```
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
import datetime as dt
from sklearn.model_selection import train_test_split
import sklearn
import statsmodels.api as sm
from sklearn.linear_model import LinearRegression
import warnings
warnings.filterwarnings('ignore')
```

Evil Geniuses Data Science Assessment

Load Data

```
df = pd.read_csv('data/starcraft_player_data.csv')
df.head()
```

```
   GameID  LeagueIndex Age HoursPerWeek TotalHours       APM
SelectByHotkeys  \
0      52            5  27           10       3000  143.7180
0.003515
1      55            5  23           10       5000  129.2322
0.003304
2      56            4  30           10        200   69.9612
0.001101
3      57            3  19           20        400  107.6016
0.001034
4      58            3  32           10        500  122.8908
0.001136

   AssignToHotkeys  UniqueHotkeys  MinimapAttacks  MinimapRightClicks
\
0         0.000220              7        0.000110            0.000392

1         0.000259              4        0.000294            0.000432

2         0.000336              4        0.000294            0.000461

3         0.000213              1        0.000053            0.000543

4         0.000327              2        0.000000            0.001329


   NumberOfPACs  GapBetweenPACs  ActionLatency  ActionsInPAC  \
0      0.004849         32.6677        40.8673        4.7508
1      0.004307         32.9194        42.3454        4.8434
2      0.002926         44.6475        75.3548        4.0430
```

```
3      0.003783          29.2203         53.7352         4.9155
4      0.002368          22.6885         62.0813         9.3740

   TotalMapExplored  WorkersMade  UniqueUnitsMade  ComplexUnitsMade  \
0                28     0.001397                6               0.0
1                22     0.001193                5               0.0
2                22     0.000745                6               0.0
3                19     0.000426                7               0.0
4                15     0.001174                4               0.0

   ComplexAbilitiesUsed
0              0.000000
1              0.000208
2              0.000189
3              0.000384
4              0.000019
```

Cleaning Data

Removing NaN

There are many rows with ? as data entries, so I dropped those rows from the dataset for simplicity.

```
mask = np.column_stack([df[col].astype(str).str.contains(r"\?") for
col in df])
df = df.loc[~mask.any(axis=1)].dropna()
df
```

```
      GameID  LeagueIndex Age HoursPerWeek TotalHours       APM  \
0         52            5  27           10       3000  143.7180
1         55            5  23           10       5000  129.2322
2         56            4  30           10        200   69.9612
3         57            3  19           20        400  107.6016
4         58            3  32           10        500  122.8908
...      ...          ...  ..          ...        ...       ...
3335    9261            4  20            8        400  158.1390
3336    9264            5  16           56       1500  186.1320
3337    9265            4  21            8        100  121.6992
3338    9270            3  20           28        400  134.2848
3339    9271            4  22            6        400   88.8246

      SelectByHotkeys  AssignToHotkeys  UniqueHotkeys  MinimapAttacks
\
0            0.003515         0.000220              7        0.000110

1            0.003304         0.000259              4        0.000294
```

```
2            0.001101         0.000336              4        0.000294

3            0.001034         0.000213              1        0.000053

4            0.001136         0.000327              2        0.000000

...               ...              ...            ...             ...

3335         0.013829         0.000504              7        0.000217

3336         0.006951         0.000360              6        0.000083

3337         0.002956         0.000241              8        0.000055

3338         0.005424         0.000182              5        0.000000

3339         0.000844         0.000108              2        0.000000
```

```
      MinimapRightClicks  NumberOfPACs  GapBetweenPACs  ActionLatency
\
0                 0.000392      0.004849         32.6677        40.8673

1                 0.000432      0.004307         32.9194        42.3454

2                 0.000461      0.002926         44.6475        75.3548

3                 0.000543      0.003783         29.2203        53.7352

4                 0.001329      0.002368         22.6885        62.0813

...                    ...           ...             ...            ...

3335              0.000313      0.003583         36.3990        66.2718

3336              0.000166      0.005414         22.8615        34.7417

3337              0.000208      0.003690         35.5833        57.9585

3338              0.000480      0.003205         18.2927        62.4615

3339              0.000341      0.003099         45.1512        63.4435
```

```
      ActionsInPAC  TotalMapExplored  WorkersMade  UniqueUnitsMade  \
0           4.7508                28     0.001397                6
1           4.8434                22     0.001193                5
2           4.0430                22     0.000745                6
```

```
3           4.9155                19     0.000426                 7
4           9.3740                15     0.001174                 4
...            ...               ...          ...               ...
3335        4.5097                30     0.001035                 7
3336        4.9309                38     0.001343                 7
3337        5.4154                23     0.002014                 7
3338        6.0202                18     0.000934                 5
3339        5.1913                20     0.000476                 8

      ComplexUnitsMade  ComplexAbilitiesUsed
0                  0.0              0.000000
1                  0.0              0.000208
2                  0.0              0.000189
3                  0.0              0.000384
4                  0.0              0.000019
...                ...                   ...
3335               0.0              0.000287
3336               0.0              0.000388
3337               0.0              0.000000
3338               0.0              0.000000
3339               0.0              0.000054

[3338 rows x 20 columns]
```

