# Tamas Flesch Thesis - Decision Tree step

## LMJU - UpGrad - DS

### Fifa 23 Ultimate Team player price prediction based on the player's attributes

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#### Imports

In [2]:
```
# Importing the required libraries
import pandas as pd, numpy as np
import matplotlib.pyplot as plt, seaborn as sns
%matplotlib inline
```

#### Read data

In [4]:
```
# Reading the csv file and putting it into 'df' object.
df = pd.read_csv('futbin.csv')
```

#### Inspecting the data

In [5]:
```
df.head()
```

Out[5]:

| | Name | Rating | Price | Skills_Star | Weak_Foot_Star | Pace / Diving | Shooting / Handling | Passing / Kicking | Dribbling / Reflexes | De / S |
|---|---|---|---|---|---|---|---|---|---|---|
| **0** | Pelé | 98 | 3270000.0 | 5 | 4 | 95.0 | 96 | 93 | 96 | |
| **1** | Lionel Messi | 98 | 4350000.0 | 4 | 4 | 93.0 | 98 | 97 | 99 | |
| **2** | Lionel Messi | 98 | 4640000.0 | 4 | 4 | 94.0 | 97 | 96 | 99 | |
| **3** | Karim Benzema | 97 | 1850000.0 | 4 | 5 | 92.0 | 97 | 90 | 94 | |
| **4** | Kylian Mbappé | 97 | 9750000.0 | 5 | 4 | 99.0 | 96 | 88 | 98 | |

5 rows × 105 columns

In [32]:
```
df_names = df.pop('Name')
```

In [33]:
```
df.head()
```

Out[33]:

| | Rating | Price | Skills_Star | Weak_Foot_Star | Pace / Diving | Shooting / Handling | Passing / Kicking | Dribbling / Reflexes | Defense / Speed | Pl Pos |
|---|---|---|---|---|---|---|---|---|---|---|
| **0** | 98 | 3270000.0 | 5 | 4 | 95.0 | 96 | 93 | 96 | 60 | |
| **1** | 98 | 4350000.0 | 4 | 4 | 93.0 | 98 | 97 | 99 | 40 | |
| **2** | 98 | 4640000.0 | 4 | 4 | 94.0 | 97 | 96 | 99 | 40 | |
| **3** | 97 | 1850000.0 | 4 | 5 | 92.0 | 97 | 90 | 94 | 45 | |
| **4** | 97 | 9750000.0 | 5 | 4 | 99.0 | 96 | 88 | 98 | 44 | |

5 rows × 104 columns

In [34]:
```
df_names.head()
```

Out[34]:
```
0             Pelé
1     Lionel Messi
2     Lionel Messi
3    Karim Benzema
4    Kylian Mbappé
Name: Name, dtype: object
```

## Build a decision tree model

In [20]:
```
from sklearn.tree import DecisionTreeRegressor
```

In [21]:
```
dt = DecisionTreeRegressor(random_state=42, max_depth=4, min_samples_leaf=10)
```

In [35]:
```
np.random.seed(0)
df_train, df_test = train_test_split(df, train_size=0.8, random_state=100)
```

In [36]:
```
df_train.shape, df_test.shape
```

Out[36]:
```
((5117, 104), (1280, 104))
```

In [37]:
```
df_test.head()
```

Out[37]:

| | Rating | Price | Skills_Star | Weak_Foot_Star | Pace / Diving | Shooting / Handling | Passing / Kicking | Dribbling / Reflexes | Defense / Speed | Ph Posi |
|---|---|---|---|---|---|---|---|---|---|---|
| **2691** | 69 | 250.0 | 3 | 3 | 60.0 | 69 | 51 | 62 | 28 | |
| **3785** | 66 | 200.0 | 3 | 3 | 73.0 | 65 | 49 | 66 | 22 | |
| **4989** | 62 | 200.0 | 0 | 3 | 64.0 | 61 | 61 | 64 | 40 | |
| **1222** | 75 | 450.0 | 3 | 3 | 53.0 | 53 | 74 | 79 | 61 | |
| **3640** | 66 | 200.0 | 2 | 3 | 65.0 | 61 | 58 | 64 | 65 | |

5 rows × 104 columns

In [38]:
```
scaler = MinMaxScaler()
```

In [39]:
```
df_train['Price'] = scaler.fit_transform(df_train[['Price']])
df_test['Price'] = scaler.transform(df_test[['Price']])
```

In [40]:
```
df_train.Price.describe()
```

Out[40]:
```
count    5117.000000
mean        0.001729
std         0.022844
min         0.000000
25%         0.000000
50%         0.000010
75%         0.000053
max         1.000000
Name: Price, dtype: float64
```

