Quora_Data_Challenge

November 3, 2019

1 Quora Data Challenge

Suppose you are a Data Scientist on the Mobile team at Quora. The team has just introduced a new UI design to the Quora app. The goal of the new design is to increase user engagement (measured by minutes spent on site). The team ran an A/B test to evaluate the change. Using the data, help the team understand the impact of the UI change better.

```
In [1]: import pandas as pd
        import datetime
        import matplotlib.pyplot as plt
        import seaborn as sns
```

```
In [7]: #take a look at different tables
        #This table contains active minutes data logged after experiment started.
        #Each row represents the total number of minutes spent on site for each user on a date.
        #If a user never visited the site for a given date, there wouldn't be data for that uid
        t1 = pd.read_csv("t1_user_active_min.csv")
        print("the number of records is ",t1.shape)
        t1.head()
        t1['active_mins'].describe()
```

```
the number of records is  (1066402, 3)
```

```
Out[7]: count    1.066402e+06
        mean     3.616809e+01
        std      1.270484e+03
        min      1.000000e+00
        25%      2.000000e+00
        50%      5.000000e+00
        75%      1.700000e+01
        max      9.999900e+04
        Name: active_mins, dtype: float64
```

```
In [49]: len(t1.uid.unique())
```

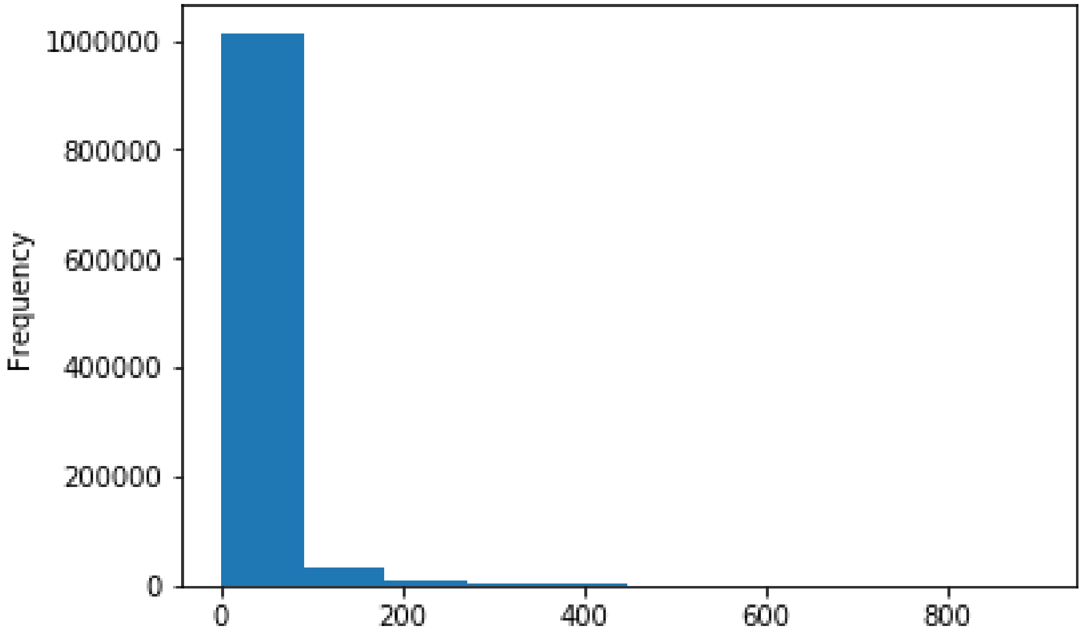
```
Out[49]: 46525
```

```
In [10]: # By definition, a user cannot be more than 24*60 minutes using quora on a given day.
         # I assume these are some hard_coded value that has some meaning,e.g., for some reason,
         # Quora could not capture the number of minutes on the given day.
