Human Activity Recognition

February 3, 2019

```
In [1]: import numpy as np
        import pandas as pd
        import matplotlib.pyplot as plt
        import seaborn as sns
        from tabulate import tabulate
```

```
In [151]: plt.style.use('ggplot')
          %config InlineBackend.figure_format = 'retina'
          sns.set(rc={'figure.figsize':(10,6)})
```

```
In [3]: !gpustat
```

```
instance-gpu  Sat Feb  2 10:51:28 2019
[0] Tesla P100-PCIE-16GB | 39'C,   0 % |    82 / 16280 MB | root(82M)
```

```
In [4]: !ls
```

```
breast_cancer_1.csv  Human Activity Recognition.ipynb  UCI HAR Dataset
HAR_RAW_1.csv             nohup.out                              UCI HAR Dataset.names
```

```
In [5]: !ls "UCI HAR Dataset"/"train"/"Inertial Signals"
```

```
body_acc_x_train.txt  body_gyro_x_train.txt  total_acc_x_train.txt
body_acc_y_train.txt  body_gyro_y_train.txt  total_acc_y_train.txt
body_acc_z_train.txt  body_gyro_z_train.txt  total_acc_z_train.txt
```

```
In [6]: %%sh
        head -n 1 "UCI HAR Dataset"/"train"/"Inertial Signals"/body_acc_x_train.txt | wc -w
```

```
128
```

```
In [7]: %%sh
        cat "UCI HAR Dataset"/"train"/y_train.txt | wc -l
        cat "UCI HAR Dataset"/"test"/y_test.txt | wc -l
```

```
7352
2947
```

0.0.1 Preparing the dataset

```
In [8]: SIGNALS = [
            'body_acc_x',
            'body_acc_y',
            'body_acc_z',
            'body_gyro_x',
            'body_gyro_y',
            'body_gyro_z',
            'total_acc_x',
            'total_acc_y',
            'total_acc_z'
        ]
```

```
In [9]: def get_data(subset, part, oneHotEncoded=True):
            if part == 'features':
                all_signals = []
                for signal in SIGNALS:
                    all_signals.append(np.genfromtxt(
                        "UCI HAR Dataset/{}/Inertial Signals/{}_{}.txt".format(subset, signal, s
                return np.transpose(all_signals, (1, 2, 0))
            elif part == 'labels':
                y = np.genfromtxt("UCI HAR Dataset/{s}/y_{s}.txt".format(s=subset))
                if oneHotEncoded:
                    return pd.get_dummies(y).values
                return y
```

```
In [10]: %%time
         X_train = get_data(subset='train', part='features')
         X_test = get_data(subset='test', part='features')
```

```
CPU times: user 8.35 s, sys: 626 ms, total: 8.98 s
Wall time: 8.98 s
```

```
In [11]: %%time
         y_train = get_data(subset='train', part='labels')
         y_test = get_data(subset='test', part='labels')
```

```
CPU times: user 32.2 ms, sys: 3.15 ms, total: 35.3 ms
Wall time: 33.2 ms
```

```
In [12]: X_train.shape
```

```
Out[12]: (7352, 128, 9)
```

```
In [13]: X_test.shape
```

```
Out[13]: (2947, 128, 9)
```

```
In [14]: y_train.shape
```

```
Out[14]: (7352, 6)
```

```
In [15]: y_test.shape
```

```
Out[15]: (2947, 6)
```