In [41]:
```
y_train = df_train.pop("Price")
X_train = df_train

y_test = df_test.pop("Price")
X_test = df_test
```

In [42]:
```
X_test.shape, X_train.shape
```

Out[42]:
```
((1280, 103), (5117, 103))
```

## Fit the DT model

In [43]:
```
dt.fit(X_train, y_train)
```

Out[43]:
```
DecisionTreeRegressor(max_depth=4, min_samples_leaf=10, random_state=42)
```

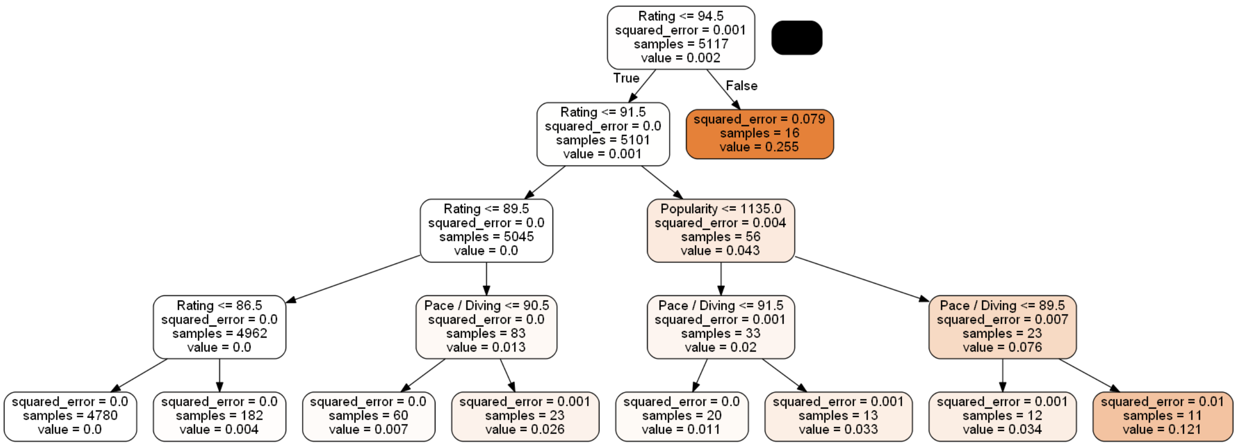
In [44]:
```
from IPython.display import Image
from six import StringIO
from sklearn.tree import export_graphviz
import pydotplus, graphviz

dot_data = StringIO()

export_graphviz(dt, out_file=dot_data, filled=True, rounded=True,
                feature_names=X_train.columns)

graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
Image(graph.create_png())
```

Out[44]:




In [45]:
```
y_train_pred = dt.predict(X_train)
```

In [47]:
```
from sklearn.metrics import r2_score
```

In [48]:
```
r2_score(y_train, y_train_pred)
```

Out[48]:
```
0.46511633392209173
```

In [49]:
```
y_test_pred = dt.predict(X_test)
```

In [50]:
```
r2_score(y_test, y_test_pred)
```

Out[50]:
```
0.41381406125743336
```

## Using Random Forest Regressor

In [51]:
```
from sklearn.ensemble import RandomForestRegressor
```

In [52]:
```
rf = RandomForestRegressor(random_state=42, n_jobs=-1, max_depth=5, min_samples_leaf=
```

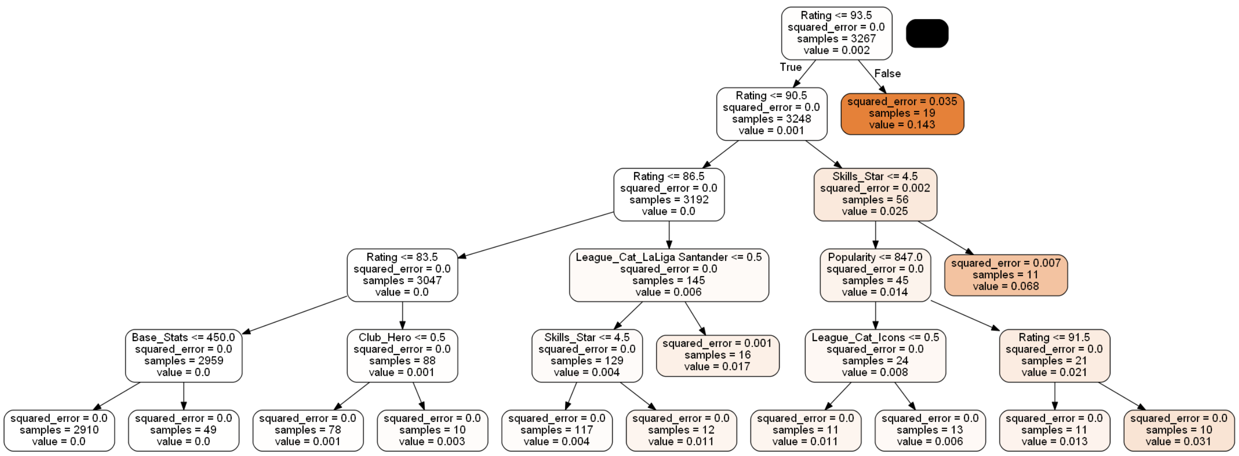
In [53]:
```
rf.fit(X_train, y_train)
```

