7ms/step - loss: 5.6245 - ac
c: 0.6510

Epoch 00013: acc did not improve from 0.65104
Epoch 14/250
768/768 [==============================] - 7s 9ms/step - loss: 5.6245 - ac
c: 0.6510

Epoch 00014: acc did not improve from 0.65104
Epoch 15/250
768/768 [==============================] - 7s 9ms/step - loss: 5.6245 - ac
c: 0.6510

Epoch 00015: acc did not improve from 0.65104
Epoch 16/250
768/768 [==============================] - 6s 7ms/step - loss: 5.6245 - ac
c: 0.6510

Epoch 00016: acc did not improve from 0.65104
Epoch 17/250
768/768 [==============================] - 6s 7ms/step - loss: 5.6245 - ac
c: 0.6510

Epoch 00017: acc did not improve from 0.65104
Epoch 18/250
768/768 [==============================] - 6s 7ms/step - loss: 5.6245 - ac
c: 0.6510

Epoch 00018: acc did not improve from 0.65104
Epoch 00018: early stopping
Wall time: 1min 44s
```

Out[23]:

```
<keras.callbacks.History at 0x1c8a34f6940>
```

Evaluate the model

In [24]:

```
scores = model.evaluate(X, Y)
print("%s: %.2f%%" % (model.metrics_names[1], scores[1]*100))
```

```
768/768 [==============================] - 0s 464us/step
acc: 65.10%
```

In [25]:

```
# serialize model to JSON
model_json = model.to_json()
with open("model.json", "w") as json_file:
    json_file.write(model_json)
# serialize weights to HDF5
model.save_weights("model.h5")
print("Saved model to disk")
```

```
Saved model to disk
```

In [26]:

```
# load json and create model
json_file = open('model.json', 'r')
loaded_model_json = json_file.read()
json_file.close()
loaded_model = model_from_json(loaded_model_json)

# load weights into new model
loaded_model.load_weights("model.h5")
print("Loaded model from disk")

# evaluate loaded model on test data
loaded_model.compile(loss='binary_crossentropy', optimizer='rmsprop', metrics=['accurac
y'])
score = loaded_model.evaluate(X, Y, verbose=0)
print("%s: %.2f%%" % (loaded_model.metrics_names[1], score[1]*100))
```

```
Loaded model from disk
acc: 65.10%
```

We can improve out model accuracy but point of the lecture today was

to teach how to save a model

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