Brian_McKean_Stress_Management

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2 ===========

3 BioTrak Health

https://www.biotrakhealth.com/ ## Session Management ## Identify ineffective sessions during user trials # =========== ## Galvanize Data Science Immersion ## Capstone Project

First data exploration

```
In [1]: from docx import Document
        from docx.shared import Inches
        import pandas as pd
        import numpy as np
        import matplotlib.pyplot as plt
        from mpl_toolkits.axes_grid.parasite_axes import SubplotHost
        from mpl_toolkits.axes_grid1 import host_subplot
        import mpl_toolkits.axisartist as AA
        import seaborn as sns
        import requests
        import scipy.stats as stats
        from sklearn.ensemble import RandomForestClassifier
        from sklearn.model_selection import train_test_split
        from sklearn.metrics import precision_recall_curve
        from sklearn.externals import joblib
        from sklearn.model_selection import cross_val_score
        from sklearn.model_selection import cross_val_score
        from sklearn.metrics import precision_recall_curve
        from sklearn.ensemble import AdaBoostClassifier
        from sklearn.ensemble import GradientBoostingClassifier
```

3.1 Get Data from files

```
In [2]: # Read in data
        df_users = pd.read_json('users_02_26_2017.txt')
        df_sessions = pd.read_json('sessions_02_26_2017.txt')
        print df_users.columns
        print df_sessions.columns
```

```
Index([u'YOB', u'_id', u'email', u'first_name', u'gender', u'last_name',
       u'userid'],
      dtype='object')
Index([u'Build#', u'Device_info_id', u'End_GMT_time', u'End_local_time',
       u'GMT_Date', u'GMT_date', u'Local_date', u'Session_data_header',
       u'Session_name', u'Session_name:', u'Session_time_interval',
       u'Session_type', u'Start_GMT_time', u'Start_local_time',
       u'Start_time_zone', u'User_info_id', u'Version#', u'_id',
       u'session_data', u'user_info_id', u'userid'],
      dtype='object')
```

3.1.1 Initial Data Exploration

```
In [3]: print len(df_users), " users are set up"
        print len(df_sessions), "sessions are uploaded"
```

```
66  users are set up
356 sessions are uploaded
```

```
In [4]: # Read Ratings File
        df_ratings = pd.read_csv('data/ratings.csv')
        print "Number of ratings is ",len(df_ratings)
```

```
Number of ratings is  356
```

```
In [5]: print "Rated Bad:", df_ratings[df_ratings['rating']=='Bad'].count()
```

```
Rated Bad: Unnamed: 0     237
session_num    237
rating         237
dtype: int64
```

```
In [6]: print "Rated Good:",df_ratings[df_ratings['rating']=='Good'].count()
```

```
Rated Good: Unnamed: 0     119
session_num    119
rating         119
dtype: int64
```

```
In [7]: df_sessions = df_sessions.ix[:356,:]
```

Set up scoring After a review session the project firmware engineer and I graded 356 sessions. There were 237 bad and 119 good ratings. a

In addition to coming up with the ratings we jointly decided on some heuristics for determing a good and bad sessions

1. If the session was less than 60 seconds the session is bad. It is possible that a user may have an properly operating device over the 60 seconds, but we consider that not an effective use as there is not enough time to use the sessions as designed.
2. If the session, after 60 seconds, goes to 0 (Min) or 4095 (Max), the session is bad. Some of the sessions in this category show a significant amount of good data, but the fact that the user had problems idnicate someting that needs to be addressed.

- These two extremes indicate that an electrode has lost contact with the skin. Once a session has started the electrodes should continue to make proper contact until the end of the session.

3. Low signal values are not a problem.
4. Signal may be smooth with gradual peaks or there may be sharp peaks. The peaks come from activities such as jaw clenching that may be part of a session or may simply be the user exploring the operation of the device.

Add New Features In order to incororate the heuristics I add the following features

1. min_len (T/F) – is the length at least 3600 units (60 seconds)
2. pegged_L (T/F) – at least one value of 0 after 60 seconds
3. pegged_H (T/F) – at least one value of 4095 afte 60 seconds

```
In [8]: # add ratings to session data
        df_sessions['rating'] = df_ratings['rating']
```

```
In [9]: print df_sessions.columns
```

```
Index([                u'Build#',          u'Device_info_id',
                 u'End_GMT_time',          u'End_local_time',
                     u'GMT_Date',                u'GMT_date',
                   u'Local_date',   u'Session_data_header',
                 u'Session_name',          u'Session_name:',
         u'Session_time_interval',           u'Session_type',
               u'Start_GMT_time',       u'Start_local_time',
              u'Start_time_zone',           u'User_info_id',
                    u'Version#',                    u'_id',
                 u'session_data',           u'user_info_id',
                      u'userid',                u'rating'],
      dtype='object')
```

A litte data exploration

```
In [10]: df_sessions.Session_name.unique()

Out[10]: array([u'Open', u'Breathing for Relief', u'Head and Neck Relax',
                u'3 Minute Relax', u'Deep Breathing', u'Forest Visualization',
                u'Deep Relax for Sleep', u'Elevator Excercise',
                u'Beach Visualization', u'Cloud Visualization',
                u'Extended Exercise', u'Breath and Relax', u'Progress Muscle Relax'

In [11]: df_sessions.Session_type.unique()

Out[11]: array([u'open', u'managed'], dtype=object)

In [12]: df_groups = df_sessions.groupby('Session_name')

In [13]: df_groups['Device_info_id'].count()

Out[13]: Session_name
         3 Minute Relax            32
         Beach Visualization        9
         Breath and Relax           4
         Breathing for Relief      10
         Cloud Visualization        6
         Deep Breathing             6
         Deep Relax for Sleep       6
         Elevator Excercise         7
         Extended Exercise          1
         Forest Visualization       6
         Head and Neck Relax       10
         Open                     257
         Progress Muscle Relax      2
         Name: Device_info_id, dtype: int64

In [14]: df_results = df_sessions[['Session_name','userid']]

In [15]: # Score is True if session is bad
         # we are looking for bad sessions
         df_results['score'] = np.where(df_sessions['rating']=='Good', False, True)

/Users/brianmckean/anaconda2/lib/python2.7/site-packages/ipykernel/__main__.py:3: S
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/i
  app.launch_new_instance()
```