0.0.2 Building a LSTM structure

```
In [16]: X_train.shape[1:]
```

```
Out[16]: (128, 9)
```

```
In [17]: from keras.layers import LSTM, Dropout, Dense
         from keras.models import Sequential
```

```
Using TensorFlow backend.
```

```
In [18]: from talos import live
         import talos
```

```
In [23]: def get_best_lstm_model(x_train, y_test, x_val, y_val, params):

             timesteps, data_point_size = X_train.shape[1:]
             n_classes = y_train.shape[1]

             model = Sequential()

             model.add(LSTM(units=params['first_neuron'],
                            input_shape=(timesteps, data_point_size)))
             model.add(Dropout(rate=params['dropout']))

             model.add(Dense(n_classes, activation='softmax'))

             model.compile(optimizer=params['optimizer'],
                           loss=params['losses'],
                           metrics=['accuracy'])

             history = model.fit(x_train, y_train,
                                 validation_data=[x_val, y_val],
                                 batch_size=params['batch_size'],
                                 callbacks=[live()],
                                 epochs=params['epochs'],
                                 verbose=2)

             return history, model
```

```
In [24]: y_train.shape[1]
```

```
Out[24]: 6
```

```
In [25]: params = {
             'optimizer': ['Adam'],
             'losses': ['binary_crossentropy'],
             'first_neuron': [16, 32, 64],
             'batch_size': [16],
             'epochs': [20],
             'dropout': [0.3, 0.5, 0.7]
         }
```

```
In [148]: get_ipython().run_line_magic('matplotlib', 'inline')
```

0.0.3 Randomised GridSearch with one layer LSTM

```
In [ ]: # The ouput of this cell has been omitted because it
        # the connection from the jupyter server is broken due to
        # poor internet connections.

        # This code runs for almost 6 hours on my GPU (Nvidia Titan XP)
        t = talos.Scan(x=X_train, y=y_train,
                  x_val=X_test, y_val=y_test,
                  model=get_best_lstm_model,
                  params=params, search_method='random',
                  shuffle=True, dataset_name='HAR_RAW',
                  experiment_no='1', seed=42)
```

```
In [31]: t.details
```

```
Out[31]: complete_time            02/02/19/16:10
         experiment_name                HAR_RAW_1
         grid_downsample                     None
         random_method          uniform_mersenne
         reduce_loss                        False
         reduction_interval                    50
         reduction_method                    None
         reduction_metric                 val_acc
         reduction_threshold                  0.2
         reduction_window                      20
         x_shape                   (7352, 128, 9)
         y_shape                        (7352, 6)
         dtype: object
```

```
In [35]: print('We have fit {} number of models'.format(len(t.saved_models)))
```

```
We have fit 9 number of models
```

```
In [100]: epoch_results = t.data.drop(['losses', 'optimizer',
                             'epochs', 'batch_size', 'round_epochs'], axis=1)
```

```
          epoch_results['val_loss'] = epoch_results.val_loss.astype(float, inplace=True)
          epoch_results['loss'] = epoch_results.loss.astype(float, inplace=True)
          epoch_results['val_acc'] = epoch_results.val_acc.astype(float, inplace=True)
          epoch_results['acc'] = epoch_results.acc.astype(float, inplace=True)
          epoch_results.sort_values(by='val_acc', ascending=False, inplace=True)
          columns = ['Val Loss', 'Train Loss',
                          'Val Accuracy', 'Train Accuracy',
                          'LSTM cells', 'Dropout']
```

```
In [101]: print(tabulate(epoch_results.values,
                         headers=columns,
                         tablefmt='fancy_grid'))
```

```
   Val Loss     Train Loss    Val Accuracy    Train Accuracy    LSTM cells    Dropout

  0.0829701      0.0447081        0.971044          0.982567            64        0.3

  0.0801187      0.0529833        0.96816           0.979529            64        0.5

  0.0936313      0.0711846        0.967255          0.976356            64        0.7

  0.107525       0.0581586        0.96488           0.978963            32        0.5

  0.113176       0.0646532        0.961769          0.97792             32        0.3

  0.132993       0.080815         0.960355          0.97257             32        0.7

  0.139463       0.134935         0.956566          0.948699            16        0.3

  0.136943       0.116637         0.954021          0.95287             16        0.5

  0.175511       0.182294         0.919692          0.914558            16        0.7
```

```
In [102]: r = talos.Reporting(t)
```

```
In [115]: r.best_params()
```