Out[53]:
```
RandomForestRegressor(max_depth=5, min_samples_leaf=10, n_jobs=-1,
                      random_state=42)
```

In [54]:
```
sample_tree = rf.estimators_[20]
```

In [55]:
```
dot_data = StringIO()
export_graphviz(sample_tree, out_file=dot_data, filled=True, rounded=True,
                feature_names=X_train.columns)
graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
Image(graph.create_png())
```

Out[55]:




In [56]:
```
y_train_pred = rf.predict(X_train)
y_test_pred = rf.predict(X_test)
```

In [57]:
```
r2_score(y_train, y_train_pred)
```

Out[57]: 0.4665518871340596

In [58]:
```
r2_score(y_test, y_test_pred)
```

Out[58]: 0.6085673962637769

In [59]:
```
rf.feature_importances_
```

Out[59]:
```
array([8.63107840e-01, 4.11047310e-03, 0.00000000e+00, 2.35199905e-02,
       1.84573743e-04, 7.48589702e-03, 7.71977045e-02, 3.47173992e-04,
       4.02122200e-04, 1.96892230e-02, 3.62010511e-04, 9.44533176e-04,
       4.62558964e-06, 4.77114424e-04, 8.55871299e-04, 5.08042821e-05,
       0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
       0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
       0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
       0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
       0.00000000e+00, 4.59991441e-07, 3.69134191e-04, 5.66323717e-04,
       0.00000000e+00, 0.00000000e+00, 3.23781650e-07, 0.00000000e+00,
       0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
       0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
       0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
       0.00000000e+00, 2.36985890e-05, 2.04145436e-04, 2.39002353e-07,
       0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
       0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 3.12153841e-05,
       0.00000000e+00, 0.00000000e+00, 5.30923721e-05, 0.00000000e+00,
       0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
       0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
       0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
       0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
       0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
       0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 1.14105389e-05,
       0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
       0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
       0.00000000e+00, 0.00000000e+00, 0.00000000e+00])
```

In [60]:
```python
imp_df = pd.DataFrame({
    "Varname": X_train.columns,
    "Imp": rf.feature_importances_})
```

In [61]:
```python
imp_df.sort_values(by="Imp", ascending=False)
```

Out[61]:

| | Varname | Imp |
|---|---|---|
| **0** | Rating | 0.863108 |
| **6** | Dribbling / Reflexes | 0.077198 |
| **3** | Pace / Diving | 0.023520 |
| **9** | Popularity | 0.019689 |
| **5** | Passing / Kicking | 0.007486 |
| **...** | ... | ... |
| **43** | BodyType_Text_Messi | 0.000000 |
| **42** | BodyType_Text_Lean | 0.000000 |
| **41** | BodyType_Text_High & Stocky | 0.000000 |
| **40** | BodyType_Text_High & Lean | 0.000000 |
| **102** | Alt_Pos_3_missing | 0.000000 |

103 rows × 2 columns

## Grid search for hyper-parameter tuning

In [62]:
```
#from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import GridSearchCV
```

In [63]:
```
classifier_rf = RandomForestRegressor(random_state=42, n_jobs=-1)
```

In [64]:
```
# Create the parameter grid based on the results of random search
params = {
    'max_depth': [5, 8, 10, 13, 15, 17, 20],
    'min_samples_leaf': [5, 10, 20, 50, 100],
    'max_features': [2,3,4],
    'n_estimators': [10, 30, 50, 100, 200]
}
```

In [85]:
```
# Instantiate the grid search model
# cv=4 -> 4-fold cross validation schema
grid_search = GridSearchCV(estimator=RandomForestRegressor(), param_grid=params,
                          cv=10, n_jobs=-1, verbose=1, scoring = "r2", error_score="ra
```