Converting dTypes

Checking data types to ensure all numerical data is in int/float form

```
df.dtypes
```

```
GameID                   int64
LeagueIndex              int64
Age                     object
HoursPerWeek            object
TotalHours              object
APM                    float64
SelectByHotkeys        float64
AssignToHotkeys        float64
UniqueHotkeys            int64
MinimapAttacks         float64
MinimapRightClicks     float64
NumberOfPACs           float64
GapBetweenPACs         float64
ActionLatency          float64
ActionsInPAC           float64
TotalMapExplored         int64
WorkersMade            float64
UniqueUnitsMade          int64
ComplexUnitsMade       float64
ComplexAbilitiesUsed   float64
dtype: object
```

Age, HoursPerWeek, and TotalHours are objects (likely due to previous existing ? entries), so these columns will be converted to integers.

```
df[["Age", "HoursPerWeek", "TotalHours"]] = df[["Age", "HoursPerWeek",
"TotalHours"]].astype(int)
df.dtypes
```

```
GameID                  int64
LeagueIndex             int64
Age                     int64
HoursPerWeek            int64
TotalHours              int64
APM                   float64
SelectByHotkeys       float64
AssignToHotkeys       float64
UniqueHotkeys           int64
MinimapAttacks        float64
MinimapRightClicks    float64
NumberOfPACs          float64
GapBetweenPACs        float64
ActionLatency         float64
ActionsInPAC          float64
TotalMapExplored        int64
WorkersMade           float64
UniqueUnitsMade         int64
ComplexUnitsMade      float64
ComplexAbilitiesUsed  float64
dtype: object
```

EDA

A general description of the data:

```
df.describe().T
```

```
                       count         mean           std        min  \
GameID                3338.0  4719.552127   2656.919630  52.000000
LeagueIndex           3338.0     4.120731      1.448170   1.000000
Age                   3338.0    21.650389      4.206357  16.000000
HoursPerWeek          3338.0    15.909527     11.964495   0.000000
TotalHours            3338.0   960.421809  17318.133922   3.000000
APM                   3338.0   114.575763     48.111912  22.059600
SelectByHotkeys       3338.0     0.004023      0.004726   0.000000
AssignToHotkeys       3338.0     0.000364      0.000210   0.000000
UniqueHotkeys         3338.0     4.316357      2.333322   0.000000
MinimapAttacks        3338.0     0.000094      0.000159   0.000000
MinimapRightClicks    3338.0     0.000380      0.000359   0.000000
NumberOfPACs          3338.0     0.003433      0.000966   0.000679
GapBetweenPACs        3338.0    40.713819     17.057191   6.666700
ActionLatency         3338.0    64.209584     19.037394  24.632600
ActionsInPAC          3338.0     5.266955      1.500605   2.038900
```

TotalMapExplored	3338.0	22.116836	7.440875	5.000000
WorkersMade	3338.0	0.001031	0.000520	0.000077
UniqueUnitsMade	3338.0	6.541043	1.859049	2.000000
ComplexUnitsMade	3338.0	0.000060	0.000112	0.000000
ComplexAbilitiesUsed	3338.0	0.000142	0.000266	0.000000