         t1[(t1.active_mins > (24*60))]
         # We have 172 records where active_mins >1440 which contradicts the metrics definition.
         # I will filter them out.
         t1 = t1[(t1.active_mins<=1440)]
         t1.shape
```

```
Out[10]: (1066230, 3)
```

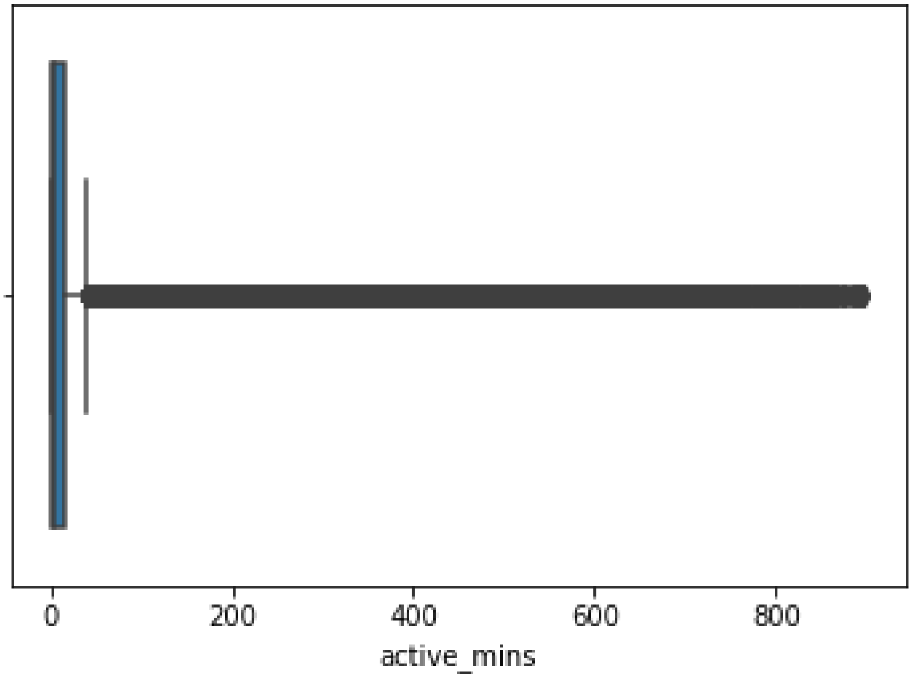
```
In [12]: %matplotlib inline
         t1['active_mins'].plot.hist()
         t1['active_mins'].describe()
```

```
Out[12]: count    1.066230e+06
         mean     2.004248e+01
         std      4.653763e+01
         min      1.000000e+00
         25%      2.000000e+00
         50%      5.000000e+00
         75%      1.700000e+01
         max      8.970000e+02
         Name: active_mins, dtype: float64
```



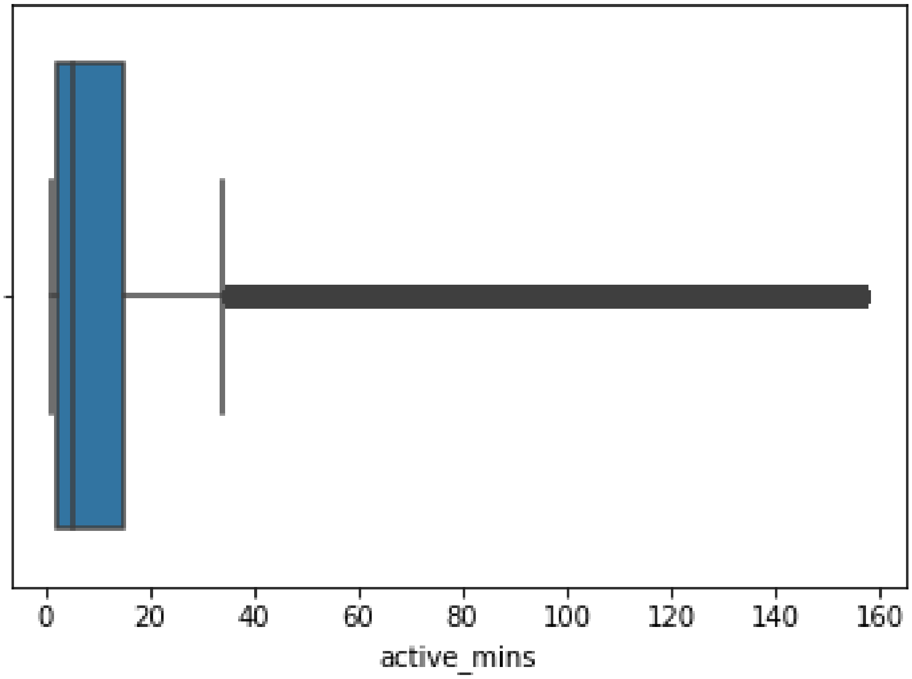
```
In [13]: sns.boxplot(x=t1['active_mins'])
         # we still observe some outliers. I will explore the possibility of filtering the out.
```

```
Out[13]: <matplotlib.axes._subplots.AxesSubplot at 0x7fc66beb1b00>
```



```
In [15]: t1=t1[(t1.active_mins<(20+(3*46)))]
         sns.boxplot(x=t1['active_mins'])

Out[15]: <matplotlib.axes._subplots.AxesSubplot at 0x7fc66be7f390>
```



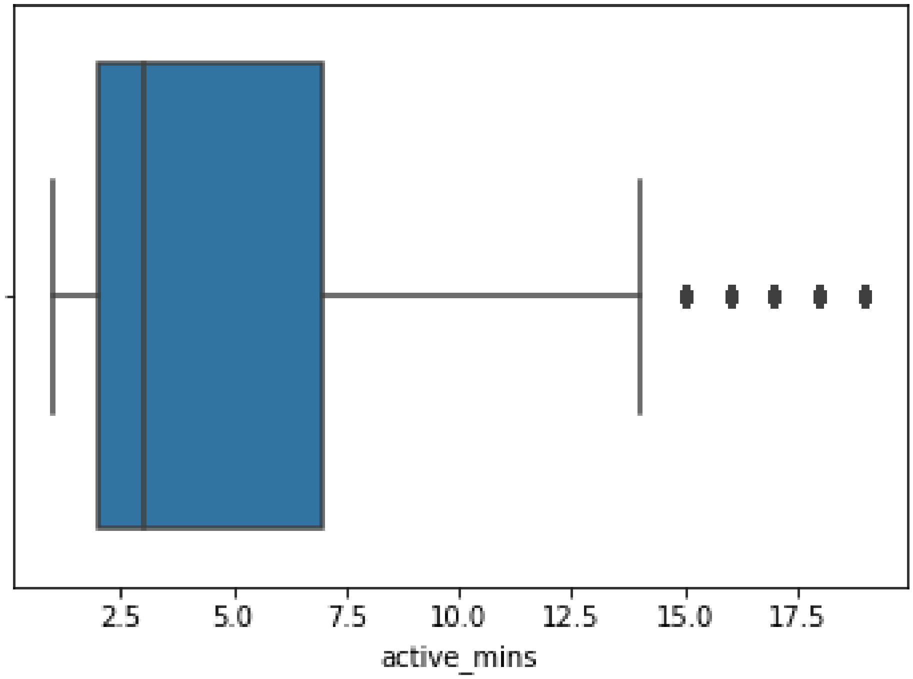
```
In [22]: # compute IQ range to filter outliers
         q1 = t1['active_mins'].quantile(0.25)
         q3 = t1['active_mins'].quantile(0.75)
         print(q1,q3)
         iqr = q3 - q1
         cutoff = 1.5*iqr
         t1 = t1[((t1.active_mins)> q1 - cutoff)]
         t1 = t1[((t1.active_mins)< q3 + cutoff)]

2.0 9.0


Out[22]: (828130, 3)

In [23]: t1.shape
         sns.boxplot(x=t1['active_mins'])

Out[23]: <matplotlib.axes._subplots.AxesSubplot at 0x7fc66be015c0>
```



```
In [4]: #This table contains users treatment assignment.