In [70]:
```
X_train.head()
```

Out[70]:

| | Rating | Skills_Star | Weak_Foot_Star | Pace / Diving | Shooting / Handling | Passing / Kicking | Dribbling / Reflexes | Defense / Speed | Physical / Positioning |
|---|---|---|---|---|---|---|---|---|---|
| **2556** | 69 | 2 | 3 | 68.0 | 64 | 65 | 68 | 66 | 71 |
| **5208** | 61 | 2 | 3 | 37.0 | 27 | 39 | 39 | 58 | 71 |
| **2567** | 69 | 2 | 2 | 68.0 | 37 | 63 | 66 | 67 | 68 |
| **3412** | 67 | 3 | 4 | 77.0 | 66 | 56 | 67 | 29 | 56 |
| **2673** | 69 | 2 | 3 | 73.0 | 67 | 65 | 70 | 36 | 55 |

5 rows × 103 columns

In [71]:
```
y_train.head()
```

Out[71]:
```
2556    0.000043
5208    0.000653
2567    0.000113
3412    0.000027
2673    0.000017
Name: Price, dtype: float64
```

In [81]:
```
X_train.shape
```

Out[81]:
```
(5117, 103)
```

In [82]:
```
y_train.shape
```

Out[82]:
```
(5117,)
```

In [86]:
```
%%time
grid_search.fit(X_train,y_train)
```

```
Fitting 10 folds for each of 525 candidates, totalling 5250 fits
CPU times: total: 25.4 s
Wall time: 7min 48s
```

Out[86]:
```
GridSearchCV(cv=10, error_score='raise',
             estimator=RandomForestRegressor(n_jobs=-1, random_state=42),
             n_jobs=-1,
             param_grid={'max_depth': [5, 8, 10, 13, 15, 17, 20],
                         'max_features': [2, 3, 4],
                         'min_samples_leaf': [5, 10, 20, 50, 100],
                         'n_estimators': [10, 30, 50, 100, 200]},
             scoring='r2', verbose=1)
```

In [87]:
```
rf_best = grid_search.best_estimator_
```

In [88]:
```
rf_best
```

Out[88]:
```
RandomForestRegressor(max_depth=10, max_features=4, min_samples_leaf=5,
                      n_estimators=200, n_jobs=-1, random_state=42)
```

In [89]:
```
y_train_pred = rf_best.predict(X_train)
y_test_pred = rf_best.predict(X_test)
```

In [90]:
```
r2_score(y_train, y_train_pred)
```

Out[90]:
```
0.42985622276084756
```

In [91]:
```
r2_score(y_test, y_test_pred)
```

Out[91]:
```
0.43889540025568174
```

In [92]:
```
rf_best.feature_importances_
```

Out[92]:
```
array([1.27692642e-01, 4.83770707e-02, 1.59748454e-02, 7.20043965e-02,
       1.25897401e-01, 6.42622827e-02, 1.44817704e-01, 2.91795004e-02,
       2.34158031e-02, 5.72564589e-02, 6.34699221e-02, 6.74117801e-02,
       1.84441807e-02, 9.71723894e-03, 1.29137152e-02, 3.04718328e-03,
       1.73705341e-04, 2.03632739e-04, 8.11418527e-04, 1.51815146e-03,
       5.67718424e-05, 4.88507780e-05, 1.98656505e-05, 3.95510989e-03,
       5.93939023e-06, 3.87282426e-04, 1.68129795e-04, 6.87949271e-05,
       3.80398324e-06, 4.95817141e-03, 2.84880037e-03, 1.50803630e-03,
       3.05452165e-05, 2.59960910e-03, 8.65948284e-03, 2.93119221e-03,
       0.00000000e+00, 0.00000000e+00, 5.23205658e-04, 1.32026536e-04,
       0.00000000e+00, 6.17288287e-05, 7.75539661e-04, 0.00000000e+00,
       0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
       2.88387919e-06, 6.88842143e-05, 5.63710998e-07, 2.78378520e-05,
       6.65866942e-03, 2.54568151e-02, 4.19120803e-04, 5.38554725e-03,
       2.72782966e-05, 7.62377128e-03, 9.41663787e-04, 2.51730785e-04,
       3.51470124e-04, 5.85266245e-03, 3.27916229e-04, 5.31958718e-03,
       1.77003759e-04, 7.05235981e-06, 4.09450579e-04, 9.20927124e-03,
       1.01654689e-04, 1.66282089e-05, 1.76081732e-03, 1.45226799e-06,
       1.26045267e-05, 6.03409815e-05, 5.95764833e-04, 8.38360790e-06,
       8.82600803e-05, 3.80730845e-04, 1.41696119e-03, 4.68024100e-07,
       1.03565768e-09, 3.25459223e-05, 1.67554247e-05, 2.54097029e-08,
       3.58939524e-04, 2.80577548e-03, 3.45847481e-07, 0.00000000e+00,
       1.96593675e-05, 8.52184913e-04, 2.81891856e-04, 5.30810895e-03,
       2.24765404e-08, 1.99289790e-06, 0.00000000e+00, 0.00000000e+00,
       7.54046813e-07, 3.89393230e-04, 1.67210044e-07, 0.00000000e+00,
       1.19433210e-08, 2.59899766e-07, 6.35997383e-04])
```