We have to change format for the time series data. It starts as a string of comma delimted values. The last value is uploaded incorrectly in some sessions so we discard it.

```
In [16]: # Pull session data dictionary info into it's own clumns
         dfNew = df_sessions.join(pd.DataFrame(df_sessions["session_data"].to_dict
In [17]: dfNew.columns
```

```
Out[17]: Index([               u'Build#',        u'Device_info_id',
                         u'End_GMT_time',        u'End_local_time',
                             u'GMT_Date',              u'GMT_date',
                           u'Local_date',   u'Session_data_header',
                         u'Session_name',         u'Session_name:',
                u'Session_time_interval',          u'Session_type',
                       u'Start_GMT_time',      u'Start_local_time',
                      u'Start_time_zone',          u'User_info_id',
                             u'Version#',                   u'_id',
                         u'session_data',          u'user_info_id',
                               u'userid',                u'rating',
                         u'average_data',    u'average_data_count',
                        u'baseline_data',         u'data_interval',
                           u'final_data',          u'graphed_data',
                   u'graphed_data_count',              u'raw_data',
                       u'raw_data_count'],
               dtype='object')
```

```
In [18]: # Start calculation of features
         # Convert session data from string to array of ints
         # -- Drop the last entry as there was a bug that put in a bad last entry
         temp = dfNew['average_data'].str.replace(" ","").str.split(',').str[:-1].m
```

```
In [19]: # Some of the time series are empty, if so insert an entry of one sample a
         # Signal is inverted -- need to change it
         temp = temp.map(lambda x: np.array( [0] if not len(x) else x ))
         temp = temp.map(lambda x: 4095 - x)
```

```
In [20]: # Get the mean
         temp2 = temp.map(lambda x: x.mean())
```

```
In [21]: temp2.fillna(0,inplace=True)
         df_results['avg_data_mean'] = temp2
```

```
/Users/brianmckean/anaconda2/lib/python2.7/site-packages/ipykernel/__main__.py:2: S
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/i
  from ipykernel import kernelapp as app
```

```
In [22]: # Get the max
         t_max = temp.map(lambda x: x.max())
```

```
In [23]: df_results['avg_data_max'] = t_max
```

```
/Users/brianmckean/anaconda2/lib/python2.7/site-packages/ipykernel/__main__.py:1: S
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/i
  if __name__ == '__main__':
```

```
In [24]: # Get the min
         df_results['avg_data_min'] = temp.map(lambda x: x.min())
```

```
/Users/brianmckean/anaconda2/lib/python2.7/site-packages/ipykernel/__main__.py:2: S
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/i
  from ipykernel import kernelapp as app
```

```
In [25]: # Get the length
         df_results['avg_data_len'] = temp.map(lambda x: len(x))
```

```
/Users/brianmckean/anaconda2/lib/python2.7/site-packages/ipykernel/__main__.py:2: S
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/i
  from ipykernel import kernelapp as app
```

```
In [26]: # Get the standard deviation
         df_results['avg_data_std'] = temp.map(lambda x: x.std())
```

```
/Users/brianmckean/anaconda2/lib/python2.7/site-packages/ipykernel/__main__.py:2: S
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/i
  from ipykernel import kernelapp as app
```

```
In [27]: df_results.columns
```

```
Out[27]: Index([ u'Session_name',        u'userid',         u'score', u'avg_data_me
                 u'avg_data_max',  u'avg_data_min',  u'avg_data_len',  u'avg_data_s
               dtype='object')
```

```
In [28]: # Load in session num
         df_results['session_num'] = df_results.index
```

```
/Users/brianmckean/anaconda2/lib/python2.7/site-packages/ipykernel/__main__.py:2: S
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/i
  from ipykernel import kernelapp as app
```

```
In [29]: # Add heuristics
         df_results['min_len'] = df_results['avg_data_len']>3600
         df_results['pegged_low'] = [False if (len(x)<3600 or min(x[3600:])>0) else
         df_results['pegged_high'] = [False if (len(x)<3600 or max(x[3600:])<4095)
```

```
/Users/brianmckean/anaconda2/lib/python2.7/site-packages/ipykernel/__main__.py:2: S
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/i
  from ipykernel import kernelapp as app
/Users/brianmckean/anaconda2/lib/python2.7/site-packages/ipykernel/__main__.py:3: S
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/i
  app.launch_new_instance()
/Users/brianmckean/anaconda2/lib/python2.7/site-packages/ipykernel/__main__.py:4: S
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/i
```

```
In [30]: df_results.columns

Out[30]: Index([ u'Session_name',        u'userid',         u'score', u'avg_data_me
                 u'avg_data_max',  u'avg_data_min',  u'avg_data_len',  u'avg_data_s
                  u'session_num',       u'min_len',    u'pegged_low',   u'pegged_hi
               dtype='object')
```

```
In [31]: df_key_columns = [x  for x in list(df_results.columns) if x not  in ['Sess
         print df_key_columns

['avg_data_mean', 'avg_data_max', 'avg_data_min', 'avg_data_len', 'avg_data_std', '
```

```
In [32]: df_res_save = df_results.copy()

In [33]: y = df_results['score'].as_matrix()
         X_df = df_results[df_key_columns]
         X = X_df.as_matrix()
```

```
In [34]: X_train, X_test, y_train, y_test = train_test_split(
             X, y, test_size=0.33, random_state=42)

In [35]: df_results.describe()

Out[35]:        avg_data_mean  avg_data_max  avg_data_min   avg_data_len  avg_data_
         count     356.000000    356.000000    356.000000     356.000000    356.000
         mean     2080.052353   3521.893258   1021.233146   13404.457865    602.631
         std       997.930074    883.259504   1220.579913   34697.181848    424.079
         min         0.000000      0.000000      0.000000       1.000000      0.000
         25%      1317.220337   3357.250000      0.000000    1152.000000    264.431
         50%      2090.857233   3901.000000    423.000000    3736.000000    508.647
         75%      2837.760875   4047.000000   1945.250000   13222.000000    939.515
         max      4095.000000   4095.000000   4095.000000  382019.000000   1667.963

                session_num
         count   356.000000
         mean    177.500000
         std     102.912584
         min       0.000000
         25%      88.750000
         50%     177.500000
         75%     266.250000
         max     355.000000

In [36]: clf = RandomForestClassifier(n_estimators=10, random_state=42).fit(X_train

In [37]: scores = cross_val_score(clf, X_train, y_train, cv=10)

In [38]: print scores
         print scores.mean()

[ 0.83333333  0.79166667  0.95833333  0.91666667  0.79166667  0.875
  0.95833333  0.875       0.82608696  0.82608696]
0.865217391304


In [39]: pred = clf.predict(X_train)

In [40]: print clf.feature_importances_

         for i in range(len(clf.feature_importances_)):
             print X_df.columns[i], clf.feature_importances_[i]

         clf_save = clf
         clf_name_save = X_df.columns
         X_save = X_df.as_matrix()

[ 0.07482741  0.05206467  0.09356981  0.28436927  0.10351105  0.08949767
  0.15199783  0.14889914  0.00126317]
```

```
avg_data_mean 0.074827409527
avg_data_max 0.0520646674285
avg_data_min 0.0935698076556
avg_data_len 0.284369266812
avg_data_std 0.10351104636
session_num 0.0894976678294
min_len 0.151997825363
pegged_low 0.148899139956
pegged_high 0.00126316906828
```

```
In [41]: pred_test = clf.predict(X_test)
```

```
In [42]: clf.score(X_test,y_test)
```

```
Out[42]: 0.92372881355932202
```

```
In [43]: clf.get_params
```

```
Out[43]: <bound method RandomForestClassifier.get_params of RandomForestClassifier
                     max_depth=None, max_features='auto', max_leaf_nodes=None,
                     min_impurity_split=1e-07, min_samples_leaf=1,
                     min_samples_split=2, min_weight_fraction_leaf=0.0,
                     n_estimators=10, n_jobs=1, oob_score=False, random_state=42,
                     verbose=0, warm_start=False)>
```

```
In [44]: y_prob = clf.predict_proba(X_test)[:,1:]
```

```
In [45]: missed = np.where([pred_test != y_test])[1]
```

```
In [46]: for idx in missed:
             print df_results.iloc[idx]['session_num']
```

```
10
20
29
56
64
67
71
88
115
```

```
In [47]: for i in range(len(missed)):
             print i, clf.predict_proba(X_test)[i]
```

```
0 [ 0.  1.]
1 [ 0.  1.]
2 [ 0.7  0.3]
```

```
3 [ 0.   1.]
4 [ 0.   1.]
5 [ 0.2  0.8]
6 [ 0.   1.]
7 [ 0.   1.]
8 [ 0.8  0.2]
```

```
In [ ]:
```

```
In [48]: precision, recall, thresholds = precision_recall_curve(y_test, y_prob)
```

```
In [49]: print precision, recall, thresholds
```

```
[ 0.75238095  0.84615385  0.90588235  0.94805195  0.97260274  1.          1.
  1.          1.          1.          1.        ] [ 1.          0.97468354  0.97468
  0.87341772  0.83544304  0.82278481  0.65822785  0.        ] [ 0.1  0.2  0.3  0.4
```

```
In [50]: df = pd.DataFrame()
```

```
In [51]: df['precision'] = precision
```

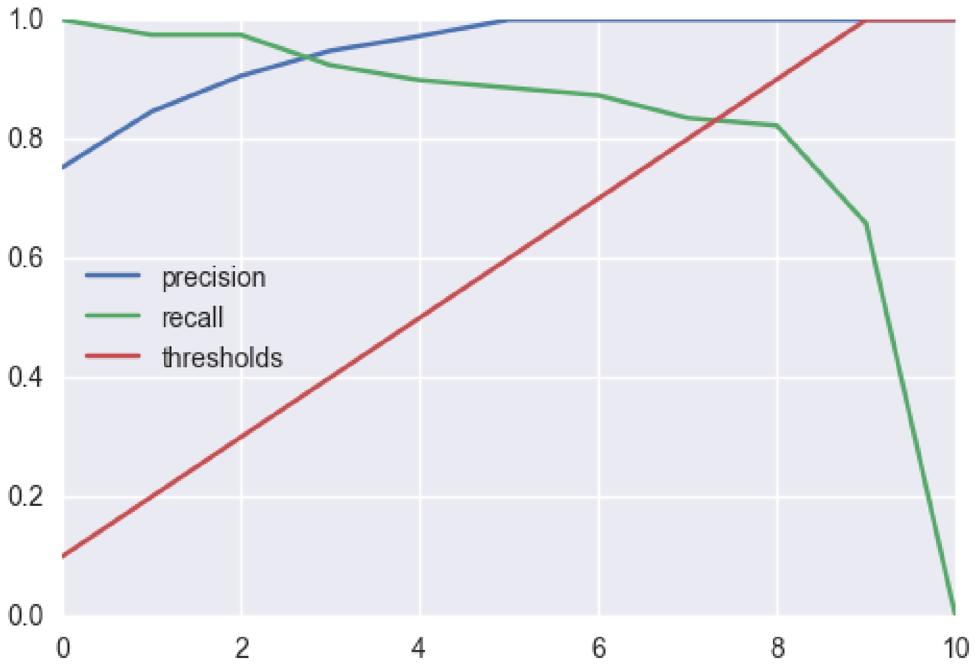
```
In [52]: print len(precision), len(recall), len(thresholds)
         thresholds = np.append(thresholds,1.0)
         print len(precision), len(recall), len(thresholds)
```

```
11 11 10
11 11 11
```

```
In [53]: df['recall'] = recall
         df['thresholds'] = thresholds
```

```
In [54]: %matplotlib inline
         df.plot()
```

```
Out[54]: <matplotlib.axes._subplots.AxesSubplot at 0x12e04b050>
```



```
In [55]: byScore = df_results.groupby('score').count()

In [56]: print byScore['avg_data_min']

score
False    119
True     237
Name: avg_data_min, dtype: int64


In [57]: ## Add in the cycles and largest swing features

         def count_crosses(s, pts=10, intv=600):
             '''
             Looks at series
             for each 'intv' points
             - count crossings of 'pts' lookback moving average
             INPUTS:
                 s = list of measurements
                 pts = how many pts to collect for moving average
                 intv = interval to measure crossing (600 = 10 sec)
             OUTPUTS
                 crossings / intv = average crossing per interval
                 biggest_move = on a crossing biggest move
```

```
    '''
    if len(s) < intv:
        return 0, 0
    if pts >= intv:
        return 0,0
    s = np.array(s)
    crossing_counts = [0]
    index = pts
    max_swing = 0
    up = True # True for last cross up, False for down
    while (index + intv < len(s)):
        #print index
        interval_crossings = 0
        for i in range(intv):
            last_n = s[index-pts:index]
            avg = last_n.mean()
            if up and s[index] < avg:
                up = False
                interval_crossings += 1
                swing = abs(s[index]-s[index-1])
                if swing > max_swing:
                    max_swing = swing
            if not up and s[index] > avg:
                up = True
                interval_crossings += 1
                swing = abs(s[index]-s[index-1])
                if swing > max_swing:
                    max_swing = swing
            index += 1
        crossing_counts.append(interval_crossings)

    time_sec = intv/60.0
    return np.array(crossing_counts).mean()/(2*time_sec), max_swing
```