        #Each row represents the assignment information for a unique user.
        t2 = pd.read_csv("t2_user_variant.csv")
        print("the number of records is ",t2.shape)
        t2.head()
```

```
the number of records is  (50000, 4)
```

```
Out[4]:    uid  variant_number          dt signup_date
        0    0               0  2019-02-06  2018-09-24
        1    1               0  2019-02-06  2016-11-07
        2    2               0  2019-02-06  2018-09-17
        3    3               0  2019-02-06  2018-03-04
        4    4               0  2019-02-06  2017-03-09
```

```
In [26]: # check that we have a unique value for dt.
         t2.dt.unique()
```

```
Out[26]: array(['2019-02-06'], dtype=object)
```

```
In [162]: t2.variant_number.value_counts()
```

```
Out[162]: 0    40000
          1    10000
          Name: variant_number, dtype: int64
```

```
In [24]: #join by userid
         merged_df = pd.merge(left=t1,right=t2, left_on='uid', right_on='uid')
```

```
In [48]: len(merged_df.uid.unique())
```

```
Out[48]: 46525
```

```
In [ ]: merged_df.shape
```

```
In [42]: merged_df.head(15)
```

```
Out[42]:     uid        dt_x  active_mins  variant_number        dt_y signup_date
         0     0  2019-02-22          5.0               0  2019-02-06  2018-09-24
         1     0  2019-03-11          5.0               0  2019-02-06  2018-09-24
         2     0  2019-03-18          3.0               0  2019-02-06  2018-09-24
         3     0  2019-03-22          4.0               0  2019-02-06  2018-09-24
         4     0  2019-04-03          9.0               0  2019-02-06  2018-09-24
         5     0  2019-04-06          1.0               0  2019-02-06  2018-09-24
         6     0  2019-04-17          1.0               0  2019-02-06  2018-09-24
         7     0  2019-05-07          3.0               0  2019-02-06  2018-09-24
         8     0  2019-05-14          1.0               0  2019-02-06  2018-09-24
         9     0  2019-05-19          1.0               0  2019-02-06  2018-09-24
         10    0  2019-05-22          3.0               0  2019-02-06  2018-09-24
         11    0  2019-06-14          5.0               0  2019-02-06  2018-09-24
         12    0  2019-06-16          2.0               0  2019-02-06  2018-09-24
         13    1  2019-02-16         13.0               0  2019-02-06  2016-11-07
         14    1  2019-03-17          5.0               0  2019-02-06  2016-11-07
```

```
In [32]: # double check that a user is only in one group
         aux=merged_df.groupby('uid').variant_number.nunique()
         max(aux)
```

```
Out[32]: 1
```

```
In [38]: merged_df.dtypes
         min_date = min(merged_df['dt_x'])
         max_date = max(merged_df['dt_x'])
         print('min date is',min_date)
         print('max date is',max_date)
```

```
min date is 2019-02-06
max date is 2019-07-05
```

```
In [40]: # count records in each group
         merged_df.variant_number.value_counts()
```

```
Out[40]: 0    693417
         1    134713
         Name: variant_number, dtype: int64
```

```
In [46]: # group by user to compute mean time across all his/her visit.
         df = merged_df.groupby(['uid','variant_number'], as_index=False)['active_mins'].mean()
         df.shape # we have 46525 unique users in both groups
         df.variant_number.value_counts()
```

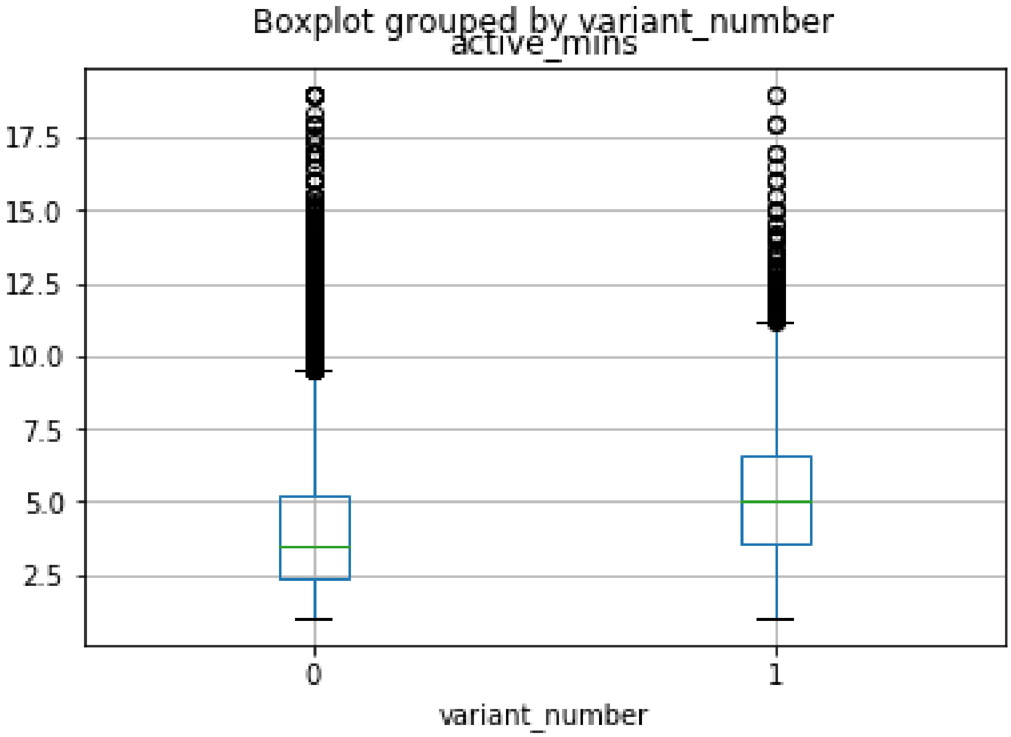
```
Out[46]: 0    37362
         1     9163
         Name: variant_number, dtype: int64
```

```
In [53]: df.head(10)
         df.groupby('variant_number', as_index=False)['active_mins'].mean()
```

```
Out[53]:    variant_number  active_mins
         0               0     4.149859
         1               1     5.291342
```

```
In [51]: %matplotlib inline
         df.boxplot(column='active_mins',by='variant_number')
```

```
Out[51]: <matplotlib.axes._subplots.AxesSubplot at 0x7fc66bcbd3c8>
```



```
In [58]: # compute confidence interval on difference of means.