In [93]:
```
imp_df = pd.DataFrame({
    "Varname": X_train.columns,
    "Imp": rf_best.feature_importances_})
```

In [95]:
```
imp_df.sort_values(by="Imp", ascending=False)
```

Out[95]:

| | Varname | Imp |
|---|---|---|
| **6** | Dribbling / Reflexes | 0.144818 |
| **0** | Rating | 0.127693 |
| **4** | Shooting / Handling | 0.125897 |
| **3** | Pace / Diving | 0.072004 |
| **11** | Ingame_Stats | 0.067412 |
| **...** | ... | ... |
| **87** | Alt_Pos_2_RB | 0.000000 |
| **99** | Alt_Pos_3_RM | 0.000000 |
| **37** | BodyType_Text_Courtois | 0.000000 |
| **36** | BodyType_Text_CR7 | 0.000000 |
| **40** | BodyType_Text_High & Lean | 0.000000 |

103 rows × 2 columns

**second grid search**

- max depth testing around 10
- max feature around 4
- sample leaf around 5
- estimator around 200

In [176…
```
# Create the parameter grid based on the results of random search
params = {
    'max_depth': [8, 9, 10, 11, 12, 13],
    'min_samples_leaf': [2,3,4,5,6,7,8],
    'max_features': [4,6,8,10],
    'n_estimators': [100, 150, 200, 250, 300]
}
```

In [177…
```
# Instantiate the grid search model
# cv=4 -> 4-fold cross validation schema
grid_search = GridSearchCV(estimator=RandomForestRegressor(), param_grid=params,
                          cv=10, n_jobs=-1, verbose=1, scoring = "r2", error_score="ra
```

In [98]:
```
%%time
grid_search.fit(X_train,y_train)
```

```
Fitting 10 folds for each of 840 candidates, totalling 8400 fits
CPU times: total: 39.3 s
Wall time: 41min 22s
```

Out[98]:
```
GridSearchCV(cv=10, error_score='raise',
             estimator=RandomForestRegressor(n_jobs=-1, random_state=42),
             n_jobs=-1,
             param_grid={'max_depth': [8, 9, 10, 11, 12, 13],
                         'max_features': [4, 6, 8, 10],
                         'min_samples_leaf': [2, 3, 4, 5, 6, 7, 8],
                         'n_estimators': [100, 150, 200, 250, 300]},
             scoring='r2', verbose=1)
```

In [99]:
```
rf_best = grid_search.best_estimator_
```

In [100…
```
rf_best
```

Out[100]:
```
RandomForestRegressor(max_depth=8, max_features=8, min_samples_leaf=2,
                      n_jobs=-1, random_state=42)
```

In [102…
```
y_train_pred = rf_best.predict(X_train)
y_test_pred = rf_best.predict(X_test)
```