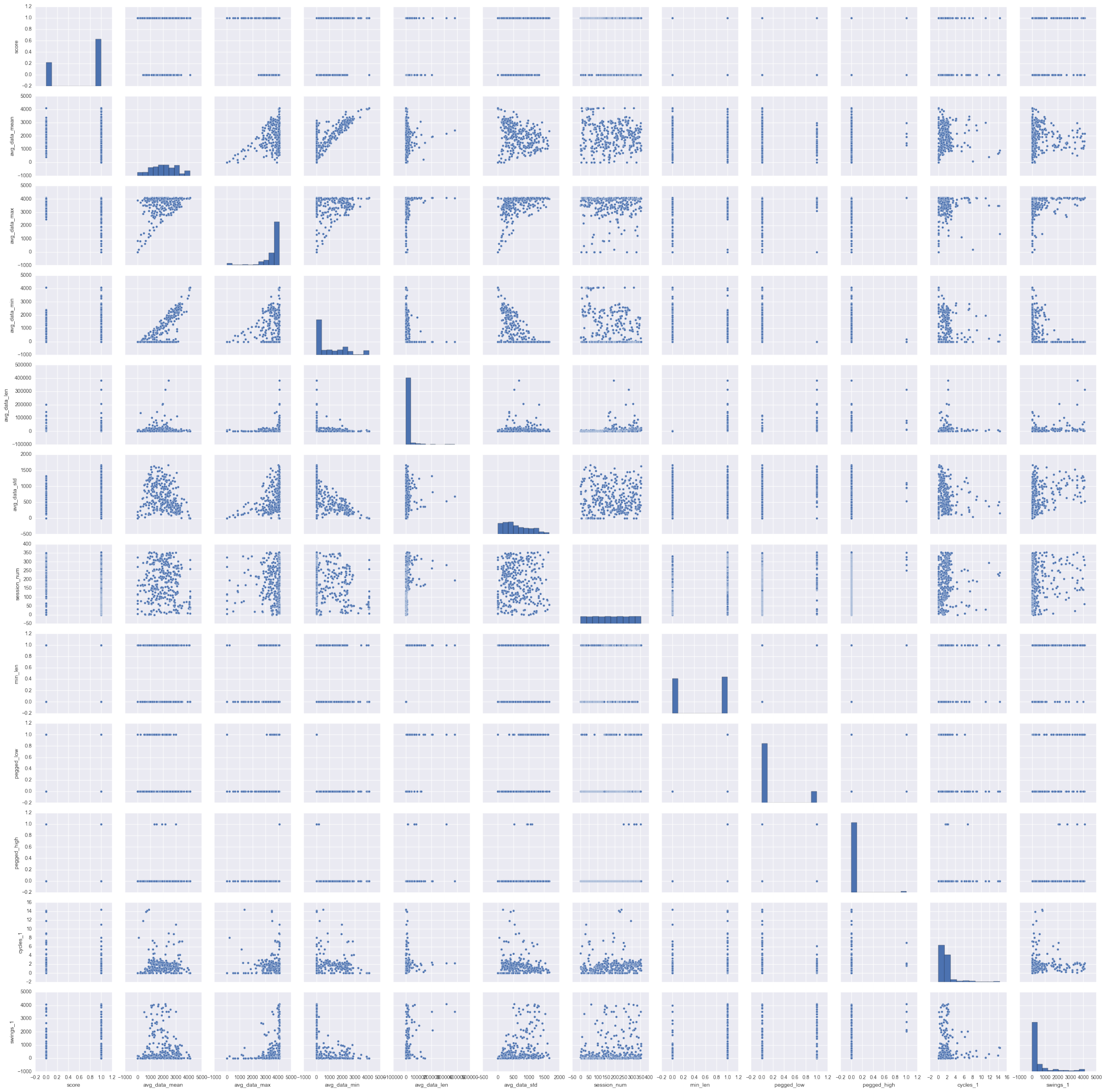
```
In [58]: df_results3 = df_res_save.copy()
         cycles = []
         swings = []

         look_back = [1]
         #look_back = [3]

         for look in look_back:
             c = []
             s = []
             for idx, elem in enumerate(temp):
                 a,b = count_crosses(elem, pts=look)
                 c.append(a)
                 s.append(b)
             cycles.append(c)
             swings.append(s)
             df_results3['cycles_{0}'.format(look)] = c
             df_results3['swings_{0}'.format(look)] = s

             #plt.hist(cycles)
             #plt.hist(swings)
```

```
In [59]: #df_results3
```

```
In [60]: df4 = df_results.copy()
         df4['cycles_1'] = df_results3['cycles_1']
         df4['swings_1'] = df_results3['swings_1']
```

```
In [ ]:
```

```
In [61]: sns_plot = sns.pairplot(df4)
         sns_plot.savefig("sns-pairplot.png")
```



```
In [62]: y2 = df4['score'].as_matrix()
         X_df2 = df4[['avg_data_mean',
                  'avg_data_max',  'avg_data_min',  'avg_data_std', 'avg_data_len',
                      'cycles_1','swings_1','min_len','pegged_low','pegged_high']]
         X2 = X_df2.as_matrix()

In [63]: X_train, X_test, y_train, y_test = train_test_split(
             X2, y2, test_size=0.33, random_state=42)

In [64]: clf = RandomForestClassifier(n_estimators=10, random_state=42).fit(X_trai
         clf = clf.fit(X_train, y_train)

In [65]: clf_save = clf
         clf_name_save = X_df2.columns
         X_save = X_df2.as_matrix()
```

```
In [66]: scores = cross_val_score(clf, X_train, y_train, cv=10)
```

```
In [67]: print scores
         print np.average(scores)
```

```
[ 0.79166667  0.95833333  0.875       0.875       0.875       0.95833333
  0.91666667  0.95833333  0.82608696  0.82608696]
0.886050724638
```

```
In [68]: print clf.feature_importances_

         for i in range(len(clf.feature_importances_)):
             print X_df2.columns[i], clf.feature_importances_[i]
```

```
[ 0.07064774  0.05054319  0.09737334  0.10564576  0.25162631  0.1348587
  0.0572746   0.13476878  0.09468364  0.00257796]
avg_data_mean 0.070647739072
avg_data_max 0.050543185561
avg_data_min 0.0973733381049
avg_data_std 0.10564575551
avg_data_len 0.251626310731
cycles_1 0.134858702122
swings_1 0.0572745976741
min_len 0.134768777261
pegged_low 0.094683635819
pegged_high 0.00257795814473
```

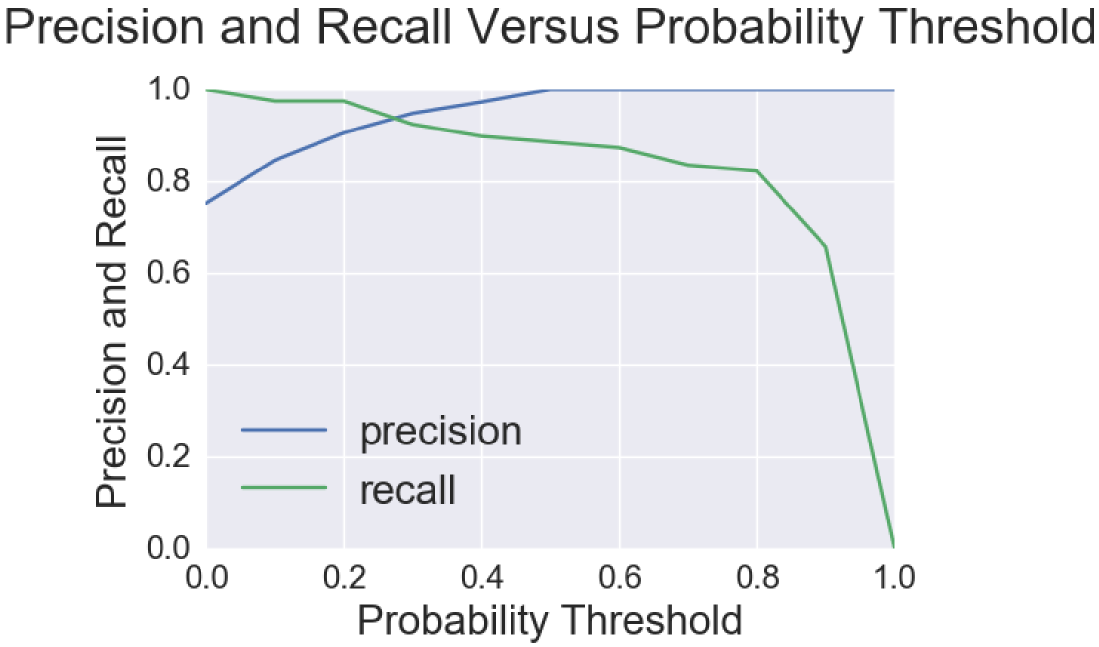
```
In [ ]:
```

```
In [69]: precision, recall, thresholds = precision_recall_curve(y_test, y_prob)
         print precision, recall, thresholds
```

```
[ 0.75238095  0.84615385  0.90588235  0.94805195  0.97260274  1.          1.
  1.          1.          1.          1.        ] [ 1.          0.97468354  0.97468
  0.87341772  0.83544304  0.82278481  0.65822785  0.        ] [ 0.1   0.2   0.3   0.4
```

```
In [70]: fig = plt.figure()
         ax = fig.add_subplot(1,1,1)
         ax.set_ylabel('Precision and Recall',fontsize=20)
         x1 = np.arange(0,10)/5.0
         #ax.plot(x1,df['precision'])
         labels = [item.get_text() for item in ax.get_xticklabels()]
         labels[1] = 'Testing'
         ax.plot(df['precision'])
         ax.plot(df['recall'])
         #ax.plot(df['thresholds'])
```

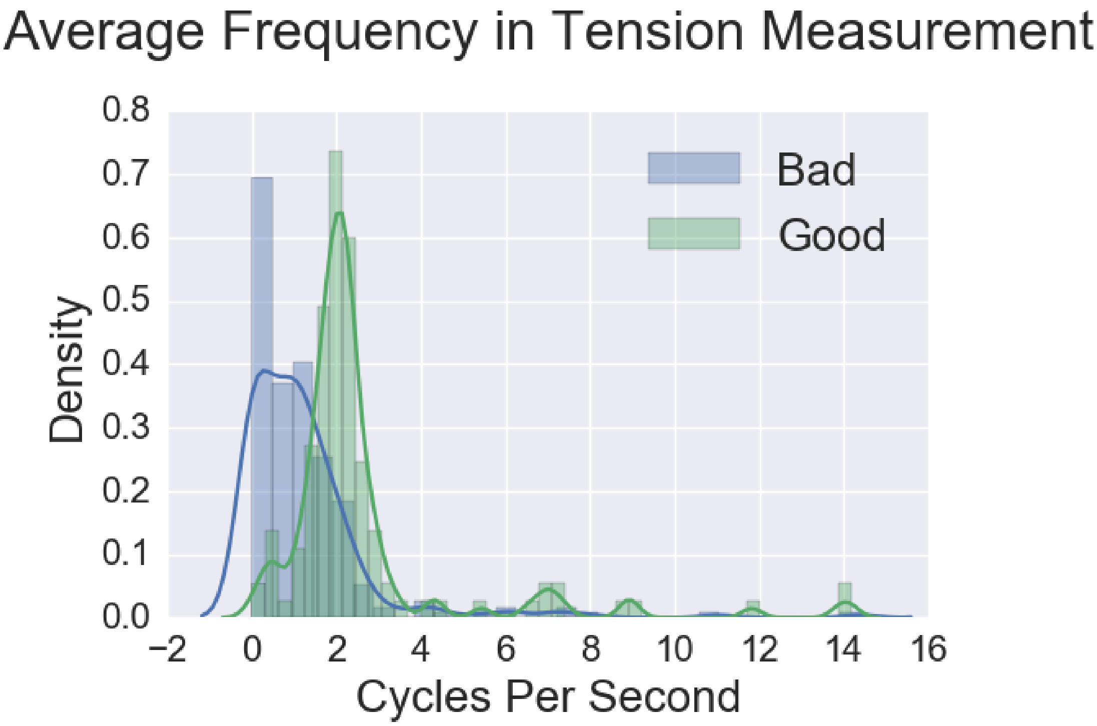
```
        ax.set_xlim(0,10)
        #labels =
        ax.set_xticklabels(x1)
        ax.set_title('Precision and Recall Versus Probability Threshold',fontsize=
        ax.set_xlabel('Probability Threshold',fontsize=20)
        #plt.ylabel('Density',fontsize=18)
        #plt.title('Average Frequency in Tension Measurement', fontsize=24)
        ax.tick_params(axis='both',labelsize=16)
        plt.legend(fontsize=20,loc=0)
        plt.show()
        plt.savefig('prec-recall.png',bbox_inches='tight')
```