         stats = df.groupby(['variant_number'])['active_mins'].agg(['mean', 'count', 'std','var'
         stats
```

```
Out[58]:                      mean  count      std       var
         variant_number
         0               4.149859  37362  2.40873  5.801981
         1               5.291342   9163  2.34741  5.510334
```

```
In [60]: stats.loc[0]['var']
```

```
Out[60]: 5.80198115819105
```

```
In [65]: import math
         # estimated standard deviation of the difference between the two means.
         sigma_dif = math.sqrt((stats.loc[0]['var']/stats.loc[0]['count'])+((stats.loc[1]['var']
         upper = (stats.loc[1]['mean']-stats.loc[0]['mean']) + (1.96 * sigma_dif)
         lower = (stats.loc[1]['mean']-stats.loc[0]['mean']) - (1.96 * sigma_dif)
         print([lower,upper])
```

```
[1.08756830375531, 1.1953974370435352]
```

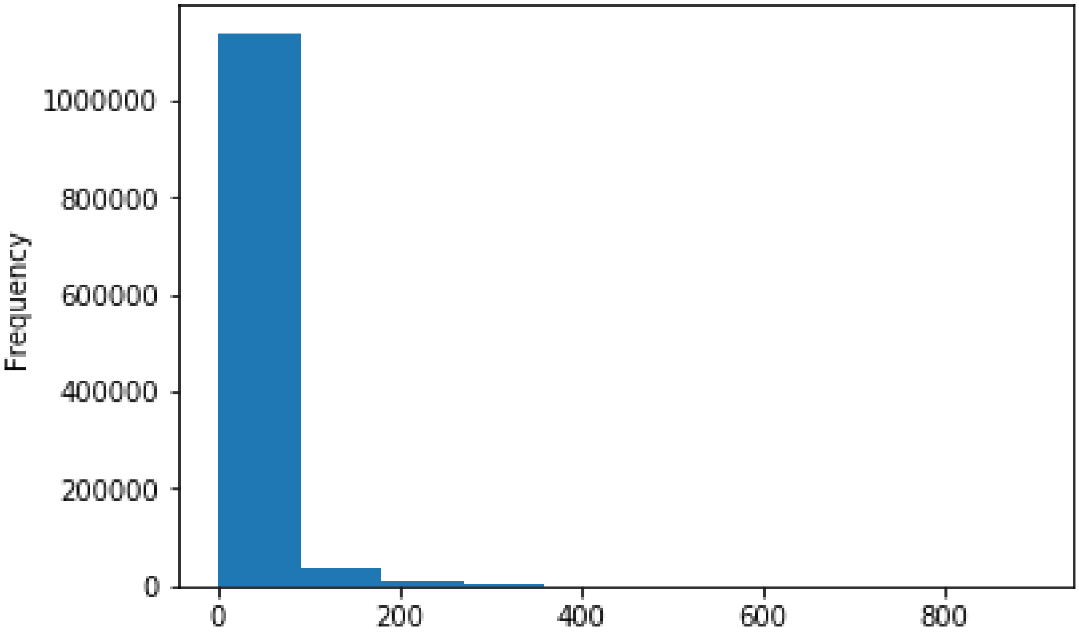
```
In [67]: #This table contains active minutes data before the experiment started.
         #It has a similar format as t1, except the dt range can extend before
         #the experiment start date.
         t3 = pd.read_csv("t3_user_active_min_pre.csv")
         print("the number of records is ",t3.shape)
         t3.head()
```

```
the number of records is  (1190093, 3)
```

```
Out[67]:    uid          dt  active_mins
         0    0  2018-09-24          3.0
         1    0  2018-11-08          4.0
         2    0  2018-11-24          3.0
         3    0  2018-11-28          6.0
         4    0  2018-12-02          6.0
```

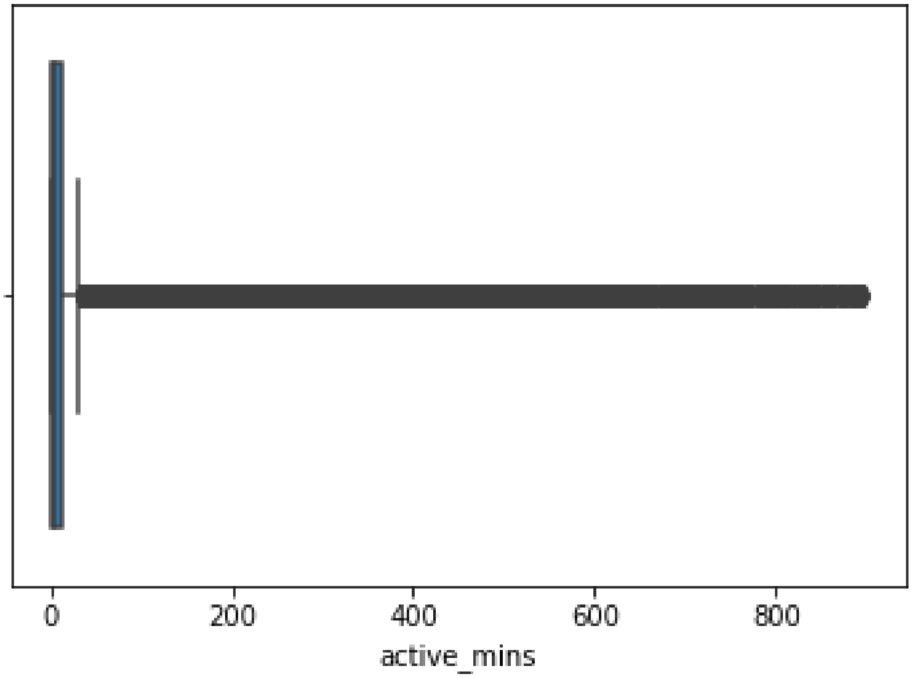
```
In [70]: t3 = t3[(t3.active_mins<=1440)]
         %matplotlib inline
         t3['active_mins'].plot.hist()
         t3['active_mins'].describe()
```

```
Out[70]: count    1.189927e+06
         mean     1.825735e+01
         std      4.354546e+01
         min      1.000000e+00
         25%      2.000000e+00
         50%      4.000000e+00
         75%      1.400000e+01
         max      8.970000e+02
         Name: active_mins, dtype: float64
```



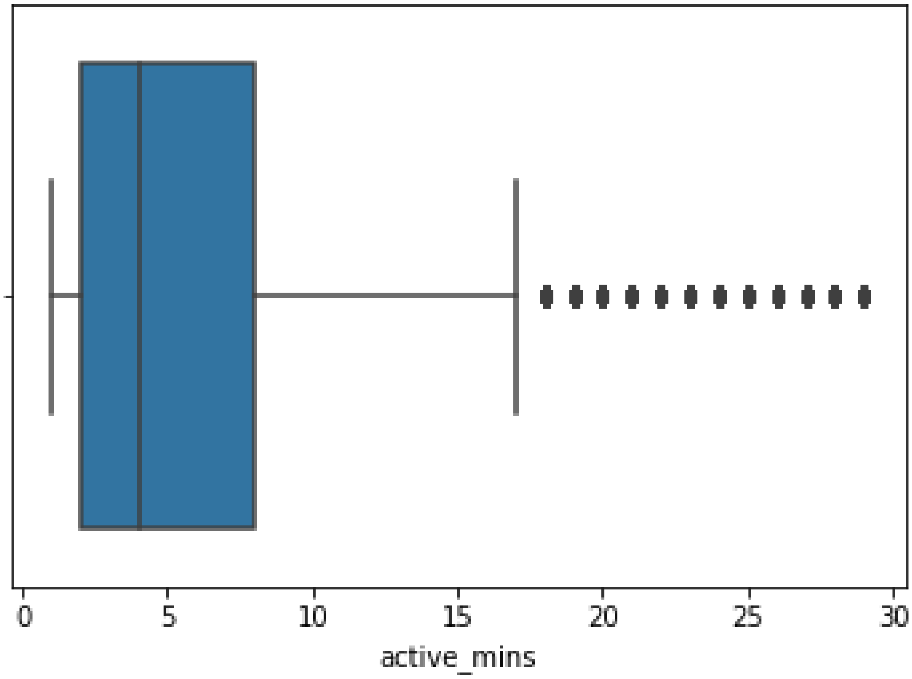
```
In [71]: sns.boxplot(x=t3['active_mins'])

Out[71]: <matplotlib.axes._subplots.AxesSubplot at 0x7fc66bc438d0>
```



```
In [74]: t3=t3[(t3.active_mins<(18.25+(3*43.54)))]
         sns.boxplot(x=t3['active_mins'])

Out[74]: <matplotlib.axes._subplots.AxesSubplot at 0x7fc66bb46d30>
```

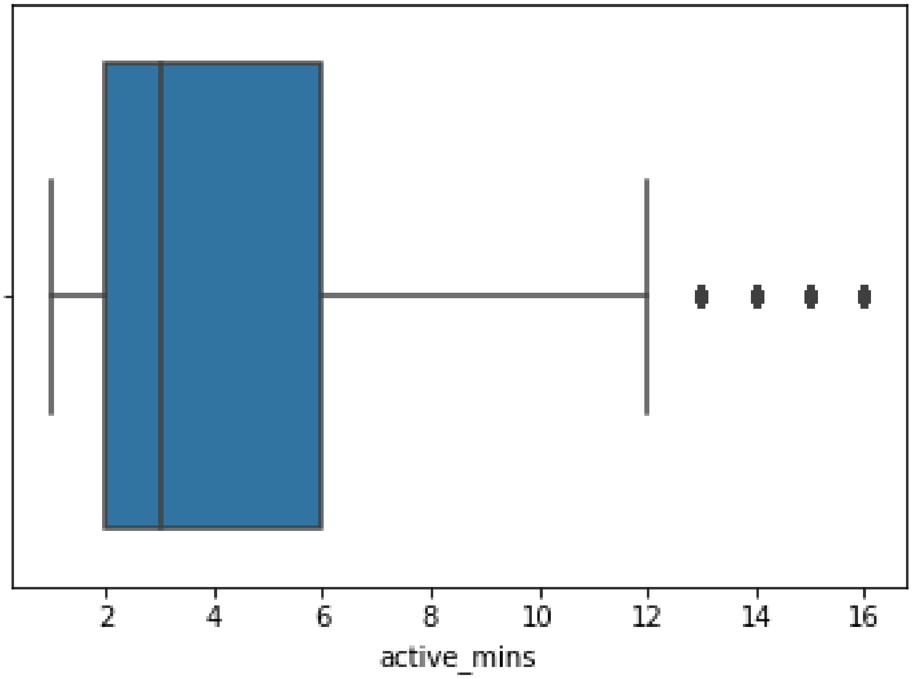


```
In [75]: # compute IQ range to filter outliers
         q1 = t3['active_mins'].quantile(0.25)
         q3 = t3['active_mins'].quantile(0.75)
         print(q1,q3)
         iqr = q3 - q1
         cutoff = 1.5*iqr
         t3 = t3[((t3.active_mins)> q1 - cutoff)]
         t3 = t3[((t3.active_mins)< q3 + cutoff)]

2.0 8.0
```

```
In [76]: sns.boxplot(x=t3['active_mins'])

Out[76]: <matplotlib.axes._subplots.AxesSubplot at 0x7fc66b759390>
```



```
In [80]: #check the dates of dataframe