In [103…
```
r2_score(y_train, y_train_pred)
```

Out[103]:
```
0.7268290034088154
```

In [104…
```
r2_score(y_test, y_test_pred)
```

Out[104]:
```
0.6122313567377293
```

In [105…
```
rf_best.feature_importances_
```

Out[105]:
```
array([1.38489015e-01, 4.66858447e-02, 1.51138366e-02, 8.28239884e-02,
       1.08141260e-01, 5.74164927e-02, 1.26643262e-01, 3.73862489e-02,
       2.83327822e-02, 4.88247605e-02, 5.54882980e-02, 4.12670687e-02,
       1.53507463e-02, 1.37700267e-02, 1.60956680e-02, 2.00895569e-03,
       1.26215167e-04, 6.95812904e-06, 1.30401345e-03, 1.33142932e-03,
       9.07435426e-05, 1.82934812e-04, 6.30403671e-05, 1.51820461e-02,
       1.25060262e-06, 4.52118325e-05, 2.80795915e-04, 1.16865943e-04,
       2.21889599e-07, 9.76897426e-03, 2.31602367e-03, 1.17541680e-04,
       1.33593246e-05, 2.19611689e-03, 1.77063715e-02, 4.95317456e-03,
       0.00000000e+00, 0.00000000e+00, 2.81857258e-04, 2.38660430e-05,
       2.92761059e-07, 7.57767917e-09, 7.08016776e-04, 5.55441104e-03,
       0.00000000e+00, 2.16383224e-02, 0.00000000e+00, 0.00000000e+00,
       2.83678825e-06, 1.11221718e-05, 1.28650138e-07, 3.47949213e-06,
       7.19721972e-03, 1.79522994e-02, 1.61142358e-04, 6.74598724e-03,
       8.03629055e-05, 1.20973113e-03, 2.06139183e-03, 6.32214843e-05,
       1.32951783e-04, 3.92989831e-03, 9.04149985e-06, 4.41874535e-03,
       2.76849241e-04, 2.83567090e-06, 1.32693296e-03, 6.05009338e-03,
       3.58926598e-04, 2.21020250e-05, 1.22392886e-02, 5.34552132e-10,
       9.55474349e-05, 1.50988231e-04, 1.61348511e-03, 3.23384668e-05,
       4.40615221e-05, 3.01687466e-04, 7.27018012e-04, 0.00000000e+00,
       0.00000000e+00, 1.58692422e-07, 8.16173342e-06, 2.19814835e-06,
       7.60430400e-04, 1.49256156e-03, 3.25608299e-07, 5.71065547e-09,
       9.13209993e-09, 1.11797017e-04, 1.46286353e-04, 7.17550745e-03,
       1.13647612e-09, 2.32284173e-05, 0.00000000e+00, 0.00000000e+00,
       7.38528353e-06, 9.10773651e-04, 2.26690642e-09, 0.00000000e+00,
       4.46735026e-06, 3.73632595e-07, 4.28629382e-03])
```

In [106…
```
imp_df = pd.DataFrame({
    "Varname": X_train.columns,
    "Imp": rf_best.feature_importances_})
```

In [107…
```
imp_df.sort_values(by="Imp", ascending=False)
```

Out[107]:

| | Varname | Imp |
|---|---|---|
| **0** | Rating | 0.138489 |
| **6** | Dribbling / Reflexes | 0.126643 |
| **4** | Shooting / Handling | 0.108141 |
| **3** | Pace / Diving | 0.082824 |
| **5** | Passing / Kicking | 0.057416 |
| **...** | ... | ... |
| **80** | Alt_Pos_2_CDM | 0.000000 |
| **95** | Alt_Pos_3_LB | 0.000000 |
| **44** | BodyType_Text_R9 | 0.000000 |
| **46** | BodyType_Text_Salah | 0.000000 |
| **94** | Alt_Pos_3_CM | 0.000000 |

103 rows × 2 columns

### third grid search

In [108…
```
# Create the parameter grid based on the results of random search
params = {
    'max_depth': [8, 9, 10],
    'min_samples_leaf': [1,2,3],
    'max_features': [7,8,9,10],
    'n_estimators': [100, 150, 200, 250, 300]
}
```

In [110…
```
# Instantiate the grid search model
# cv=4 -> 4-fold cross validation schema
grid_search = GridSearchCV(estimator=RandomForestRegressor(), param_grid=params,
                          cv=10, n_jobs=-1, verbose=2, scoring = "r2", error_score="ra
```

In [111…
```
%%time
grid_search.fit(X_train,y_train)
```

```
Fitting 10 folds for each of 180 candidates, totalling 1800 fits
CPU times: total: 8.41 s
Wall time: 8min 35s
```

Out[111]:
```
GridSearchCV(cv=10, error_score='raise', estimator=RandomForestRegressor(),
             n_jobs=-1,
             param_grid={'max_depth': [8, 9, 10], 'max_features': [7, 8, 9, 10],
                         'min_samples_leaf': [1, 2, 3],
                         'n_estimators': [100, 150, 200, 250, 300]},
             scoring='r2', verbose=2)
```

In [112…
```
rf_best = grid_search.best_estimator_
```

In [113…
```
rf_best
```
Out[113]:
```
RandomForestRegressor(max_depth=9, max_features=10, min_samples_leaf=2)
```

In [114…
```
y_train_pred = rf_best.predict(X_train)
y_test_pred = rf_best.predict(X_test)
```

In [115…
```
r2_score(y_train, y_train_pred)
```
Out[115]:
```
0.755998374506422
```

In [116…
```
r2_score(y_test, y_test_pred)
```
Out[116]:
```
0.6320821355740586
```

### forth gridsearch

In [117…
```
# Create the parameter grid based on the results of random search
params = {
    'max_depth': [8, 9, 10],
    'min_samples_leaf': [1,2,3],
    'max_features': [10,20,30,40],
    'n_estimators': [100,200,300]
}
```