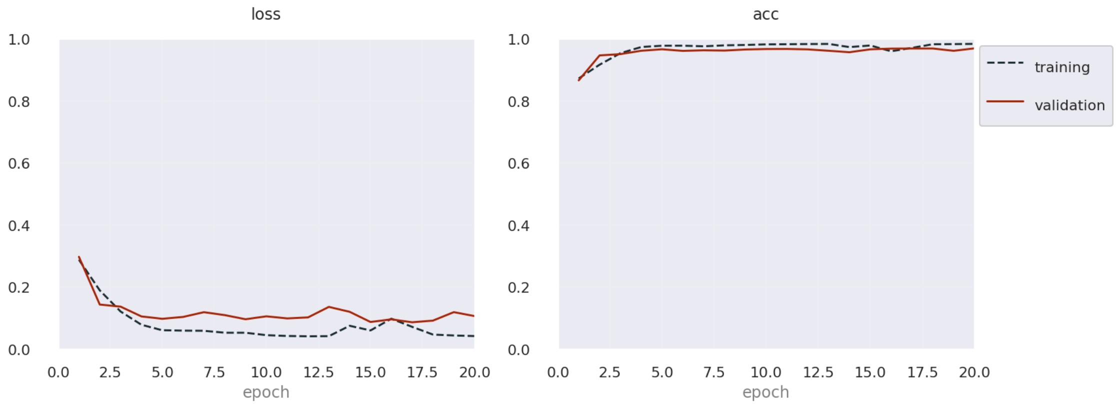
```
Out[115]: array([[3, '20', '64', 'binary_crossentropy', 'Adam', '16', '0.3', 0],
                 [7, '20', '64', 'binary_crossentropy', 'Adam', '16', '0.5', 1],
                 [0, '20', '64', 'binary_crossentropy', 'Adam', '16', '0.7', 2],
                 [2, '20', '32', 'binary_crossentropy', 'Adam', '16', '0.5', 3],
                 [8, '20', '32', 'binary_crossentropy', 'Adam', '16', '0.3', 4],
                 [6, '20', '32', 'binary_crossentropy', 'Adam', '16', '0.7', 5],
                 [5, '20', '16', 'binary_crossentropy', 'Adam', '16', '0.3', 6],
                 [1, '20', '16', 'binary_crossentropy', 'Adam', '16', '0.5', 7],
                 [4, '20', '16', 'binary_crossentropy', 'Adam', '16', '0.7', 8]],
                dtype=object)
```

```
In [142]: # from keras.callbacks import Callback
          # from IPython.display import clear_output
```

```
In [143]: # Code Courtesy : https://gist.github.com/stared/dfb4dfaf6d9a8501cd1cc8b8cb806d2e

          # class PlotLearning(Callback):
          #     def on_train_begin(self, logs={}):
          #         self.i = 0
          #         self.x = []
          #         self.losses = []
          #         self.val_losses = []
          #         self.acc = []
          #         self.val_acc = []
          #         self.fig = plt.figure()

          #         self.logs = []

          #     def on_epoch_end(self, epoch, logs={}):

          #         self.logs.append(logs)
          #         self.x.append(self.i)
          #         self.losses.append(logs.get('loss'))
          #         self.val_losses.append(logs.get('val_loss'))
          #         self.acc.append(logs.get('acc'))
          #         self.val_acc.append(logs.get('val_acc'))
          #         self.i += 1
          #         f, (ax1, ax2) = plt.subplots(1, 2, sharex=True)

          #         clear_output(wait=True)

          #         ax1.set_yscale('log')
          #         ax1.plot(self.x, self.losses, label="loss")
          #         ax1.plot(self.x, self.val_losses, label="val_loss")
          #         ax1.legend()

          #         ax2.plot(self.x, self.acc, label="accuracy")
          #         ax2.plot(self.x, self.val_acc, label="validation accuracy")
          #         ax2.legend()

          #         plt.show();

          # plot = PlotLearning()
```