         min_date = min(t3['dt'])
         max_date = max(t3['dt'])
         print('min_date is',min_date)
         print('max_date is',max_date)

min_date is 2018-08-10
max_date is 2019-02-05
```

```
In [81]: merged_df2 = pd.merge(left=t3,right=t2, left_on='uid', right_on='uid')
```

```
In [82]: merged_df2.head(10)
```

```
Out[82]:    uid        dt_x  active_mins  variant_number        dt_y signup_date
         0    0  2018-09-24          3.0               0  2019-02-06  2018-09-24
         1    0  2018-11-08          4.0               0  2019-02-06  2018-09-24
         2    0  2018-11-24          3.0               0  2019-02-06  2018-09-24
         3    0  2018-11-28          6.0               0  2019-02-06  2018-09-24
         4    0  2018-12-02          6.0               0  2019-02-06  2018-09-24
         5    0  2018-12-04          1.0               0  2019-02-06  2018-09-24
         6    0  2018-12-07          8.0               0  2019-02-06  2018-09-24
         7    0  2018-12-09          5.0               0  2019-02-06  2018-09-24
         8    0  2018-12-14          8.0               0  2019-02-06  2018-09-24
         9    0  2018-12-15          2.0               0  2019-02-06  2018-09-24
```

```
In [84]: merged_df2.variant_number.unique()
         merged_df2.variant_number.value_counts()

Out[84]: 0    754497
         1    164195
         Name: variant_number, dtype: int64

In [85]: df2 = merged_df2.groupby(['uid','variant_number'], as_index=False)['active_mins'].mean(
         df2.head()

Out[85]:    uid  variant_number  active_mins
         0    0               0     3.333333
         1    1               0    11.333333
         2    2               0     3.700000
         3    3               0     3.833333
         4    4               0     2.357143

In [99]: # mean before is computed based on all the users before the beginning of the experiment
         mean_before = df2['active_mins'].mean()
         var_before = df2['active_mins'].var()
         n_before = df2.shape[0]

         #compute the mean after rollout but only for users under treatment
         mean_after = df[df.variant_number==1]['active_mins'].mean()
         var_after = df[df.variant_number==1]['active_mins'].var()
         n_after = df[df.variant_number==1].shape[0]

         print(n_after)

         #print('mean before',mean_before)
         #print('mean after',mean_after)


9163


In [101]: # estimated standard deviation of the difference between the two means.
          sigma_dif = math.sqrt((var_before/n_before)+(var_after/n_after))
          upper = (mean_after-mean_before) + (1.96 * sigma_dif)
          lower = (mean_after-mean_before) - (1.96 * sigma_dif)
          print([lower,upper])

[1.2698277548728634, 1.372264409083204]


In [103]: #This table contains data about some user attributes.
          #Each row represents attributes of a unique user.
          t4 = pd.read_csv("t4_user_attributes.csv")