In [119…
```
grid_search = GridSearchCV(estimator=RandomForestRegressor(), param_grid=params,
                          cv=10, n_jobs=-1, verbose=2, scoring = "r2", error_score="ra
```

In [120…
```
%%time
grid_search.fit(X_train,y_train)
```
```
Fitting 10 folds for each of 108 candidates, totalling 1080 fits
CPU times: total: 6.23 s
Wall time: 9min 41s
```
Out[120]:
```
GridSearchCV(cv=10, error_score='raise', estimator=RandomForestRegressor(),
             n_jobs=-1,
             param_grid={'max_depth': [8, 9, 10],
                         'max_features': [10, 20, 30, 40],
                         'min_samples_leaf': [1, 2, 3],
                         'n_estimators': [100, 200, 300]},
             scoring='r2', verbose=2)
```

In [121…
```
rf_best = grid_search.best_estimator_
```

In [122…
```
rf_best
```
Out[122]:
```
RandomForestRegressor(max_depth=10, max_features=10, min_samples_leaf=2,
                      n_estimators=200)
```

In [123…
```
y_train_pred = rf_best.predict(X_train)
y_test_pred = rf_best.predict(X_test)
```

In [124…
```
r2_score(y_train, y_train_pred)
```
Out[124]:
```
0.7601409765037306
```

In [125…
```
r2_score(y_test, y_test_pred)
```
Out[125]:
```
0.5793143634800904
```

### fifth gridsearch

In [126…
```
# Create the parameter grid based on the results of random search
params = {
    'max_depth': [8,9,10,11],
    'min_samples_leaf': [1,2,3],
    'max_features': [9,10,11,12],
    'n_estimators': [150,200,250]
}
```

In [127…
```
grid_search = GridSearchCV(estimator=RandomForestRegressor(), param_grid=params,
                          cv=10, n_jobs=-1, verbose=2, scoring = "r2", error_score="ra
```

In [128…
```
%%time
grid_search.fit(X_train,y_train)
```
```
Fitting 10 folds for each of 144 candidates, totalling 1440 fits
CPU times: total: 6.61 s
Wall time: 7min 52s
```
Out[128]:
```
GridSearchCV(cv=10, error_score='raise', estimator=RandomForestRegressor(),
             n_jobs=-1,
             param_grid={'max_depth': [8, 9, 10, 11],
                         'max_features': [9, 10, 11, 12],
                         'min_samples_leaf': [1, 2, 3],
                         'n_estimators': [150, 200, 250]},
             scoring='r2', verbose=2)
```

In [129…
```
rf_best = grid_search.best_estimator_
```

In [130…
```
rf_best
```
Out[130]:
```
RandomForestRegressor(max_depth=9, max_features=10, n_estimators=200)
```

In [131…
```
y_train_pred = rf_best.predict(X_train)
y_test_pred = rf_best.predict(X_test)
```

In [132…
```
r2_score(y_train, y_train_pred)
```
Out[132]:
```
0.9204138340558483
```

In [133…
```
r2_score(y_test, y_test_pred)
```
Out[133]:
```
0.6727454133535952
```

## Final model after grid search

In [166…
```
rf = RandomForestRegressor(random_state=42, n_jobs=-1, max_depth=9, n_estimators=200,
```

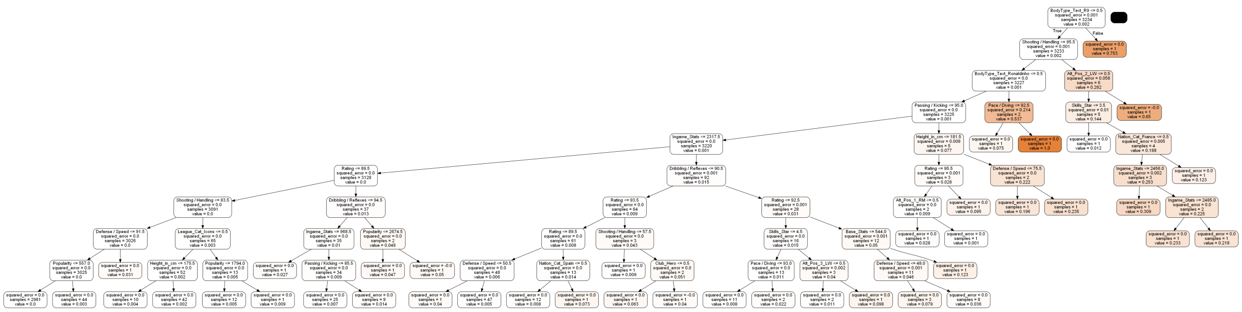
In [167…
```
rf.fit(X_train, y_train)
```