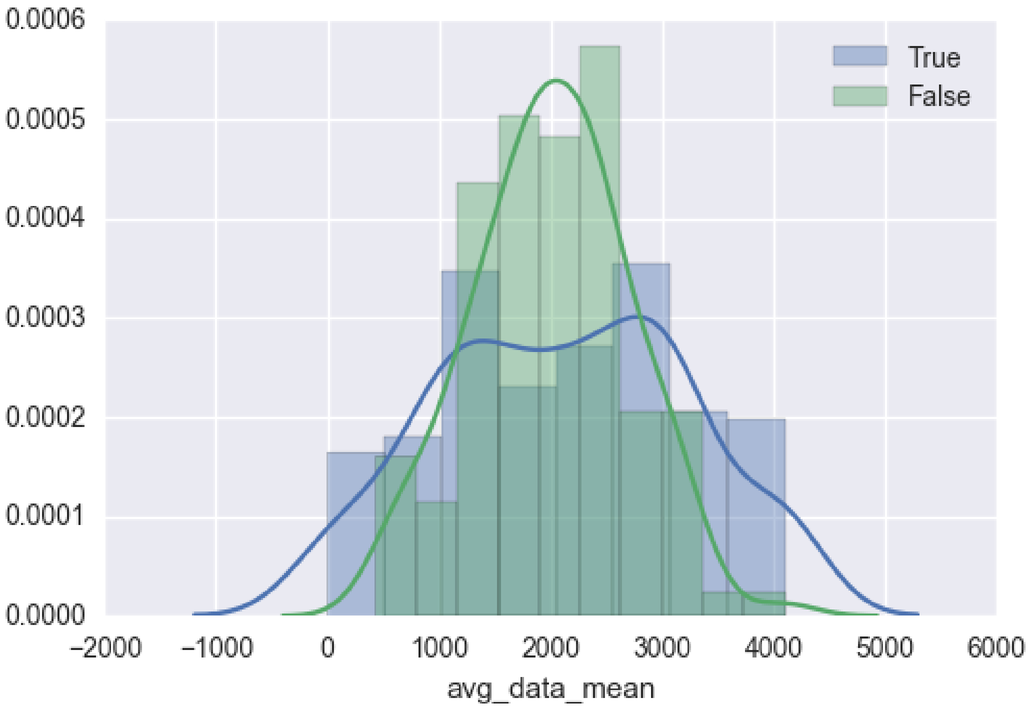
```
<matplotlib.figure.Figure at 0x12819ba90>
```

```
In [71]: df4_t = df4[df4['score']==True]

In [72]: df4_f = df4[df4['score']==False]

In [73]: # Set up the matplotlib figure

         sns.distplot( df4_t['cycles_1'], label = 'Bad')
         sns.distplot( df4_f['cycles_1'], label = 'Good')
         plt.xlabel('Cycles Per Second',fontsize=20)
         plt.ylabel('Density',fontsize=20)
         plt.title('Average Frequency in Tension Measurement', fontsize=24, y=1.10)
```

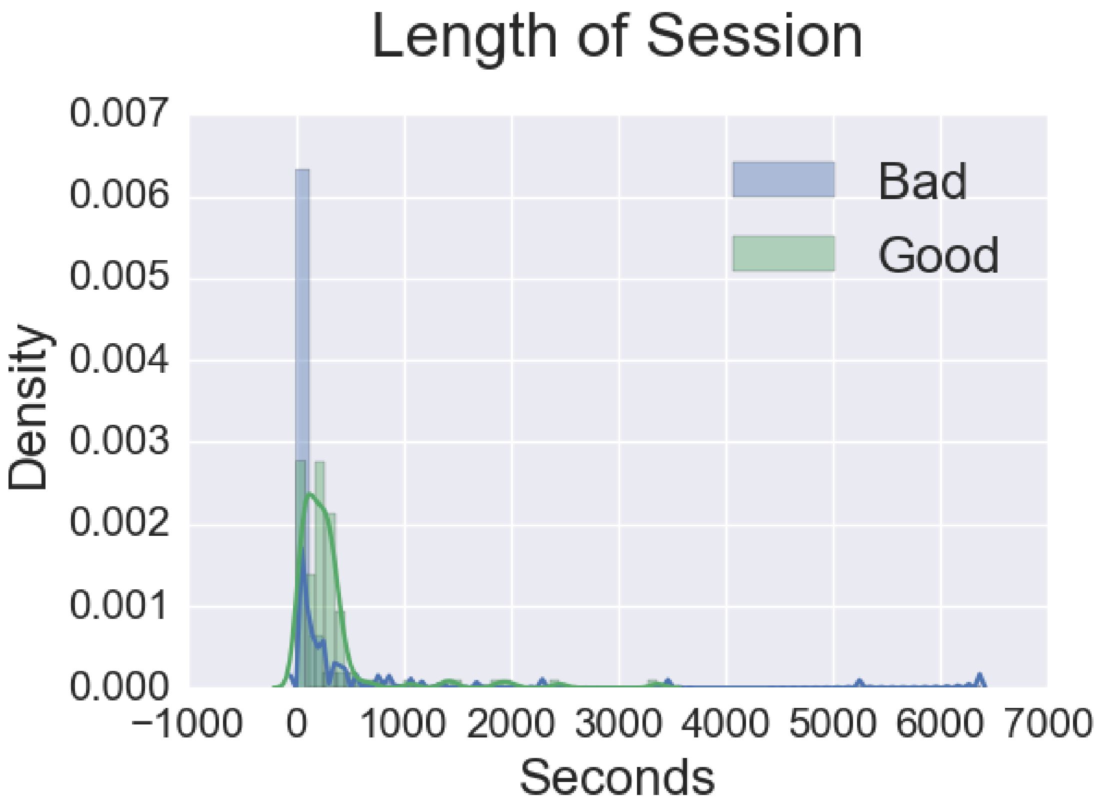
```
        plt.tick_params(axis='both',labelsize=16)
        plt.legend(fontsize=20)
        plt.savefig('feat-freq.png',bbox_inches='tight')
```



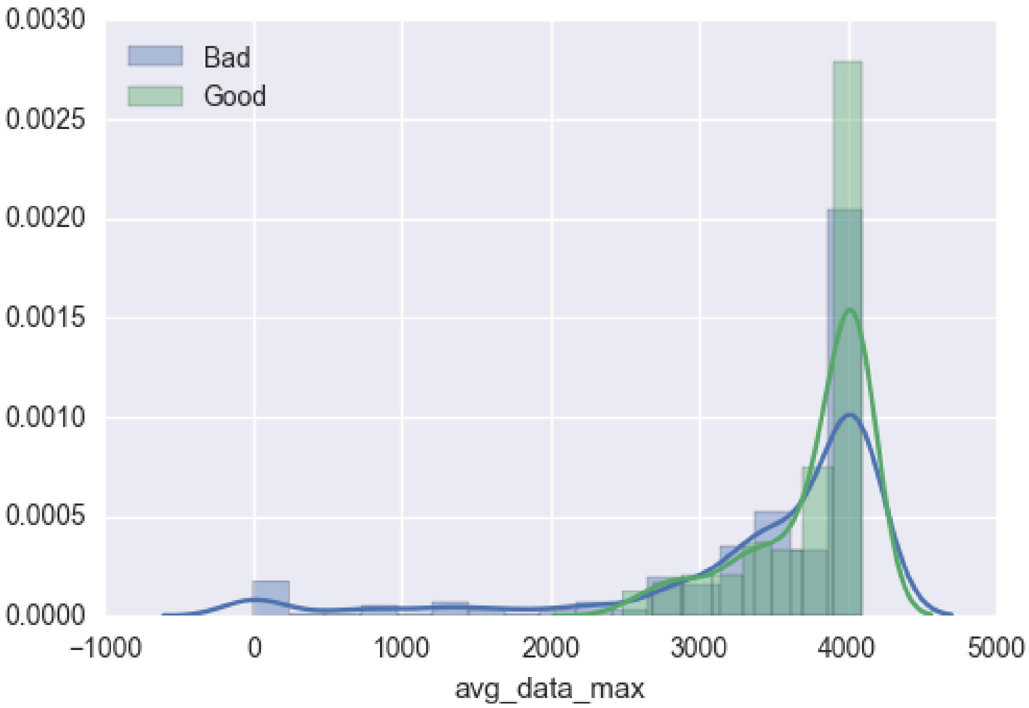
```
In [74]: sns.distplot( df4_t['avg_data_mean'],label = 'True')
         sns.distplot( df4_f['avg_data_mean'], label = 'False')
         plt.legend()

Out[74]: <matplotlib.legend.Legend at 0x12c8afd90>
```