          print("the number of records is ",t4.shape)
          t4.head()
```

```
the number of records is  (50000, 3)
```

```
Out[103]:    uid gender   user_type
          0    0   male  non_reader
          1    1   male      reader
          2    2   male  non_reader
          3    3   male  non_reader
          4    4   male  non_reader
```

```
In [104]: t5 = pd.merge(left=t4,right=t2, left_on='uid', right_on='uid')
          t5.head()
```

```
Out[104]:    uid gender   user_type  variant_number          dt signup_date
          0    0   male  non_reader               0  2019-02-06  2018-09-24
          1    1   male      reader               0  2019-02-06  2016-11-07
          2    2   male  non_reader               0  2019-02-06  2018-09-17
          3    3   male  non_reader               0  2019-02-06  2018-03-04
          4    4   male  non_reader               0  2019-02-06  2017-03-09
```

```
In [105]: t5.shape
```

```
Out[105]: (50000, 6)
```

```
In [108]: pd.crosstab(t5['variant_number'],t5['gender']).apply(lambda r: r/r.sum(), axis=1)
```

```
Out[108]: gender            female      male  unknown
          variant_number
          0               0.290175  0.555925   0.1539
          1               0.287000  0.552000   0.1610
```

```
In [109]: pd.crosstab(t5['variant_number'],t5['user_type']).apply(lambda r: r/r.sum(), axis=1)
```

```
Out[109]: user_type       contributor  new_user  non_reader    reader
          variant_number
          0                  0.022875  0.091325    0.717475  0.168325
          1                  0.012900  0.123500    0.736700  0.126900
```

```
In [110]: pd.crosstab(t5['gender'],t5['user_type']).apply(lambda r: r/r.sum(), axis=1)
```

```
Out[110]: user_type  contributor  new_user  non_reader    reader
          gender
          female        0.017200  0.109898    0.723907  0.148995
          male          0.024462  0.083619    0.716108  0.175812
          unknown       0.014937  0.125676    0.735127  0.124260
```

```
In [111]: merged_df3 = pd.merge(left=t1,right=t5, left_on='uid', right_on='uid')
          merged_df3.head()
```

```
Out[111]:    uid        dt_x  active_mins gender   user_type  variant_number  \
          0     0  2019-02-22          5.0    male  non_reader               0
          1     0  2019-03-11          5.0    male  non_reader               0
          2     0  2019-03-18          3.0    male  non_reader               0
          3     0  2019-03-22          4.0    male  non_reader               0
          4     0  2019-04-03          9.0    male  non_reader               0

                   dt_y signup_date
          0  2019-02-06  2018-09-24
          1  2019-02-06  2018-09-24
          2  2019-02-06  2018-09-24
          3  2019-02-06  2018-09-24
          4  2019-02-06  2018-09-24
```

```
In [116]: # group by user to compute mean time across all his/her visit.