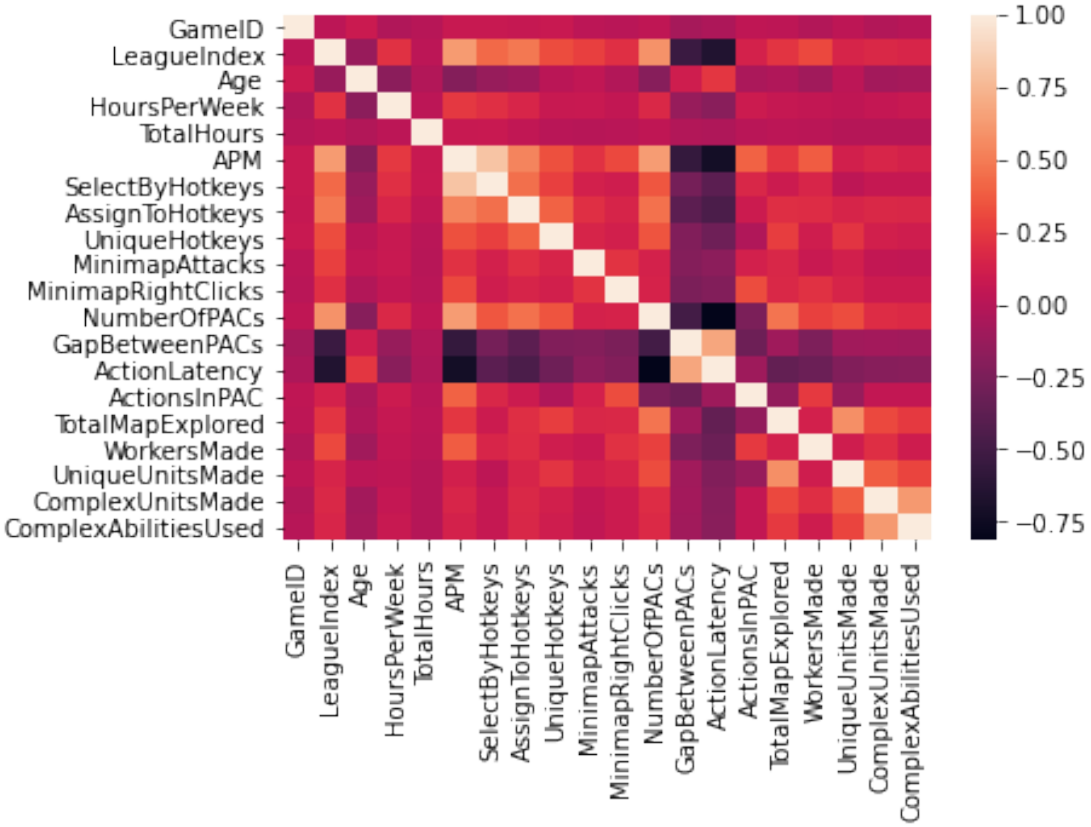
	25%	50%	75%	max
GameID	2423.250000	4788.000000	6994.750000	9271.000000
LeagueIndex	3.000000	4.000000	5.000000	7.000000
Age	19.000000	21.000000	24.000000	44.000000
HoursPerWeek	8.000000	12.000000	20.000000	168.000000
TotalHours	300.000000	500.000000	800.000000	1000000.000000
APM	79.231500	107.070300	140.156100	389.831400
SelectByHotkeys	0.001245	0.002445	0.004945	0.043088
AssignToHotkeys	0.000202	0.000349	0.000493	0.001648
UniqueHotkeys	3.000000	4.000000	6.000000	10.000000
MinimapAttacks	0.000000	0.000039	0.000113	0.003019
MinimapRightClicks	0.000139	0.000278	0.000508	0.003688
NumberOfPACs	0.002743	0.003376	0.004003	0.007971
GapBetweenPACs	29.326600	37.058900	48.510425	237.142900
ActionLatency	50.886425	61.296100	74.032525	176.372100
ActionsInPAC	4.261525	5.087050	6.027350	18.558100
TotalMapExplored	17.000000	22.000000	27.000000	58.000000
WorkersMade	0.000682	0.000904	0.001258	0.005149
UniqueUnitsMade	5.000000	6.000000	8.000000	13.000000
ComplexUnitsMade	0.000000	0.000000	0.000087	0.000902
ComplexAbilitiesUsed	0.000000	0.000020	0.000182	0.003084

The table above is hard to interpret, so I will opt for a visual approach.