0.0.4 Randomised GridSearch with 2 layer GridSearch

```
In [149]: def get_best_lstm_model_2_layer(x_train, y_test, x_val, y_val, params):

              timesteps, data_point_size = X_train.shape[1:]
              n_classes = y_train.shape[1]

              model = Sequential()

              model.add(LSTM(units=params['first_neuron'],
                             input_shape=(timesteps, data_point_size),
                             return_sequences=True))
              model.add(Dropout(rate=params['dropout']))

              model.add(LSTM(units=params['first_neuron']))
              model.add(Dropout(rate=params['dropout']))

              model.add(Dense(n_classes, activation='softmax'))

              model.compile(optimizer=params['optimizer'],
                           loss=params['losses'],
                           metrics=['accuracy'])

              history = model.fit(x_train, y_train,
                                  validation_data=[x_val, y_val],
                                  batch_size=params['batch_size'],
                                  callbacks=[live()],
                                  epochs=params['epochs'],
                                  verbose=2)

              return history, model

In [147]: params = {
              'optimizer': ['Adam'],
              'losses': ['binary_crossentropy'],
              'first_neuron': [64],
              'batch_size': [16],
              'epochs': [20],
              'dropout': [0.3, 0.5]
          }

In [152]: t = talos.Scan(x=X_train, y=y_train,
                    x_val=X_test, y_val=y_test,
                    model=get_best_lstm_model_2_layer,
                    params=params, search_method='random',
                    shuffle=True, dataset_name='HAR_RAW',
                    experiment_no='2', seed=42)
```



```
100%|| 2/2 [2:21:02<00:00, 4233.94s/it]

Scan Finished!
```

```
In [153]: t.details
```

```
Out[153]: complete_time            02/02/19/20:30
          experiment_name                HAR_RAW_2
          grid_downsample                     None
          random_method          uniform_mersenne
          reduce_loss                        False
          reduction_interval                    50
          reduction_method                    None
          reduction_metric                 val_acc
          reduction_threshold                  0.2
          reduction_window                      20
          x_shape                    (7352, 128, 9)
          y_shape                        (7352, 6)
          dtype: object
```

```
In [154]: print('We have fit {} number of models'.format(len(t.saved_models)))

We have fit 2 number of models
```

```
In [155]: epoch_results = t.data.drop(['losses', 'optimizer',
                       'epochs', 'batch_size', 'round_epochs'], axis=1)
          epoch_results['val_loss'] = epoch_results.val_loss.astype(float, inplace=True)
          epoch_results['loss'] = epoch_results.loss.astype(float, inplace=True)
          epoch_results['val_acc'] = epoch_results.val_acc.astype(float, inplace=True)
          epoch_results['acc'] = epoch_results.acc.astype(float, inplace=True)
          epoch_results.sort_values(by='val_acc', ascending=False, inplace=True)
```

```
        columns = ['Val Loss', 'Train Loss',
                                'Val Accuracy', 'Train Accuracy',
                                'LSTM cells', 'Dropout']
```

```
In [156]: print(tabulate(epoch_results.values,
                         headers=columns,
                         tablefmt='fancy_grid'))
```

```
   Val Loss    Train Loss    Val Accuracy    Train Accuracy    LSTM cells    Dropout

  0.071176      0.037237         0.971553          0.983678            64        0.3

  0.0857582     0.0404991        0.969743          0.984313            64        0.5
```

```
In [157]: r = talos.Reporting(t)
```

```
In [158]: r.best_params()
```

```
Out[158]: array([['20', '64', 'binary_crossentropy', 'Adam', '16', '0.3', 0],
                 ['20', '64', 'binary_crossentropy', 'Adam', '16', '0.5', 1]],
                dtype=object)
```

0.0.5 Conclusion

- Talos is a wonderful library, a little buggy and difficult to get it perfect but reports many things and feels so native to GridSearchCV
- Dropouts are fitting the problem without much overfitting but this problem was computationally very expensive even on GPU
- Even 20 epochs seems more for the LSTMs. The problem is converging very soon within 15 epochs reminds me the power of LSTMs
- With LSTMs we are able to take the maximum validation acuuracy to staggering 97.2% which amazing thinking the fact that our Domain expert features are absent here. Means a person without haveing any domain expertise also can do wonder here.
- Building 2 layer LSTM structure didn't do much good but it took more time. Hence it seems better to stick to 1 layer sructure and looking at the number of training points it seems reasonable.
- One problems with talos is that it can parallelize a single model fit on GPU but can not parallelize all the model fits from GridSearch.