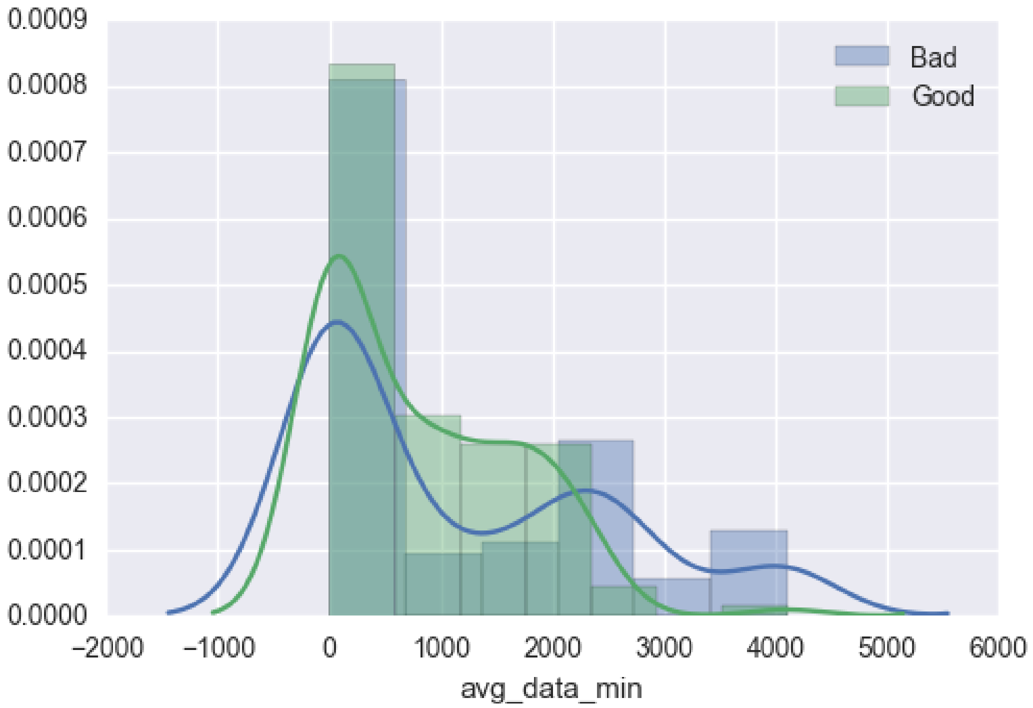
```
In [75]: sns.distplot( df4_t['avg_data_len']/60.0,label = 'Bad')
         sns.distplot( df4_f['avg_data_len']/60.0, label = 'Good')
         plt.xlabel('Seconds',fontsize=20)
         plt.ylabel('Density',fontsize=20)
         plt.title('Length of Session', fontsize=24, y=1.08)
         plt.tick_params(axis='both',labelsize=16)
         plt.legend(fontsize=20)
         plt.savefig('feat-session-length.png',bbox_inches='tight')
```



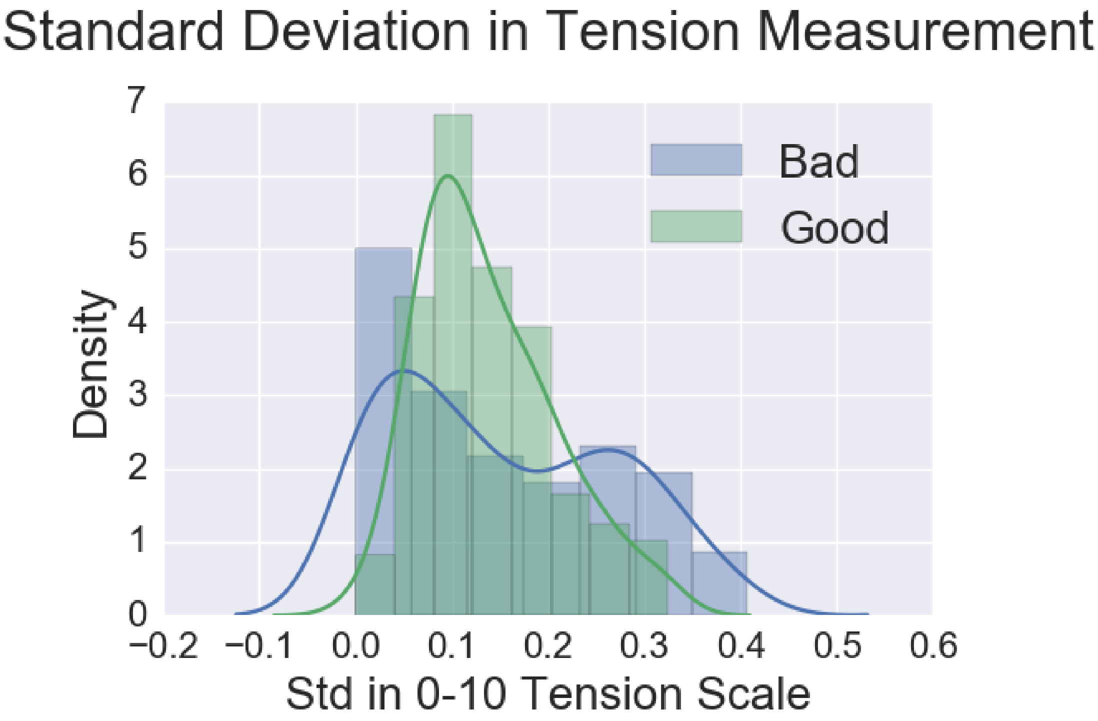
```
In [76]: sns.distplot( df4_t['avg_data_max'],label = 'Bad')
         sns.distplot( df4_f['avg_data_max'], label = 'Good')
         plt.legend(loc=0)

Out[76]: <matplotlib.legend.Legend at 0x1207f61d0>
```



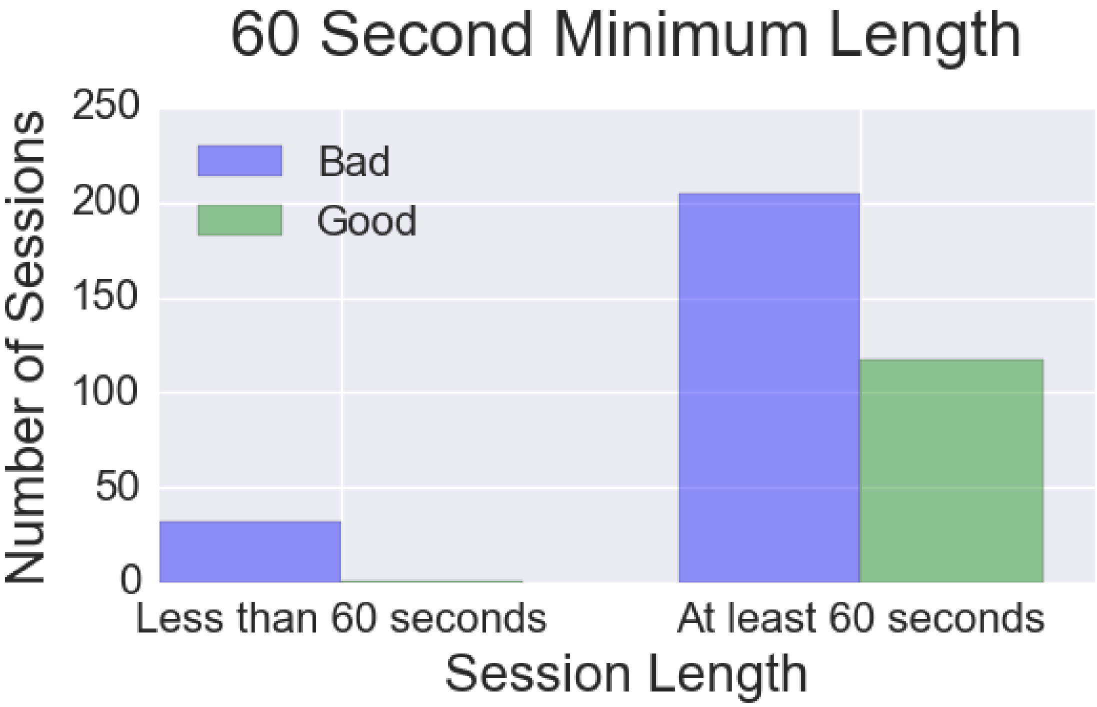
```
In [77]: sns.distplot( df4_t['avg_data_min'],label = 'Bad')
         sns.distplot( df4_f['avg_data_min'], label = 'Good')
         plt.legend()

Out[77]: <matplotlib.legend.Legend at 0x120a3efd0>
```



```
In [78]: sns.distplot( df4_t['avg_data_std']/4095.0,label = 'Bad')
         sns.distplot( df4_f['avg_data_std']/4095.0, label = 'Good')
         plt.xlabel('Std in 0-10 Tension Scale',fontsize=20)
         plt.ylabel('Density',fontsize=20)
         plt.title('Standard Deviation in Tension Measurement', fontsize=24,y=1.08)
         plt.tick_params(axis='both',labelsize=16)
         plt.legend(fontsize=20)
         plt.savefig('feat-std.png',bbox_inches='tight')
```

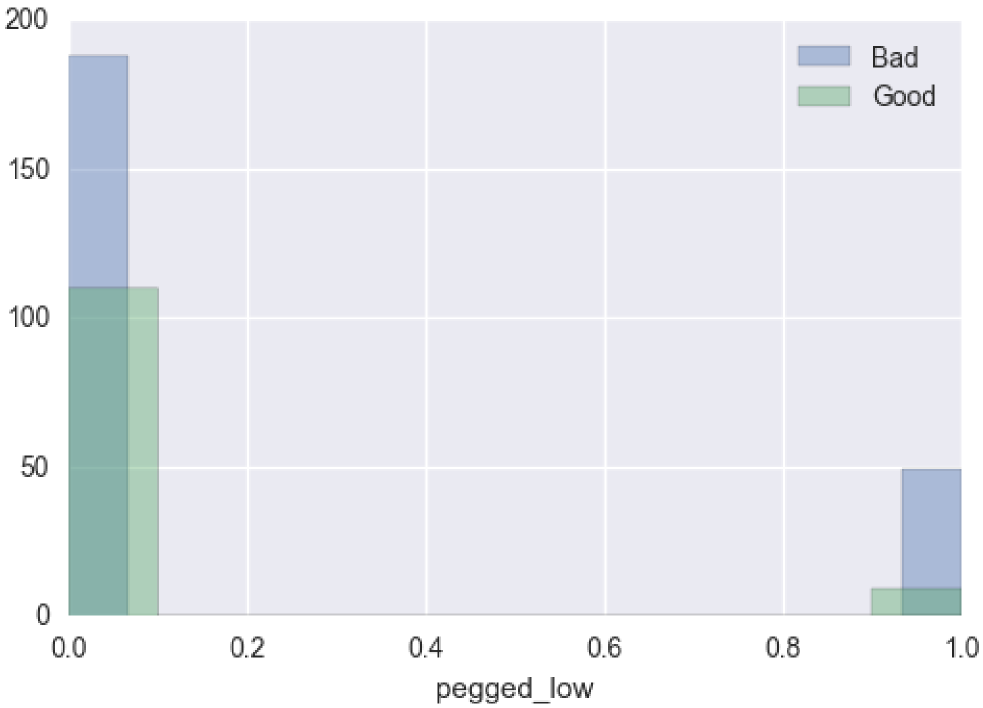


```
In [79]: good = [len(np.where(df4_f['avg_data_std']<=60)[0]),
                     len(np.where(df4_f['avg_data_std']>60)[0]) ]


         bad = [len(np.where(df4_t['avg_data_std']<=60)[0]),
                     len(np.where(df4_t['avg_data_std']>60)[0]) ]

In [80]: fig, ax = plt.subplots()

         index = np.arange(2)
         bar_width = 0.35

         opacity = 0.4
         error_config = {'ecolor': '0.3'}


         rects1 = plt.bar(index,
                          bad,
                          bar_width,
                          alpha=opacity,
                          color='b',
                          label='Bad')

         rects2 = plt.bar(index + bar_width,
                          good,
                          bar_width,
                          alpha=opacity,
                          color='g',
                          label='Good')

         plt.xlabel('Session Length',fontsize=20)
         plt.ylabel('Number of Sessions',fontsize=20)
         plt.title('60 Second Minimum Length',fontsize=24,y=1.08)
         plt.xticks(index + bar_width , ('Less than 60 seconds', 'At least 60 secon
         plt.legend(fontsize=16, loc=0)
         plt.tick_params(axis='both',labelsize=16)
         plt.tight_layout()
         plt.show()
         plt.savefig('feat-60-sec_min.png',bbox_inches='tight')
```