To see if there is any linear correlation between factors, I will plot correlations for all possible pairs of factors on a heatmap.

```
sns.heatmap(df.corr())
```

```
<AxesSubplot:>
```



Now, to get a general idea for the distribution of data values, I will plot density plots for each numerical factor based on each LeagueIndex. In order to do this, I will need to create a new table in order to easily plot the distributions for all factors.

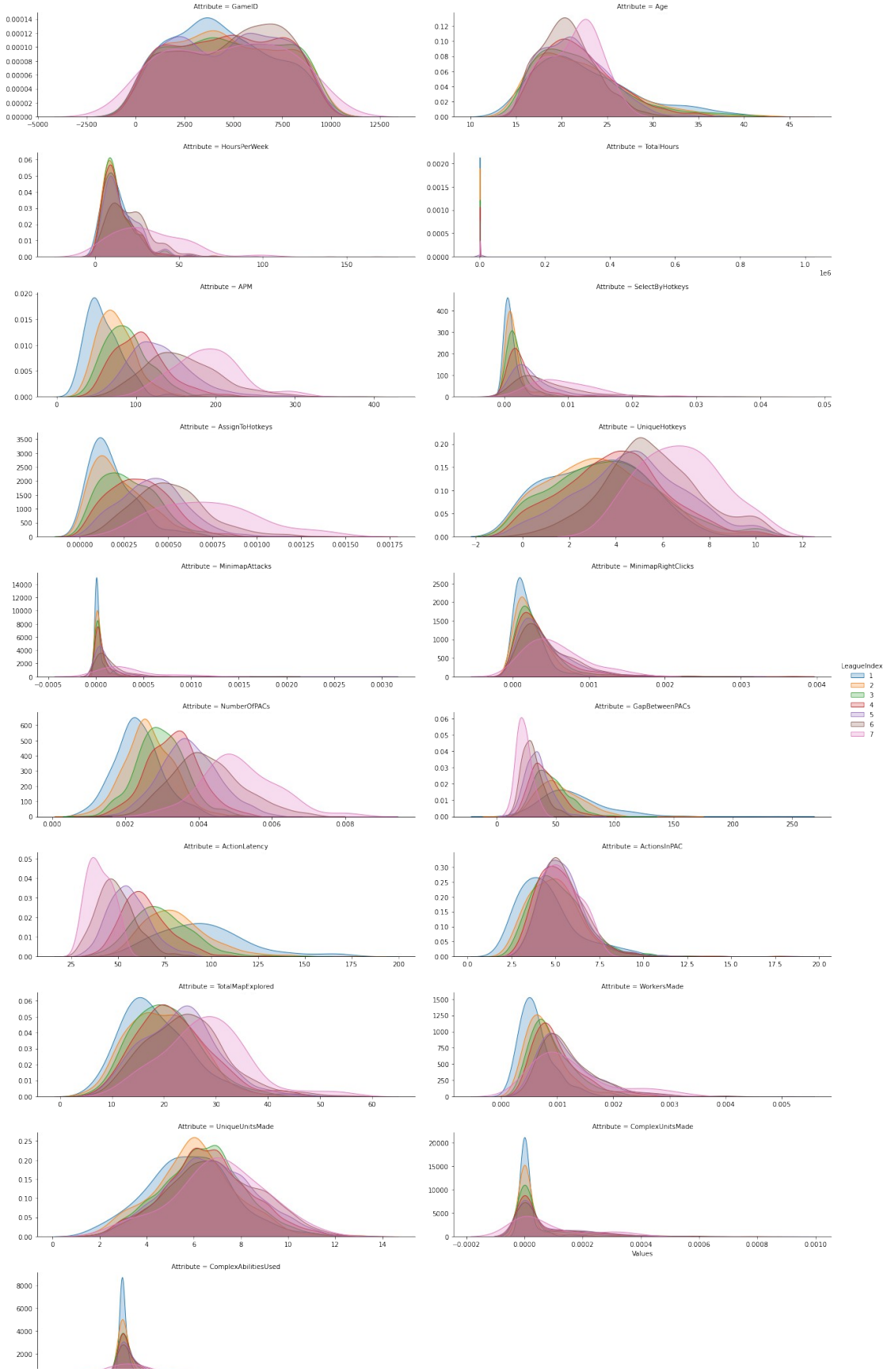
```
# Index on LeagueIndex
tidy_df = df.set_index("LeagueIndex")

# Stack column names into a column, obtaining a "long" version of the
dataset
tidy_df = tidy_df.stack()
# Reset indices into proper columns for plotting purposes
tidy_df = tidy_df.reset_index()
# Rename column names
tidy_df = tidy_df.rename(columns={
                         'level_1': 'Attribute',
                         0: 'Values'})
tidy_df
```

```
       LeagueIndex             Attribute       Values
0                5                GameID    52.000000
1                5                   Age    27.000000
2                5          HoursPerWeek    10.000000
3                5            TotalHours  3000.000000
4                5                   APM   143.718000
...            ...                   ...          ...
63417            4      TotalMapExplored    20.000000
63418            4           WorkersMade     0.000476
63419            4        UniqueUnitsMade     8.000000
63420            4      ComplexUnitsMade     0.000000
63421            4  ComplexAbilitiesUsed     0.000054

[63422 rows x 3 columns]
```

```
facets = sns.FacetGrid(data=tidy_df, col='Attribute',
hue="LeagueIndex",
                       sharey=False, sharex=False, aspect=3,
col_wrap=2)
    # Build the plot from `sns.kdeplot`
_ = facets.map(sns.kdeplot, 'Values', shade=True).add_legend()
```