          df3 = merged_df3.groupby(['uid','variant_number','gender','user_type'], as_index=False
          df3.shape # we have 46525 unique users in both groups
          #df3.variant_number.value_counts()
```

```
Out[116]: (46525, 5)
```

```
In [117]: df3.head()
```

```
Out[117]:    uid  variant_number gender   user_type  active_mins
          0     0               0   male  non_reader     3.307692
          1     1               0   male      reader     9.000000
          2     2               0   male  non_reader     2.428571
          3     3               0   male  non_reader     3.208333
          4     4               0   male  non_reader     1.950000
```

```
In [171]: df3.to_csv('df3_quora.csv')
```

```
In [122]: #stats = df3.groupby(['variant_number','gender','user_type'])['active_mins'].agg(['mea
          #stats = df3.groupby(['variant_number','gender'])['active_mins'].agg(['mean', 'count',
          stats = df3.groupby(['variant_number','user_type'])['active_mins'].agg(['mean', 'count

          stats
```

```
Out[122]:    variant_number    user_type      mean  count       std       var
          0               0  contributor  8.067700    885  2.948805  8.695448
          1               0     new_user  2.892973   2371  1.828464  3.343280
          2               0   non_reader  3.471255  27442  1.679886  2.822016
          3               0       reader  6.871204   6664  2.581401  6.663631
          4               1  contributor  8.062027    124  2.507654  6.288329
          5               1     new_user  4.414679    796  2.522767  6.364354
          6               1   non_reader  4.919898   6994  2.034194  4.137944
          7               1       reader  7.654943   1249  2.230615  4.975642
```

```
In [144]: utype='contributor'
          control = stats[(stats.variant_number==0) & (stats.user_type==utype)]
```

```
        treat = stats[(stats.variant_number==1) & (stats.user_type==utype)]
        #sigma_dif = math.sqrt((control['var'][0]/control['count'][0])+((treat['var'][0]/treat
        treat.iloc[0]['var']
```

```
Out[144]: 6.2883294657262665
```

```
In [153]: #create function to compute confidence interval given a user_type category and data fr
          def ci_usertype(stats,utype):
              control = stats[(stats.variant_number==0) & (stats.user_type==utype)]
              treat = stats[(stats.variant_number==1) & (stats.user_type==utype)]

              sigma_dif = math.sqrt((control.iloc[0]['var']/control.iloc[0]['count'])+((treat.il
              upper = (treat.iloc[0]['mean']-control.iloc[0]['mean']) + (1.96 * sigma_dif)
              lower = (treat.iloc[0]['mean']-control.iloc[0]['mean']) - (1.96 * sigma_dif)
              return (lower,upper)
```

```
(-0.4879189443104225, 0.47657393324998065)
```

```
In [155]: # run the function on all unique user_type categories

          utypes=stats['user_type'].unique()
          utypes=utypes.tolist()
          utypes

          for u in utypes:
              inter = ci_usertype(stats,u)
              print(u, '--->', inter)
```

```
contributor ---> (-0.4879189443104225, 0.47657393324998065)
new_user ---> (1.3316220606045999, 1.7117911439585125)
non_reader ---> (1.3969912190555374, 1.5002947542414995)
reader ---> (0.6453729886947472, 0.9221051371502116)
```

```
In [156]: stats2 = df3.groupby(['variant_number','gender'])['active_mins'].agg(['mean', 'count',

          stats2
```

```
Out[156]:   variant_number   gender      mean  count       std       var
          0              0   female  3.961722  10725  2.305638  5.315969
          1              0     male  4.318368  20961  2.487382  6.187067
          2              0  unknown  3.883059   5676  2.248822  5.057200
          3              1   female  5.147343   2599  2.392395  5.723552
          4              1     male  5.403433   5112  2.318357  5.374780
          5              1  unknown  5.154455   1452  2.348080  5.513481
```

```
In [158]: #create function to compute confidence interval given a user_type category and data fr
          def ci_gender(stats,gen):
              control = stats[(stats.variant_number==0) & (stats.gender==gen)]
              treat = stats[(stats.variant_number==1) & (stats.gender==gen)]

              sigma_dif = math.sqrt((control.iloc[0]['var']/control.iloc[0]['count'])+((treat.il
              upper = (treat.iloc[0]['mean']-control.iloc[0]['mean']) + (1.96 * sigma_dif)
              lower = (treat.iloc[0]['mean']-control.iloc[0]['mean']) - (1.96 * sigma_dif)
              return (lower,upper)
```

```
In [161]: ugender=stats2['gender'].unique()
          ugender=ugender.tolist()
          ugender

          for g in ugender:
              inter = ci_gender(stats2,g)
              print(g, '--->', inter)
```

```
female ---> (1.0838168999869435, 1.2874258861290009)
male ---> (1.0131414147714226, 1.1569885842349406)
unknown ---> (1.1371945853770327, 1.405597029108042)
```

```
In [163]: stats3 = df3.groupby(['variant_number','gender','user_type'])['active_mins'].agg(['mea
          stats3
```

```
Out[163]:     variant_number   gender    user_type      mean  count       std        var
          0                0   female  contributor  7.142652    220  2.676451   7.163392
          1                0   female     new_user  2.822876    762  1.777076   3.157999
          2                0   female   non_reader  3.374448   7935  1.700659   2.892242
          3                0   female       reader  6.632086   1808  2.494685   6.223454
          4                0     male  contributor  8.492587    572  2.924966   8.555426
          5                0     male     new_user  2.955687   1132  1.840741   3.388328
          6                0     male   non_reader  3.537730  15178  1.666697   2.777879
          7                0     male       reader  7.015949   4079  2.611095   6.817815
          8                0  unknown  contributor  7.642702     93  3.170050  10.049217
          9                0  unknown     new_user  2.856120    477  1.878277   3.527926
          10               0  unknown   non_reader  3.415631   4329  1.677374   2.813585
          11               0  unknown       reader  6.667744    777  2.571137   6.610747
          12               1   female  contributor  7.844039     26  2.208249   4.876364
          13               1   female     new_user  4.464382    274  2.587578   6.695559
          14               1   female   non_reader  4.810470   1968  2.142444   4.590068
          15               1   female       reader  7.503789    331  2.141313   4.585221
          16               1     male  contributor  8.320709     79  2.506627   6.283178
          17               1     male     new_user  4.354160    369  2.472309   6.112312
          18               1     male   non_reader  4.998772   3920  1.973386   3.894253
          19               1     male       reader  7.746163    744  2.221167   4.933583
          20               1  unknown  contributor  7.284756     19  2.823186   7.970380
          21               1  unknown     new_user  4.471628    153  2.539061   6.446829
```

```
        22                1   unknown   non_reader  4.835059   1106  2.038206   4.154286
        23                1   unknown       reader  7.552438    174  2.422491   5.868462
```

```
In [167]: covariates = [(a,b) for a in ugender for b in utypes]
          covariates
          len(covariates)
```

```
Out[167]: 12
```

```
In [169]: def ci_covariates(stats,cov):
              control = stats[(stats.variant_number==0) & (stats.gender==cov[0]) & (stats.user_t
              treat = stats[(stats.variant_number==1) & (stats.gender==cov[0]) & (stats.user_typ

              sigma_dif = math.sqrt((control.iloc[0]['var']/control.iloc[0]['count'])+((treat.il
              upper = (treat.iloc[0]['mean']-control.iloc[0]['mean']) + (1.96 * sigma_dif)
              lower = (treat.iloc[0]['mean']-control.iloc[0]['mean']) - (1.96 * sigma_dif)
              return (lower,upper)
```

```
In [170]: for c in covariates:
              inter = ci_covariates(stats3,c)
              print(c, '--->', inter)
```

```
('female', 'contributor') ---> (-0.2181710324317161, 1.6209454206671288)
('female', 'new_user') ---> (1.3101518625750066, 1.9728603216581513)
('female', 'non_reader') ---> (1.3342376926849375, 1.5378077703842925)
('female', 'reader') ---> (0.613943688075681, 1.1294617876307897)
('male', 'contributor') ---> (-0.7743697022060778, 0.43061390495753704)
('male', 'new_user') ---> (1.1243689244004251, 1.6725771584888394)
('male', 'non_reader') ---> (1.3938146345782447, 1.5282684611886996)
('male', 'reader') ---> (0.5516221399068965, 0.9088071350362895)
('unknown', 'contributor') ---> (-1.781544948687302, 1.0656539264384974)
('unknown', 'new_user') ---> (1.179293254438179, 2.0517219238093998)
('unknown', 'non_reader') ---> (1.2893264050791, 1.5495292036690422)
('unknown', 'reader') ---> (0.48189251181388243, 1.2874962369534175)
```

```
In [ ]:
```

```
library(readr)
library(ggplot2)
df3 <- read_csv("quora_challenge/df3_quora.csv",
                      col_types = cols(X1 = col_skip()))
View(df3)

nrow(df3)

table(df3$variant_number,exclude=NULL)


#boxplot user type
g <- ggplot(df3, aes(user_type, active_mins))
g + geom_boxplot(aes(fill=factor(variant_number)))+
  scale_fill_manual(values=c('#107896','#AA2200'))+
  theme(
    panel.background = element_blank(),
    panel.grid.major =  element_line(colour = "grey",size=0.01,linetype =
8),
    panel.grid.minor = element_blank(),
    axis.line.x = element_line(colour = "black"),
    axis.line.y = element_line(colour = "black"),
    #legend.background = element_rect(fill="transparent", size=0.5,
linetype="solid"),
    #legend.position = c(0.1,0.9),
    legend.text = element_text(colour="black", size=14),
    legend.title=element_text(size=14),
    legend.box = "horizontal",
    axis.text = element_text(colour = "black"),
    axis.text.x = element_text(size = 14,vjust=0.6),
    axis.text.y = element_text(size = 14),
    axis.title = element_text(size = 14),
    strip.text.x = element_text(size = 14)) + labs(x='User Type',y='Active
Mins') + guides(fill=guide_legend(title="Treatment"))


#boxplot user gender
g <- ggplot(df3, aes(gender, active_mins))
g + geom_boxplot(aes(fill=factor(variant_number)))+
  scale_fill_manual(values=c('#107896','#AA2200'))+
  theme(
    panel.background = element_blank(),
    panel.grid.major =  element_line(colour = "grey",size=0.01,linetype =
8),
    panel.grid.minor = element_blank(),
    axis.line.x = element_line(colour = "black"),
    axis.line.y = element_line(colour = "black"),
    #legend.background = element_rect(fill="transparent", size=0.5,
linetype="solid"),
    #legend.position = c(0.1,0.9),
    legend.text = element_text(colour="black", size=14),
    legend.title=element_text(size=14),
    legend.box = "horizontal",
    axis.text = element_text(colour = "black"),
    axis.text.x = element_text(size = 14,vjust=0.6),
    axis.text.y = element_text(size = 14),
    axis.title = element_text(size = 14),
    strip.text.x = element_text(size = 14)) + labs(x='User
Gender',y='Active Mins') + guides(fill=guide_legend(title="Treatment"))



#boxplot interaction

df3$f1f2 <- interaction(df3$user_type, df3$gender)

g <- ggplot(df3, aes(f1f2, active_mins))
g + geom_boxplot(aes(fill=factor(variant_number)))+
  scale_fill_manual(values=c('#107896','#AA2200'))+
  theme(
    panel.background = element_blank(),
    panel.grid.major =  element_line(colour = "grey",size=0.01,linetype =
8),
    panel.grid.minor = element_blank(),
    axis.line.x = element_line(colour = "black"),
    axis.line.y = element_line(colour = "black"),
    #legend.background = element_rect(fill="transparent", size=0.5,
linetype="solid"),
    #legend.position = c(0.1,0.9),
    legend.text = element_text(colour="black", size=14),
    legend.title=element_text(size=14),
    legend.box = "horizontal",
    axis.text = element_text(colour = "black"),
    axis.text.x = element_text(size = 14,vjust=0.6,angle=90),
    axis.text.y = element_text(size = 14),
    axis.title = element_text(size = 14),
    strip.text.x = element_text(size = 14)) + labs(x='User Type-
Gender',y='Active Mins') + guides(fill=guide_legend(title="Treatment"))
```