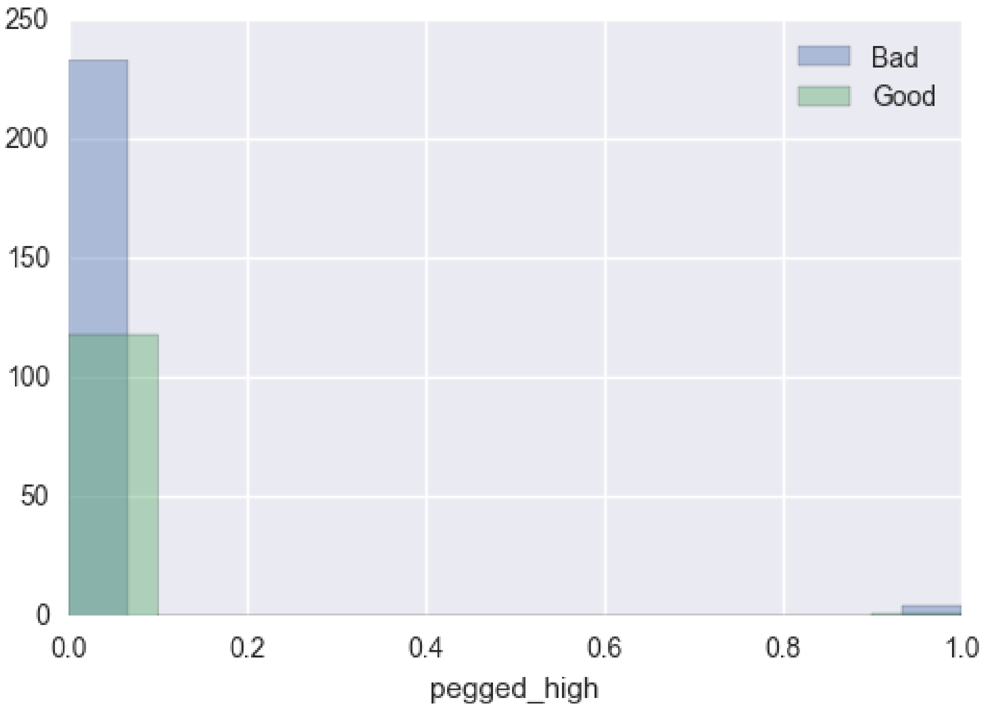


```
<matplotlib.figure.Figure at 0x120f3a510>
```

```
In [81]: sns.distplot( df4_t['pegged_low'],kde=False, label = 'Bad')
         sns.distplot( df4_f['pegged_low'],kde=False, label = 'Good')

         plt.legend()

Out[81]: <matplotlib.legend.Legend at 0x1214410d0>
```



```
In [82]: sns.distplot( df4_t['pegged_high'],kde=False, label = 'Bad')
         sns.distplot( df4_f['pegged_high'], kde=False, label = 'Good')
         plt.legend()

Out[82]: <matplotlib.legend.Legend at 0x1224f7610>
```



```
In [83]: # Set up the matplotlib figure
         df4.columns

Out[83]: Index([ u'Session_name',        u'userid',         u'score', u'avg_data_me
                 u'avg_data_max',  u'avg_data_min',  u'avg_data_len',  u'avg_data_s
                  u'session_num',       u'min_len',    u'pegged_low',   u'pegged_hi
                     u'cycles_1',      u'swings_1'],
               dtype='object')

In [84]: clf = RandomForestClassifier(n_estimators=10, random_state=42).fit(X_trair

         scores = cross_val_score(clf, X_train, y_train, cv=10)
         print scores
         print np.average(scores)

[ 0.79166667  0.95833333  0.875       0.875       0.875       0.95833333
  0.91666667  0.95833333  0.82608696  0.82608696]
0.886050724638


In [85]: joblib.dump(clf, 'brtakrf_class.pkl')

Out[85]: ['brtakrf_class.pkl']

In [ ]:
```

```
In [86]: clfab = AdaBoostClassifier(base_estimator=None,
          n_estimators=50, learning_rate=1.0, algorithm='SAMME.R',
                                    random_state=42).fit(X_train,y_train)
```

```
In [87]: scores_ab = cross_val_score(clfab, X_train, y_train, cv=10)
         print scores_ab
         print np.average(scores_ab)
```

```
[ 0.79166667  0.91666667  0.95833333  0.875       0.875       0.875       0.875
  0.875       0.7826087   0.7826087 ]
0.860688405797
```

```
In [88]: clfgb = GradientBoostingClassifier(loss='deviance', learning_rate=0.1,
                             n_estimators=100, subsample=1.0,
                             criterion='friedman_mse', min_samples_split=2,
                             min_samples_leaf=1, min_weight_fraction_leaf=0.0,
                             max_depth=3, min_impurity_split=1e-07, init=None,
                             random_state=42, max_features=None,
                             verbose=0, max_leaf_nodes=None,
                             warm_start=False, presort='auto').fit(X_train,y_train)
```

```
In [89]: scores_gb = cross_val_score(clfgb, X_train, y_train, cv=10)
         print scores_gb
         print np.average(scores_gb)
```

```
[ 0.875       0.91666667  0.91666667  0.875       0.91666667  0.91666667
  0.83333333  0.91666667  0.86956522  0.91304348]
0.894927536232
```

```
In [90]: scores_rf = cross_val_score(clf, X_train, y_train, cv=10)
         print scores_rf
```

```
[ 0.79166667  0.95833333  0.875       0.875       0.875       0.95833333
  0.91666667  0.95833333  0.82608696  0.82608696]
```

```
In [91]: RF_pred = clf.predict(X2)
```

```
In [92]: df4['RF_pred'] = RF_pred
```

```
In [93]: y2 = df4['score'].as_matrix()
         X_df2 = df4[['avg_data_mean',
                 'avg_data_max',  'avg_data_min',  'avg_data_std', 'avg_data_len',
                     'cycles_1','swings_1','min_len','pegged_low','pegged_high','RF
         X2 = X_df2.as_matrix()
```

```
In [94]: X_train, X_test, y_train, y_test = train_test_split(
             X2, y2, test_size=0.33, random_state=42)
```

```
In [95]: clfab = AdaBoostClassifier(base_estimator=None, n_estimators=50,
                    learning_rate=1.0, algorithm='SAMME.R', random_state=42).fit(X

         scores_ab = cross_val_score(clfab, X_train, y_train, cv=10)
         print scores_ab
         print np.average(scores_ab)

[ 1.          1.          1.          0.95833333  1.          1.
  0.95833333  1.          1.          0.95652174]
0.98731884058
```

```
In [96]: scores_ab = cross_val_score(clfab, X_test, y_test, cv=10)
         print scores_ab
         print np.average(scores_ab)

[ 0.91666667  0.83333333  1.          0.91666667  1.          0.91666667
  0.91666667  0.91666667  1.          0.9       ]
0.931666666667
```

```
In [97]: clfgb = GradientBoostingClassifier(loss='deviance',
                    learning_rate=0.1, n_estimators=100, subsample=1.0,
                    criterion='friedman_mse', min_samples_split=2,
                    min_samples_leaf=1, min_weight_fraction_leaf=0.0,
                    max_depth=3, min_impurity_split=1e-07, init=None,
                    random_state=42, max_features=None, verbose=0,
                    max_leaf_nodes=None, warm_start=False, presort='auto').fit(X_t
         scores_gb = cross_val_score(clfgb, X_train, y_train, cv=10)
         print scores_gb
         print np.average(scores_gb)

[ 1.          1.          1.          0.95833333  1.          1.          1.
  1.          1.          0.95652174]
0.991485507246
```

```
In [98]: scores_gb = cross_val_score(clfgb, X_test, y_test, cv=10)
         print scores_gb
         print np.average(scores_gb)

[ 0.83333333  0.83333333  0.91666667  1.          1.          0.91666667
  0.91666667  1.          1.          0.9       ]
0.931666666667
```

```
In [99]: joblib.dump(clf, 'brtakgb_class.pkl')

Out[99]: ['brtakgb_class.pkl']
```

```
In [100]: trial_users = pd.read_csv('TrialUsers.csv', header=None)
```

```
In [101]: df_trial = df4[df_results['userid'].isin(trial_users[0]) |df_results['use
```

```
In [102]: y_trial = df_trial['score'].as_matrix()
          X_trial_df = df_trial[['avg_data_mean',
                  'avg_data_max',  'avg_data_min',  'avg_data_std', 'avg_data_len',
                      'cycles_1','swings_1','min_len','pegged_low','pegged_high']]
```

```
In [103]: X_trial = X_trial_df.as_matrix()
```

```
In [104]: trial_score = clf.score(X_trial, y_trial)
          print trial_score
```

```
0.96875
```

```
In [105]: X_trial_df2= X_trial_df.copy()
          X_trial_df2['RF_pred'] = clf.predict(X_trial)
          X_trial2 = X_trial_df2.as_matrix()
          X_train, X_test, y_train, y_test = train_test_split(
              X_trial2, y_trial, test_size=0.33, random_state=42)
```

```
In [106]: trial_score_gb = clfgb.score(X_trial2, y_trial)
          print trial_score_gb
```

```
0.96875
```

```
In [107]: trial_score_ab = clfab.score(X_trial2, y_trial)
          print trial_score_ab
```

```
0.96875
```

```
In [108]: clfab.feature_importances_
```

```
Out[108]: array([ 0.04,  0.14,  0.06,  0.22,  0.08,  0.  ,  0.1 ,  0.  ,  0.  ,
                  0.  ,  0.36])
```

```
In [109]: len(X_trial[0])
```

```
Out[109]: 10
```

```
In [110]: print df_trial.columns
          len(df_trial.columns)
```

```
Index([ u'Session_name',        u'userid',         u'score', u'avg_data_mean',
         u'avg_data_max',  u'avg_data_min',  u'avg_data_len',  u'avg_data_std',
          u'session_num',       u'min_len',    u'pegged_low',   u'pegged_high',
             u'cycles_1',      u'swings_1',       u'RF_pred'],
      dtype='object')
```

```
Out[110]: 15
```

```
In [111]: print X_df.columns
          print X_df2.columns
          print X_trial_df.columns
          print X_trial_df2.columns
```

```
Index([u'avg_data_mean', u'avg_data_max', u'avg_data_min', u'avg_data_len',
       u'avg_data_std', u'session_num', u'min_len', u'pegged_low',
       u'pegged_high'],
      dtype='object')
Index([u'avg_data_mean', u'avg_data_max', u'avg_data_min', u'avg_data_std',
       u'avg_data_len', u'cycles_1', u'swings_1', u'min_len', u'pegged_low',
       u'pegged_high', u'RF_pred'],
      dtype='object')
Index([u'avg_data_mean', u'avg_data_max', u'avg_data_min', u'avg_data_std',
       u'avg_data_len', u'cycles_1', u'swings_1', u'min_len', u'pegged_low',
       u'pegged_high'],
      dtype='object')
Index([u'avg_data_mean', u'avg_data_max', u'avg_data_min', u'avg_data_std',
       u'avg_data_len', u'cycles_1', u'swings_1', u'min_len', u'pegged_low',
       u'pegged_high', u'RF_pred'],
      dtype='object')
```

```
In [112]: print 'Bad=',len([x  for x in y_trial if x==True])
          print 'Good=',len([x  for x in y_trial if x==False])
```

```
Bad= 33
Good= 31
```

```
In [113]: y_pred2 = clfgb.predict(X_trial2)
```

```
In [114]: print 'Bad=',len([x  for x in y_pred2 if x==True])
          print 'Good=',len([x  for x in y_pred2 if x==False])
```

```
Bad= 31
Good= 33
```

```
In [115]: right = y_trial == y_pred2
```

```
In [116]: print 'Correct=',len([x  for x in right if x==True])
          print 'Incorrect=',len([x  for x in right if x==False])
```

```
Correct= 62
Incorrect= 2
```

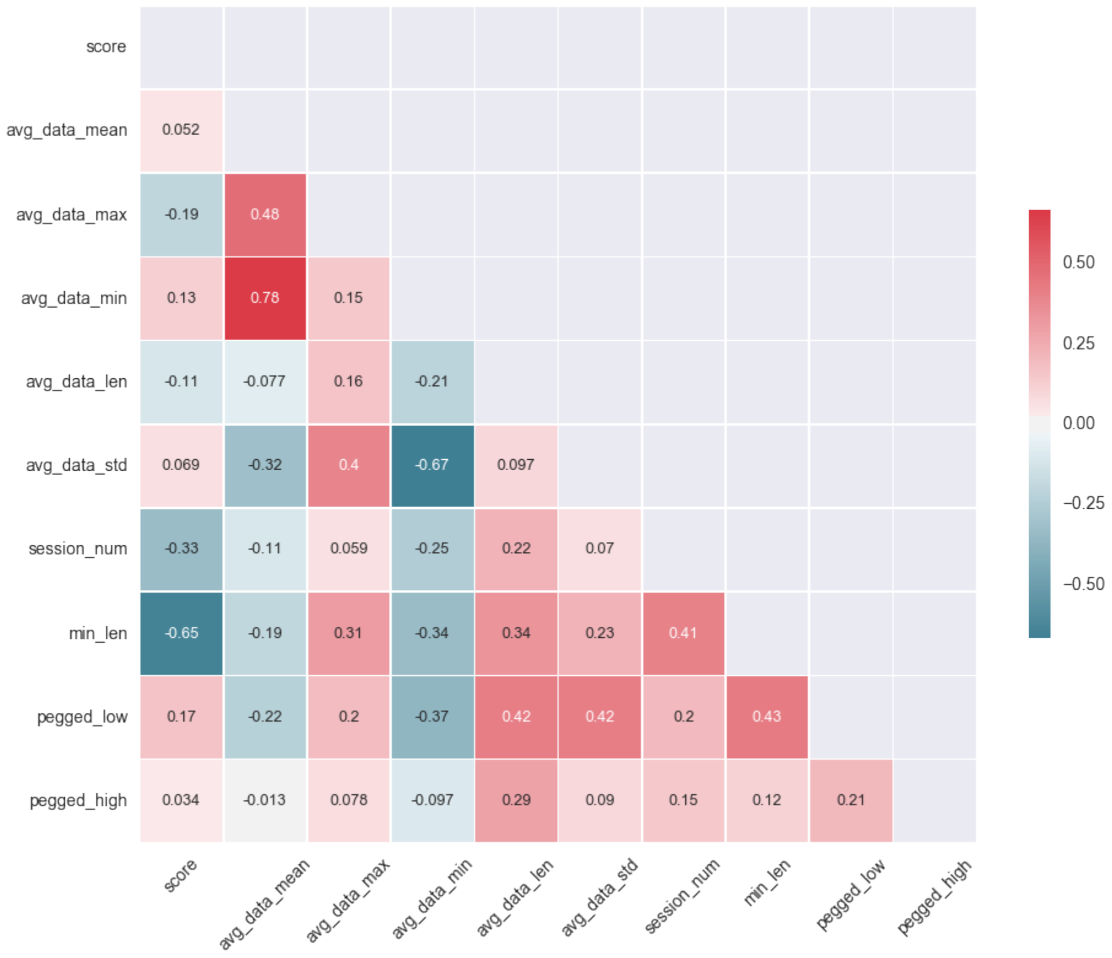
```
In [117]: y_pred2 = clf.predict(X_trial)
          right = y_trial == y_pred2
          print 'Correct=',len([x  for x in right if x==True])
          print 'Incorrect=',len([x  for x in right if x==False])
```

```
Correct= 62
Incorrect= 2
```

```
In [118]: #df_trial[df_trial['score']!=df_trial['RF_pred']]
```

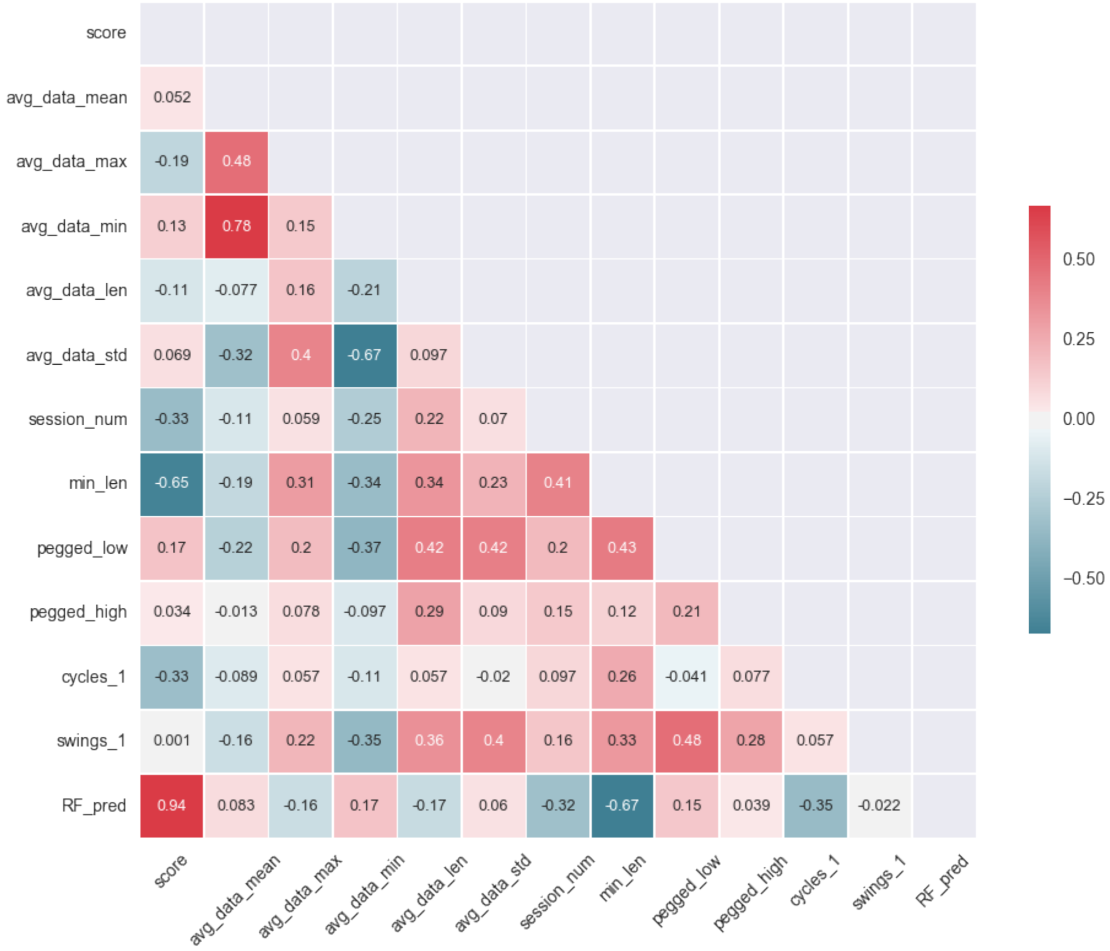
```
In [119]: # Compute the correlation matrix
          corr = df_results.corr()

          # Generate a mask for the upper triangle
          mask = np.zeros_like(corr, dtype=np.bool)
          mask[np.triu_indices_from(mask)] = True

          # Set up the matplotlib figure
          f, ax = plt.subplots(figsize=(11, 9))

          # Generate a custom diverging colormap
          cmap = sns.diverging_palette(220, 10, as_cmap=True)

          # Draw the heatmap with the mask and correct aspect ratio
          sns.heatmap(corr, mask=mask, cmap=cmap, vmax=.3,
                      square=True,
                      linewidths=.5, cbar_kws={"shrink": .5}, ax=ax, annot=True, ar
          plt.xticks(rotation=45)
          plt.yticks(rotation=0)
```

```
Out[119]: (array([ 0.5,  1.5,  2.5,  3.5,  4.5,  5.5,  6.5,  7.5,  8.5,  9.5]),
           <a list of 10 Text yticklabel objects>)
```



```
In [120]: # Compute the correlation matrix
          corr = df4.corr()

          # Generate a mask for the upper triangle
          mask = np.zeros_like(corr, dtype=np.bool)
          mask[np.triu_indices_from(mask)] = True

          # Set up the matplotlib figure
          f, ax = plt.subplots(figsize=(11, 9))

          # Generate a custom diverging colormap
          cmap = sns.diverging_palette(220, 10, as_cmap=True)

          # Draw the heatmap with the mask and correct aspect ratio
          sns.heatmap(corr, mask=mask, cmap=cmap, vmax=.3,
                      square=True,
                      linewidths=.5, cbar_kws={"shrink": .5}, ax=ax, annot=True, ar
```

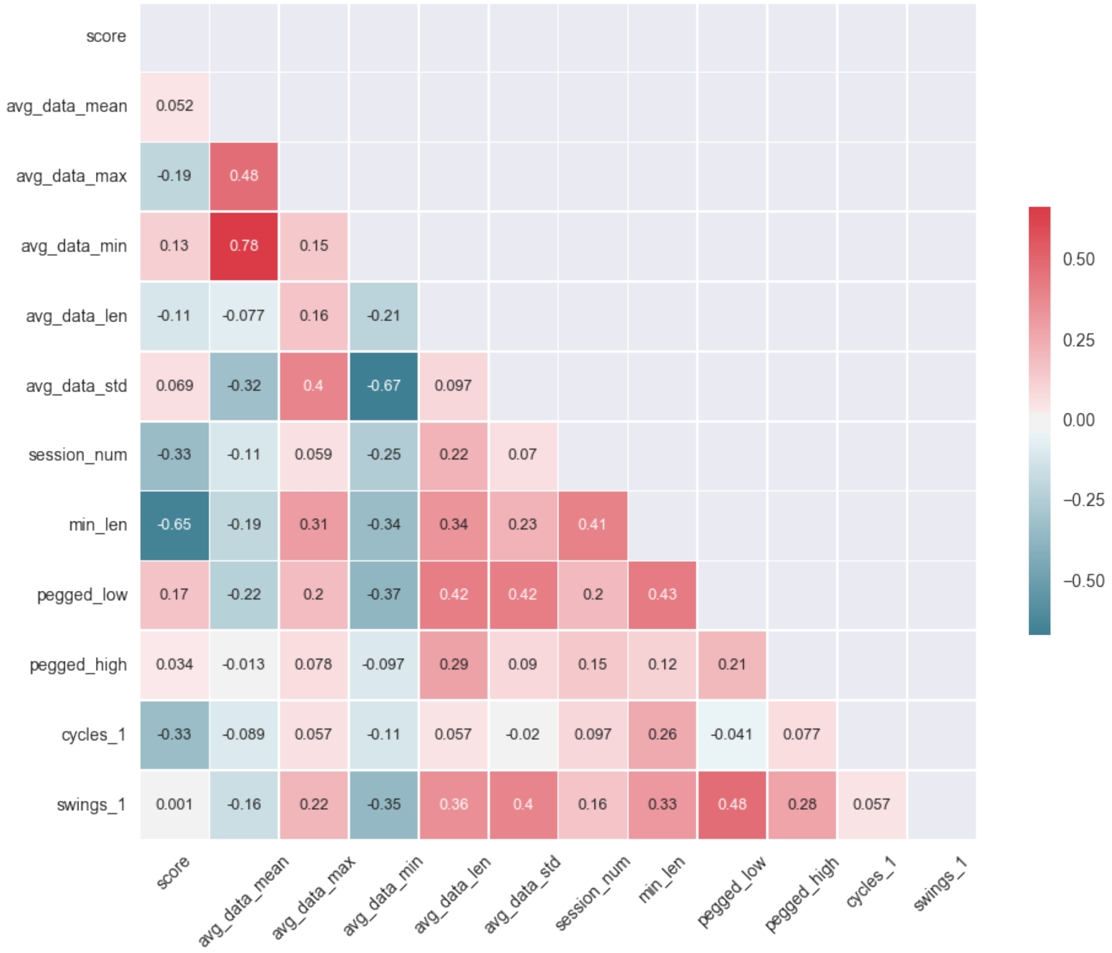
```
         plt.xticks(rotation=45)
         plt.yticks(rotation=0)

Out[120]: (array([  0.5,    1.5,    2.5,    3.5,    4.5,    5.5,    6.5,    7.5,    8.5,
                    9.5,   10.5,   11.5,   12.5]), <a list of 13 Text yticklabel objec
```



```
In [121]: # Compute the correlation matrix
          df9=df4.drop('RF_pred',axis=1)
          corr = df9.corr()

          # Generate a mask for the upper triangle
          mask = np.zeros_like(corr, dtype=np.bool)
          mask[np.triu_indices_from(mask)] = True

          # Set up the matplotlib figure
          f, ax = plt.subplots(figsize=(11, 9))
```

```
# Generate a custom diverging colormap
cmap = sns.diverging_palette(220, 10, as_cmap=True)

# Draw the heatmap with the mask and correct aspect ratio
sns.heatmap(corr, mask=mask, cmap=cmap, vmax=.3,
            square=True,
            linewidths=.5, cbar_kws={"shrink": .5}, ax=ax, annot=True, ar
plt.xticks(rotation=45)
plt.yticks(rotation=0)
```

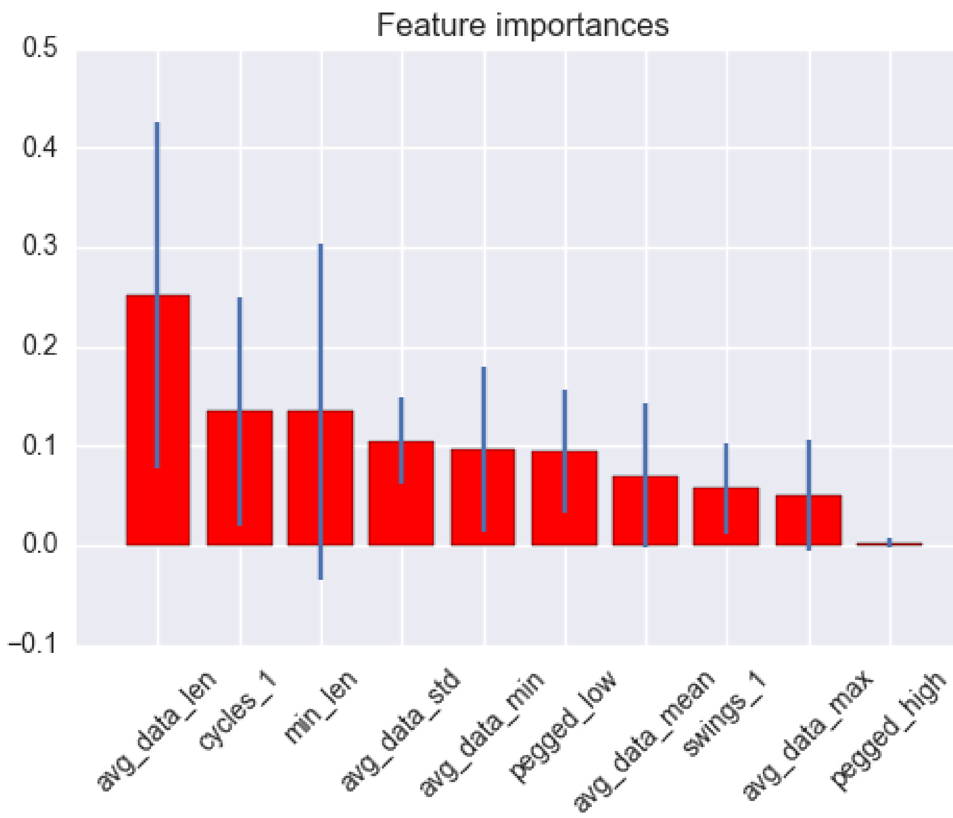
```
Out[121]: (array([  0.5,   1.5,   2.5,   3.5,   4.5,   5.5,   6.5,   7.5,   8.5,
            9.5,  10.5,  11.5]), <a list of 12 Text yticklabel objects>)
```



```
In [122]: forest = clf_save
          names = clf_name_save
          X = X_save
```

```
importances = forest.feature_importances_
print len(importances), len(forest.feature_importances_)
std = np.std([tree.feature_importances_ for tree in forest.estimators_],
             axis=0)

indices = np.argsort(importances)[::-1]

# Print the feature ranking
print("Feature ranking:")

for f in range(X.shape[1]):
    print("%d. feature %s (%f)" % (f + 1, names[indices[f]], importances

# Plot the feature importances of the forest
plt.figure()
plt.title("Feature importances")
plt.bar(range(X.shape[1]), importances[indices],
       color="r", yerr=std[indices], align="center")
plt.xticks(range(X.shape[1]), names[indices], rotation=45)
plt.xlim([-1, X.shape[1]])
plt.show()
plt.savefig('feat-imp.png',bbox_inches='tight')
```

```
10 10
Feature ranking:
1. feature avg_data_len (0.251626)
2. feature cycles_1 (0.134859)
3. feature min_len (0.134769)
4. feature avg_data_std (0.105646)
5. feature avg_data_min (0.097373)
6. feature pegged_low (0.094684)
7. feature avg_data_mean (0.070648)
8. feature swings_1 (0.057275)
9. feature avg_data_max (0.050543)
10. feature pegged_high (0.002578)
```


Feature importances
0.5
0.4
0.3
0.2
0.1
0.0
−0.1
avg_data_len
cycles_1
min_len
avg_data_std
avg_data_min
pegged_low
avg_data_mean
swings_1
avg_data_max
pegged_high

```
<matplotlib.figure.Figure at 0x123a8e690>
```