Attribute = GameID
Attribute = Age
Attribute = HoursPerWeek
Attribute = TotalHours
1e6
Attribute = APM
Attribute = SelectByHotkeys
Attribute = AssignToHotkeys
Attribute = UniqueHotkeys
Attribute = MinimapAttacks
Attribute = MinimapRightClicks
Attribute = NumberOfPACs
Attribute = GapBetweenPACs
Attribute = ActionLatency
Attribute = ActionsInPAC
Attribute = TotalMapExplored
Attribute = WorkersMade
Attribute = UniqueUnitsMade
Attribute = ComplexUnitsMade
Values
Attribute = ComplexAbilitiesUsed
LeagueIndex
1
2
3
4
5
6
7

From the plots above, factors involving Hotkeys, PACs, and ActionLatency seem to have meaningful correlations/distinctions between each league, so I will explore those further in the next section.

Modeling

```
import sklearn.ensemble as ske
from sklearn.metrics import mean_squared_error, accuracy_score,
mean_absolute_error, r2_score
from sklearn.linear_model import RidgeCV, LassoCV, ElasticNet,
LogisticRegression
```

model_performance is a function used to obtain accuracy and error scores for each model.

```
def model_performance(model, X_train, y_train, X_test, y_test):
    model.fit(X_train, y_train)
    train_score = model.score(X_train, y_train)
    test_score = model.score(X_test, y_test)
    train_sqerr = mean_squared_error(model.predict(X_train), y_train)
    test_sqerr = mean_squared_error(model.predict(X_test), y_test)
    mean_test_err = mean_absolute_error(model.predict(X_test), y_test)

    ## The lines below can be commented out to print values, currently
commented to
    ## reduce model output

#     print("score for the training set: ", train_score)
#     print("score for the test set: ", test_score)
#     print("mean squared error for the training set: ", train_sqerr)
#     print("mean squared error for the test set: ", test_sqerr)
#     print("mean abs error for test set: ", mean_test_err)

    return {"train_score": train_score,
            "test_score": test_score,
            "train_sqerr":train_sqerr,
            "test_sqerr":test_sqerr,
            "mean_test_err":mean_test_err}
```

identify_features will run a certain model using each feature individually, and rank each feature based on its resulting r2 score. The model later on will take the n best features for testing.

```
def identify_features(model, X, y):
    rankings_df = pd.DataFrame(columns=['feature', 'R2_score'])
    for feature in X.columns.values:
        m = model.fit(X[[feature]], y)
        rankings_df = rankings_df.append({'feature': feature,
```

```
'R2_score': r2_score(X[[feature]], y)}, ignore_index=True)
    return rankings_df.sort_values(by=['R2_score'])

def model(model, df, num_features, test_size, nfeatures=None):

    ## not taking GameID into consideration (simiar to a player's
name, an ID has no effect on results)
    df = df.drop(columns="GameID")

    features = identify_features(model,
df.drop(columns="LeagueIndex"), df["LeagueIndex"])
    ## Comment out to display r2 scores for each feature ##
#     display(features)

    n_features = features.feature[-num_features:]
    if nfeatures != None:
        n_features = nfeatures
    print("features: " + str(list(n_features)))

    train, test = train_test_split(df, test_size=test_size)

    X_train = train[n_features]
    y_train = train["LeagueIndex"]
    model.fit(X_train, y_train)

    X_test = test[n_features]
    y_test = test["LeagueIndex"]

    y_pred = model.predict(X_test)
    test["LeagueIndex_pred"] = y_pred

    return model_performance(model, X_train, y_train, X_test, y_test)
```

Linear Regression

Since the obvious assumption is to assume linear increases/decreases as leagues increase/decrease, I will try modeling using lnear regression.

Manually selecting features just from visually looking at plots:

```
linreg = LinearRegression()

features = {"APM",
            "AssignToHotkeys",
            "UniqueHotkeys",
            "TotalMapExplored",
            "NumberOfPACs",
```

```
            "ActionLatency",
            "HoursPerWeek"}
model(linreg, df, 7, 0.2, features)
```

```
features: ['NumberOfPACs', 'AssignToHotkeys', 'HoursPerWeek',
'UniqueHotkeys', 'APM', 'TotalMapExplored', 'ActionLatency']

{'train_score': 0.5075427766110848,
 'test_score': 0.5188473943822968,
 'train_sqerr': 1.0246396334120993,
 'test_sqerr': 1.0383926750715238,
 'mean_test_err': 0.8248180744140132}
```

Automatic feature selection based on r2 scores, then taking means of multiple random runs of each model with different n number of features selected.

```
for i in np.arange(3,9):
    print("num_features: ", i)
    mean_test_score = []
    for j in range(20):
        output = model(linreg, df, i, 0.2)["test_score"]
        if output >= 0:
            mean_test_score.append(output)

    mean_test_score = np.mean(mean_test_score)
    print("Mean test score: ", mean_test_score)
```

```
num_features:  3
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
Mean test score:  0.14158748215421138
num_features:  4
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
```

```
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
Mean test score:  0.14818979999976284
num_features:  5
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
```

```
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
Mean test score:  0.16367054229166975
num_features:  6
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
```

```
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
Mean test score:  0.3520492642398121
num_features:  7
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']

features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
```

```
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
Mean test score:  0.4648296280782176
num_features:  8
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs',
'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs',
'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs',
'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs',
'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs',
'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs',
'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs',
'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs',
'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs',
'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs',
'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs',
'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours',
```

```
'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs',
'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs',
'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs',
'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs',
'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs',
'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs',
'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs',
'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs',
'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs',
'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
Mean test score:  0.45959238601020364
```

Logistic Regression

Modeling with logistic correlation

```
logreg = LogisticRegression()
for i in np.arange(3,9):
    print("num_features: ", i)
    mean_test_score = []
    for j in range(5):
        output = model(logreg, df, i, 0.2)["test_score"]
        if output >= 0:
            mean_test_score.append(output)

    mean_test_score = np.mean(mean_test_score)
    print("Mean test score: ", mean_test_score)
```

```
num_features:  3
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
```

```
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
Mean test score:  0.24461077844311374
num_features:  4
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
Mean test score:  0.29371257485029945
num_features:  5
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
Mean test score:  0.29041916167664666
num_features:  6
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
Mean test score:  0.32395209580838324
num_features:  7
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
```

```
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
Mean test score:  0.3712574850299401
num_features:  8
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs',
'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs',
'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs',
'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs',
'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs',
'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
Mean test score:  0.3664670658682635
```

Random Forest: a non-linear approach

A more complex and less interpretable model, but potentially a better fit/predictor for the data.

```
rf = ske.RandomForestRegressor()
```

```
model(rf, df, 7, 0.2)
```

```
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
```

```
{'train_score': 0.9367271649520976,
 'test_score': 0.4585047964627068,
 'train_sqerr': 0.1347134831460674,
 'test_sqerr': 1.0527838323353294,
 'mean_test_err': 0.8144311377245509}
```

```
for i in np.arange(3,9):
    print("num_features: ", i)
    mean_test_score = 0
    for j in range(10):
        output = model(rf, df, i, 0.2)
        mean_test_score += output["test_score"]

    mean_test_score /= 10
    print("Mean test score: ", mean_test_score)
```

```
num_features:  3
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
Mean test score:  0.12678565183905435
num_features:  4
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
Mean test score:  0.24970972741847675
num_features:  5
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
```

```
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
Mean test score:  0.2662650502540685
num_features:  6
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
Mean test score:  0.436223457507287
num_features:  7
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
Mean test score:  0.5329013064715193
```

```
num_features:  8
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
Mean test score:  0.5281401598425626
```

Other models:

Testing performances of different models below for different errors, collinearity, and/or outliers.

Ridge

```
ridge = RidgeCV()

for i in np.arange(3,9):
    print("num_features: ", i)
    mean_test_score = 0
    for j in range(3):
        output = model(ridge, df, i, 0.2)
        mean_test_score += output["test_score"]
```

```
    mean_test_score /= 3
    print("Mean test score: ", mean_test_score)
```

```
num_features:  3
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
Mean test score:  0.12686054143157108
num_features:  4
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
Mean test score:  -63.24275095617651
num_features:  5
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
Mean test score:  -30.22541190257431
num_features:  6
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
Mean test score:  -23.961047157799538
num_features:  7
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
Mean test score:  0.4850690731132424
num_features:  8
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs',
'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs',
'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs',
'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours',
```

```
'UniqueHotkeys']
Mean test score:  -11.060733350922243
```

Lasso

```
l = LassoCV()

for i in np.arange(3,9):
    print("num_features: ", i)
    mean_test_score = 0
    for j in range(3):
        output = model(l, df, i, 0.2)
        mean_test_score += output["test_score"]

    mean_test_score /= 3
    print("Mean test score: ", mean_test_score)
```

```
num_features:  3
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
Mean test score:  -26.83382136709984
num_features:  4
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
Mean test score:  -0.000914553193532397
num_features:  5
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
features: ['UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek',
'TotalHours', 'UniqueHotkeys']
Mean test score:  -41.25553219584447
num_features:  6
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
Mean test score:  -44.95079931949127
num_features:  7
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
```

```
features: ['APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC',
'HoursPerWeek', 'TotalHours', 'UniqueHotkeys']
Mean test score:  -10.661653571663036
num_features:  8
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs',
'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs',
'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
features: ['TotalMapExplored', 'APM', 'GapBetweenPACs',
'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours',
'UniqueHotkeys']
Mean test score:  -0.0021519910755832448
```

These models do not seem to be particularly useful, with many outputs resulting in negative r2 values (model is worse than predicting the mean).

Interpretations

From the models above, I was able to use different factors to predict a player's league with r2 scores of ~0.45-0.55. An r2 score below 0.7 typically indicates a mediocre correlation, so the models above do not necessarily show good correlations with league.

However, there are a set of factors consistently picked out across all models, which include: 'TotalMapExplored', 'APM', 'GapBetweenPACs', 'UniqueUnitsMade', 'ActionsInPAC', 'HoursPerWeek', 'TotalHours', and 'UniqueHotkeys'. These factors are mostly skill-based factors, which would make sense since a player likely improves their league position based on differences in skill.

I also tested both linear and non-linear models, with the non-linear random forest model returning slightly higher correlation than the linear regression model. In other words, this means that the linear model may have slightly lower correlation with league compared to other models, but there is a strong enough linear correlation to say that rank can be modeled after a linear combination of factors.

Hypothetical

If players league positions were to be modeled, the findings above suggest that skill-based factors should be used. However, measurements for active vs non-active players may differ. For example, a non-active player may have 10,000 hours played over 5 years and have a league of 6, but is currently inactive and plays only 2 hours per week. However, an active player may also be a level 6, but has been playing for 15 hours per week over 1 year. Collecting more granular data on active vs non-active players may help with determining rank as well.

In a similar vein, it may be helpful to further explore the impact of aggregate vs total values. For example, my models used both total hours played and hours per week; picking one or the other may lead to different observations as well.