Out[167]:
```
RandomForestRegressor(max_depth=9, max_features=20, n_estimators=200, n_jobs=-1,
                      random_state=42)
```

In [168…
```
sample_tree = rf.estimators_[2]
```

In [169…
```
dot_data = StringIO()
export_graphviz(sample_tree, out_file=dot_data, filled=True, rounded=True,
                feature_names=X_train.columns)
graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
Image(graph.create_png())
```

Out[169]:



In [170…
```
y_train_pred = rf.predict(X_train)
y_test_pred = rf.predict(X_test)
```

In [171…
```
r2_score(y_train, y_train_pred)
```

Out[171]:
```
0.9111099629582339
```

In [172…
```
r2_score(y_test, y_test_pred)
```

Out[172]:
```
0.6946316867354081
```

In [173…
```
rf.feature_importances_
```

Out[173]:
```
array([1.54227577e-01, 3.38025014e-02, 6.13521060e-03, 8.57044644e-02,
       9.32105450e-02, 3.49512604e-02, 1.28418526e-01, 3.77531647e-02,
       1.37835014e-02, 4.18185863e-02, 4.12193749e-02, 3.46733427e-02,
       1.68488482e-02, 1.44599500e-02, 8.03670500e-03, 1.09859057e-02,
       1.10481212e-04, 9.16481082e-07, 3.02904448e-03, 7.34819817e-04,
       8.84070374e-05, 2.85144951e-04, 1.36549923e-06, 1.26327298e-02,
       1.53830061e-05, 1.41996130e-04, 9.62478940e-04, 1.93141729e-05,
       3.23521504e-06, 3.55383930e-03, 4.86880557e-03, 7.02825543e-04,
       1.25400345e-04, 2.12460059e-03, 8.77149995e-03, 3.19316754e-03,
       5.27790193e-08, 0.00000000e+00, 1.48310230e-03, 1.81494113e-04,
       6.16499733e-06, 2.43354677e-07, 7.88097204e-04, 7.13182824e-03,
       3.55364412e-02, 7.36057306e-02, 1.13237740e-05, 0.00000000e+00,
       5.86782212e-06, 2.68740766e-04, 5.62214915e-10, 3.32833972e-05,
       6.32531925e-03, 9.40655932e-03, 7.35020932e-04, 6.00569782e-03,
       1.59830095e-05, 8.61977285e-05, 2.41529934e-03, 6.86376700e-05,
       9.53154197e-04, 3.76089087e-03, 6.04007599e-05, 2.38243433e-03,
       4.12607711e-04, 4.41674367e-07, 9.74428991e-05, 6.25883367e-03,
       2.44342043e-03, 7.07906689e-06, 1.42692791e-02, 9.48818672e-08,
       1.10196878e-04, 2.09647352e-04, 2.49971385e-03, 7.49555006e-06,
       1.18550056e-04, 2.11744875e-03, 2.42444882e-04, 9.44723831e-06,
       0.00000000e+00, 1.20490703e-05, 7.77154166e-05, 2.57502802e-07,
       2.18234774e-03, 7.69509295e-03, 4.07886068e-07, 9.14060277e-06,
       1.57531629e-08, 1.68586791e-03, 4.10059193e-04, 2.67185498e-03,
       3.07371070e-08, 7.52196774e-04, 0.00000000e+00, 0.00000000e+00,
       7.65066083e-07, 2.55677591e-03, 0.00000000e+00, 0.00000000e+00,
       6.07311500e-06, 1.49999476e-05, 4.45731962e-03])
```

In [174…
```
imp_df = pd.DataFrame({
    "Varname": X_train.columns,
    "Imp": rf_best.feature_importances_})
```

In [175…
```
imp_df.sort_values(by="Imp", ascending=False)
```

Out[175]:

| | Varname | Imp |
|---|---|---|
| **6** | Dribbling / Reflexes | 1.332667e-01 |
| **0** | Rating | 1.013360e-01 |
| **4** | Shooting / Handling | 9.981897e-02 |
| **3** | Pace / Diving | 6.632334e-02 |
| **45** | BodyType_Text_Ronaldinho | 6.168733e-02 |
| **...** | ... | ... |
| **47** | BodyType_Text_Shaqiri | 1.665979e-10 |
| **99** | Alt_Pos_3_RM | 1.368178e-13 |
| **94** | Alt_Pos_3_CM | 0.000000e+00 |
| **95** | Alt_Pos_3_LB | 0.000000e+00 |
| **80** | Alt_Pos_2_CDM | 0.000000e+00 |

103 rows × 2 columns

In [ ]: