FInalExam_WQD180104

July 8, 2020

1 Final Exam

1.1 Question 3

Predict the best postion of players using their attributes (attacking, skill, movement, defending, power, goalkeeping and mentality).

3.1 Importing required libraries

[1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.tree import DecisionTreeClassifier # Import Decision Tree␣
 ↪Classifier
from sklearn.model_selection import train_test_split # Import train_test_split␣
 ↪function
from sklearn import metrics #Import scikit-learn metrics module for accuracy␣
 ↪calculation
from sklearn.metrics import classification_report
```

3.2 Loading Data

[2]:
```
df = pd.read_csv('data/players_stats.csv')
df.head()
```

[2]:

	name	photo_url	positions	age
0	Lionel Andrés Messi Cuccittini	https://cdn.sofifa.com/players/158/023/20_120.png	RW,ST,CF	32
1	Cristiano Ronaldo dos Santos Aveir	https://cdn.sofifa.com/players/020/801/20_120.png	ST,LW	34
2	Neymar da Silva Santos Júnior	https://cdn.sofifa.com/players/190/871/20_120.png	LW,CAM	27
3	Virgil van Dijk	https://cdn.sofifa.com/players/203/376/20_120.png	CB	27
4	Jan Oblak	https://cdn.sofifa.com/players/200/389/20_120.png	GK	26

```
    birth_date  height  weight        football_club national_team  \
0  1987/Jun/24     170      72         FC Barcelona     Argentina
1   1985/Feb/5     187      83              Juventus      Portugal
2   1992/Feb/5     175      68  Paris Saint-Germain        Brazil
3   1991/Jul/8     193      92            Liverpool   Netherlands
4   1993/Jan/7     188      87      Atlético Madrid      Slovenia

   overall_rating  …  Strength  LongShots  Aggression Interceptions  \
0              94  …        68         94          48            40
1              93  …        78         93          63            29
2              92  …        49         85          51            36
3              91  …        92         64          83            90
4              91  …        78         12          34            19

   Positioning Vision  Penalties  DefensiveAwareness  StandingTackle  \
0           94     94         75                  33              37
1           95     82         85                  28              32
2           87     90         92                  35              30
3           47     65         62                  93              93
4           11     65         11                  27              12

  SlidingTackle
0            26
1            24
2            29
3            86
4            18

[5 rows x 51 columns]
```

[3]:
```
# Dataset info
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 19655 entries, 0 to 19654
Data columns (total 51 columns):
 #   Column                   Non-Null Count  Dtype
---  ------                   --------------  -----
 0   name                     19655 non-null  object
 1   photo_url                19655 non-null  object
 2   positions                19655 non-null  object
 3   age                      19655 non-null  int64
 4   birth_date               19655 non-null  object
 5   height                   19655 non-null  int64
 6   weight                   19655 non-null  int64
 7   football_club            19655 non-null  object
```

```
 8   national_team             913 non-null    object
 9   overall_rating            19655 non-null  int64
 10  potential                 19655 non-null  int64
 11  value                     19655 non-null  float64
 12  wages                     19655 non-null  float64
 13  best_position             19655 non-null  object
 14  best_rating               19655 non-null  int64
 15  Preferred Foot            19655 non-null  object
 16  Weak Foot                 19655 non-null  int64
 17  Skill Moves               19655 non-null  int64
 18  International Reputation  19655 non-null  int64
 19  Work Rate                 19655 non-null  object
 20  Body Type                 19655 non-null  object
 21  Real Face                 19655 non-null  object
 22  Release Clause            17801 non-null  float64
 23  Crossing                  19655 non-null  int64
 24  Finishing                 19655 non-null  int64
 25  HeadingAccuracy           19655 non-null  int64
 26  ShortPassing              19655 non-null  int64
 27  Volleys                   19655 non-null  int64
 28  Dribbling                 19655 non-null  int64
 29  Curve                     19655 non-null  int64
 30  FKAccuracy                19655 non-null  int64
 31  LongPassing               19655 non-null  int64
 32  BallControl               19655 non-null  int64
 33  Acceleration              19655 non-null  int64
 34  SprintSpeed               19655 non-null  int64
 35  Agility                   19655 non-null  int64
 36  Reactions                 19655 non-null  int64
 37  Balance                   19655 non-null  int64
 38  ShotPower                 19655 non-null  int64
 39  Jumping                   19655 non-null  int64
 40  Stamina                   19655 non-null  int64
 41  Strength                  19655 non-null  int64
 42  LongShots                 19655 non-null  int64
 43  Aggression                19655 non-null  int64
 44  Interceptions             19655 non-null  int64
 45  Positioning               19655 non-null  int64
 46  Vision                    19655 non-null  int64
 47  Penalties                 19655 non-null  int64
 48  DefensiveAwareness        19655 non-null  int64
 49  StandingTackle            19655 non-null  int64
 50  SlidingTackle             19655 non-null  int64
dtypes: float64(3), int64(37), object(11)
memory usage: 7.6+ MB
```

3.3 Cleaning Data

[4]:
```
df.drop_duplicates(inplace = True)
```

3.4 Feature Selection

[5]:
```
# Include attr columns only
df_attr = df.iloc[:, np.r_[13, 23:51]]
df_attr
```

[5]:

	best_position	Crossing	Finishing	HeadingAccuracy	ShortPassing	\
0	RW	88	95	70	92	
1	ST	84	94	89	83	
2	LW	87	87	62	87	
3	CB	53	52	87	79	
4	GK	13	11	15	43	
…	…	…	…	…	…	
19650	RB	42	15	42	37	
19651	CDM	38	25	46	48	
19652	GK	12	9	10	22	
19653	CDM	38	29	42	56	
19654	ST	24	42	45	35	

	Volleys	Dribbling	Curve	FKAccuracy	LongPassing	…	Strength	\
0	88	97	93	94	92	…	68	
1	87	89	81	76	77	…	78	
2	87	96	88	89	81	…	49	
3	45	70	60	70	83	…	92	
4	13	12	13	14	40	…	78	
…	…	…	…	…	…	…	…	
19650	25	38	32	25	30	…	41	
19651	28	43	40	40	45	…	45	
19652	8	9	12	8	15	…	50	
19653	30	40	38	32	53	…	60	
19654	30	47	32	30	33	…	53	

	LongShots	Aggression	Interceptions	Positioning	Vision	Penalties	\
0	94	48	40	94	94	75	
1	93	63	29	95	82	85	
2	85	51	36	87	90	92	
3	64	83	90	47	65	62	
4	12	34	19	11	65	11	
…	…	…	…	…	…	…	
19650	15	40	48	41	23	31	
19651	30	50	40	42	46	37	
19652	9	25	10	7	37	8	
19653	25	56	45	37	38	40	
19654	37	33	25	42	36	43	

```
       DefensiveAwareness  StandingTackle  SlidingTackle
0                      33              37             26
1                      28              32             24
2                      35              30             29
3                      93              93             86
4                      27              12             18
…                     …               …              …
19650                  45              45             46
19651                  37              45             52
19652                   7              12             10
19653                  43              45             46
19654                  28              25             25

[19600 rows x 29 columns]
```

[6]:
```
X = df_attr.iloc[:, 1:]
X
```

[6]:
```
       Crossing  Finishing  HeadingAccuracy  ShortPassing  Volleys  Dribbling  \
0            88         95               70            92       88         97
1            84         94               89            83       87         89
2            87         87               62            87       87         96
3            53         52               87            79       45         70
4            13         11               15            43       13         12
…           …          …                …             …        …          …
19650        42         15               42            37       25         38
19651        38         25               46            48       28         43
19652        12          9               10            22        8          9
19653        38         29               42            56       30         40
19654        24         42               45            35       30         47

       Curve  FKAccuracy  LongPassing  BallControl  …  Strength  LongShots  \
0         93          94           92           96  …        68         94
1         81          76           77           92  …        78         93
2         88          89           81           95  …        49         85
3         60          70           83           77  …        92         64
4         13          14           40           30  …        78         12
…        …           …            …            …   …        …          …
19650     32          25           30           40  …        41         15
19651     40          40           45           45  …        45         30
19652     12           8           15           11  …        50          9
19653     38          32           53           45  …        60         25
19654     32          30           33           50  …        53         37

       Aggression  Interceptions  Positioning  Vision  Penalties  \
0              48             40           94      94         75
1              63             29           95      82         85
```

```
2              51              36              87      90          92
3              83              90              47      65          62
4              34              19              11      65          11
…             …               …               …       …           …
19650          40              48              41      23          31
19651          50              40              42      46          37
19652          25              10               7      37           8
19653          56              45              37      38          40
19654          33              25              42      36          43

       DefensiveAwareness  StandingTackle  SlidingTackle
0                      33              37             26
1                      28              32             24
2                      35              30             29
3                      93              93             86
4                      27              12             18
…                     …               …              …
19650                  45              45             46
19651                  37              45             52
19652                   7              12             10
19653                  43              45             46
19654                  28              25             25

[19600 rows x 28 columns]
```

[7]:
```
y = df_attr.loc[:, 'best_position']
y
```

[7]:
```
0         RW
1         ST
2         LW
3         CB
4         GK
        …
19650     RB
19651    CDM
19652     GK
19653    CDM
19654     ST
Name: best_position, Length: 19600, dtype: object
```

[8]:
```
# Correlation
corr = X.corr()
corr
```

[8]:
```
                  Crossing  Finishing  HeadingAccuracy  ShortPassing  \
Crossing          1.000000   0.669646         0.484702      0.807863
```

Finishing	0.669646	1.000000	0.488349	0.674440
HeadingAccuracy	0.484702	0.488349	1.000000	0.667811
ShortPassing	0.807863	0.674440	0.667811	1.000000
Volleys	0.692824	0.891685	0.522538	0.701872
Dribbling	0.864826	0.830424	0.574973	0.853364
Curve	0.838236	0.770543	0.458322	0.775118
FKAccuracy	0.760462	0.707325	0.415387	0.732136
LongPassing	0.750271	0.527976	0.526023	0.890305
BallControl	0.841733	0.791860	0.679031	0.919490
Acceleration	0.690526	0.619567	0.356388	0.591186
SprintSpeed	0.668604	0.608632	0.407078	0.584683
Agility	0.715809	0.657982	0.287491	0.630136
Reactions	0.392191	0.345706	0.344743	0.493237
Balance	0.637543	0.540989	0.203152	0.553496
ShotPower	0.524192	0.716946	0.359004	0.564493
Jumping	0.126117	0.097310	0.416142	0.214688
Stamina	0.686276	0.532506	0.646199	0.742508
Strength	-0.013730	0.021811	0.498276	0.169150
LongShots	0.745536	0.888177	0.516842	0.763936
Aggression	0.484006	0.275210	0.711005	0.638116
Interceptions	0.434392	0.000524	0.553247	0.560521
Positioning	0.795760	0.897883	0.548796	0.770251
Vision	0.677403	0.699623	0.268726	0.693896
Penalties	0.655839	0.844367	0.569700	0.687177
DefensiveAwareness	0.459960	0.044401	0.590525	0.587609
StandingTackle	0.439998	-0.003013	0.566014	0.563990
SlidingTackle	0.421154	-0.042368	0.541000	0.531526

	Volleys	Dribbling	Curve	FKAccuracy	LongPassing	\
Crossing	0.692824	0.864826	0.838236	0.760462	0.750271	
Finishing	0.891685	0.830424	0.770543	0.707325	0.527976	
HeadingAccuracy	0.522538	0.574973	0.458322	0.415387	0.526023	
ShortPassing	0.701872	0.853364	0.775118	0.732136	0.890305	
Volleys	1.000000	0.813281	0.810992	0.751909	0.573288	
Dribbling	0.813281	1.000000	0.848817	0.758293	0.732541	
Curve	0.810992	0.848817	1.000000	0.860814	0.711039	
FKAccuracy	0.751909	0.758293	0.860814	1.000000	0.703361	
LongPassing	0.573288	0.732541	0.711039	0.703361	1.000000	
BallControl	0.793729	0.939475	0.828067	0.754957	0.790113	
Acceleration	0.584893	0.759932	0.625876	0.517585	0.467179	
SprintSpeed	0.572810	0.741491	0.597947	0.488536	0.453573	
Agility	0.635195	0.775620	0.697457	0.608960	0.546876	
Reactions	0.400401	0.384113	0.421433	0.391725	0.473890	
Balance	0.529542	0.674861	0.604819	0.538529	0.485310	
ShotPower	0.738722	0.607144	0.677128	0.652769	0.525836	
Jumping	0.126840	0.143431	0.105669	0.073498	0.168467	
Stamina	0.539765	0.706429	0.607035	0.548936	0.658723	

Strength	0.059298	0.001833	-0.010831	-0.001249	0.142150
LongShots	0.874695	0.848529	0.839222	0.806776	0.672669
Aggression	0.350662	0.476159	0.419982	0.404561	0.604053
Interceptions	0.093959	0.319202	0.284775	0.296897	0.603362
Positioning	0.858083	0.906109	0.822716	0.739830	0.629719
Vision	0.694408	0.723067	0.742561	0.709548	0.691368
Penalties	0.841972	0.776850	0.760029	0.740253	0.554817
DefensiveAwareness	0.131841	0.361308	0.312571	0.312044	0.609940
StandingTackle	0.086980	0.331820	0.280593	0.288957	0.598577
SlidingTackle	0.048822	0.304068	0.250759	0.257309	0.574623

	BallControl	…	Strength	LongShots	Aggression	\
Crossing	0.841733	…	-0.013730	0.745536	0.484006	
Finishing	0.791860	…	0.021811	0.888177	0.275210	
HeadingAccuracy	0.679031	…	0.498276	0.516842	0.711005	
ShortPassing	0.919490	…	0.169150	0.763936	0.638116	
Volleys	0.793729	…	0.059298	0.874695	0.350662	
Dribbling	0.939475	…	0.001833	0.848529	0.476159	
Curve	0.828067	…	-0.010831	0.839222	0.419982	
FKAccuracy	0.754957	…	-0.001249	0.806776	0.404561	
LongPassing	0.790113	…	0.142150	0.672669	0.604053	
BallControl	1.000000	…	0.117836	0.832768	0.578695	
Acceleration	0.695248	…	-0.144683	0.592970	0.280737	
SprintSpeed	0.686681	…	-0.059930	0.577072	0.310312	
Agility	0.717627	…	-0.202736	0.662917	0.268466	
Reactions	0.448058	…	0.323563	0.430351	0.414318	
Balance	0.619410	…	-0.348731	0.551783	0.218396	
ShotPower	0.601462	…	0.176037	0.793032	0.311808	
Jumping	0.203087	…	0.336536	0.131815	0.391302	
Stamina	0.749451	…	0.275639	0.608145	0.659446	
Strength	0.117836	…	1.000000	0.075241	0.480507	
LongShots	0.832768	…	0.075241	1.000000	0.410744	
Aggression	0.578695	…	0.480507	0.410744	1.000000	
Interceptions	0.437907	…	0.348860	0.198231	0.749688	
Positioning	0.868367	…	0.031231	0.874003	0.410409	
Vision	0.699692	…	-0.024236	0.755007	0.301419	
Penalties	0.773708	…	0.091773	0.820105	0.364797	
DefensiveAwareness	0.478835	…	0.343127	0.226058	0.743273	
StandingTackle	0.445828	…	0.319840	0.184513	0.742952	
SlidingTackle	0.412439	…	0.294271	0.145759	0.723776	

	Interceptions	Positioning	Vision	Penalties	\
Crossing	0.434392	0.795760	0.677403	0.655839	
Finishing	0.000524	0.897883	0.699623	0.844367	
HeadingAccuracy	0.553247	0.548796	0.268726	0.569700	
ShortPassing	0.560521	0.770251	0.693896	0.687177	
Volleys	0.093959	0.858083	0.694408	0.841972	

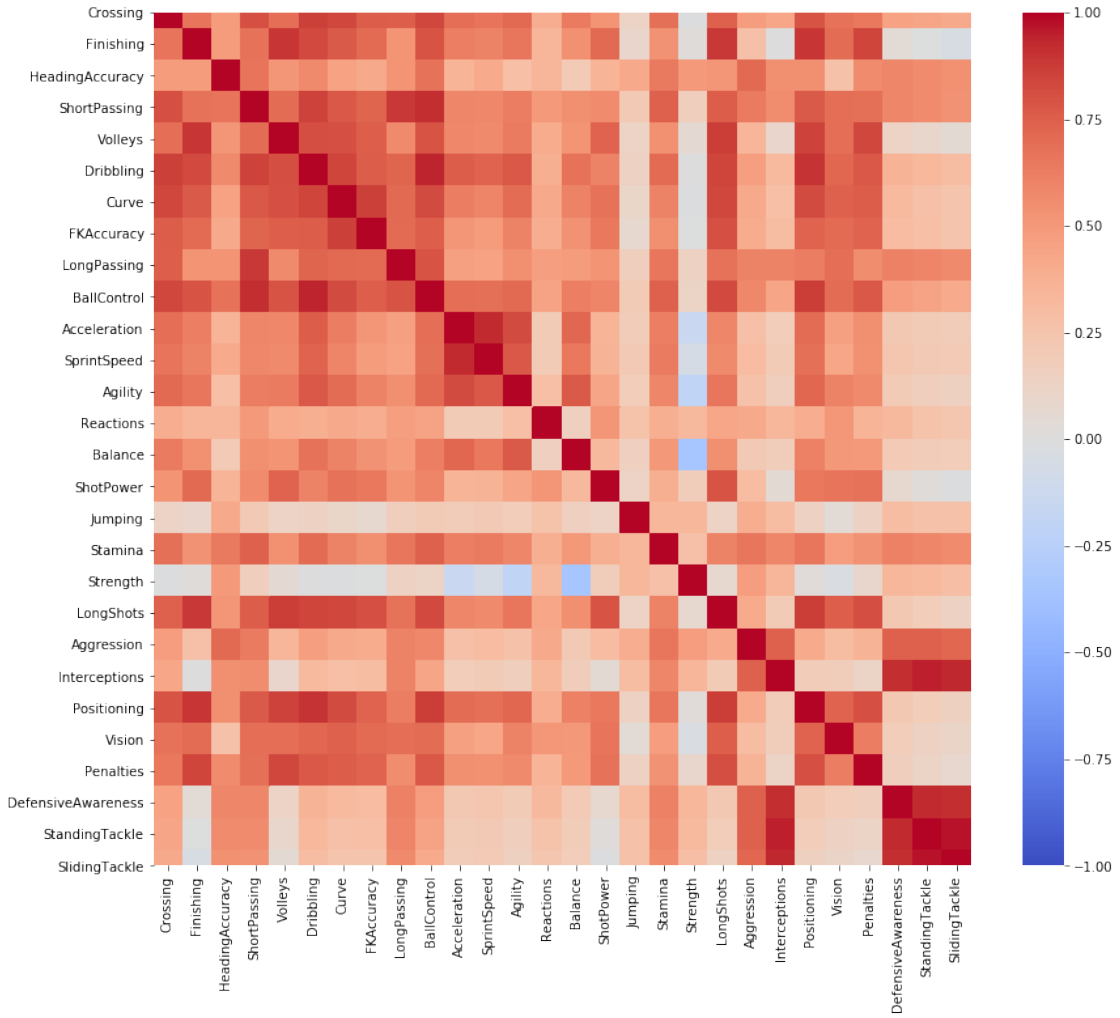
Dribbling	0.319202	0.906109	0.723067	0.776850
Curve	0.284775	0.822716	0.742561	0.760029
FKAccuracy	0.296897	0.739830	0.709548	0.740253
LongPassing	0.603362	0.629719	0.691368	0.554817
BallControl	0.437907	0.868367	0.699692	0.773708
Acceleration	0.181375	0.696220	0.467782	0.548405
SprintSpeed	0.195895	0.681966	0.437090	0.539984
Agility	0.166779	0.722034	0.602657	0.578057
Reactions	0.338432	0.392345	0.511854	0.356814
Balance	0.178043	0.614692	0.501114	0.497410
ShotPower	0.050780	0.654799	0.671042	0.672744
Jumping	0.301464	0.135976	0.046272	0.144787
Stamina	0.590959	0.658357	0.477375	0.535290
Strength	0.348860	0.031231	-0.024236	0.091773
LongShots	0.198231	0.874003	0.755007	0.820105
Aggression	0.749688	0.410409	0.301419	0.364797
Interceptions	1.000000	0.189324	0.177369	0.121064
Positioning	0.189324	1.000000	0.734416	0.810656
Vision	0.177369	0.734416	1.000000	0.630460
Penalties	0.121064	0.810656	0.630460	1.000000
DefensiveAwareness	0.915837	0.224089	0.184223	0.164226
StandingTackle	0.946551	0.184865	0.147486	0.120048
SlidingTackle	0.935401	0.150686	0.113345	0.084777

	DefensiveAwareness	StandingTackle	SlidingTackle
Crossing	0.459960	0.439998	0.421154
Finishing	0.044401	-0.003013	-0.042368
HeadingAccuracy	0.590525	0.566014	0.541000
ShortPassing	0.587609	0.563990	0.531526
Volleys	0.131841	0.086980	0.048822
Dribbling	0.361308	0.331820	0.304068
Curve	0.312571	0.280593	0.250759
FKAccuracy	0.312044	0.288957	0.257309
LongPassing	0.609940	0.598577	0.574623
BallControl	0.478835	0.445828	0.412439
Acceleration	0.222322	0.198080	0.190654
SprintSpeed	0.240339	0.215994	0.207792
Agility	0.200690	0.165519	0.150178
Reactions	0.320578	0.265392	0.236810
Balance	0.203819	0.189235	0.184231
ShotPower	0.071869	0.022522	-0.009595
Jumping	0.299237	0.273169	0.272954
Stamina	0.610159	0.587490	0.562918
Strength	0.343127	0.319840	0.294271
LongShots	0.226058	0.184513	0.145759
Aggression	0.743273	0.742952	0.723776
Interceptions	0.915837	0.946551	0.935401

```
Positioning                0.224089        0.184865        0.150686
Vision                     0.184223        0.147486        0.113345
Penalties                  0.164226        0.120048        0.084777
DefensiveAwareness         1.000000        0.923719        0.915806
StandingTackle             0.923719        1.000000        0.975995
SlidingTackle              0.915806        0.975995        1.000000

[28 rows x 28 columns]
```

[9]:
```
plt.figure(figsize=(14, 12))
sns.heatmap(corr, annot = False, vmin=-1, vmax=1, center= 0, cmap= 'coolwarm');
```



[10]:
```
# Select features that correlation < 0.9
columns = np.full((corr.shape[0],), True, dtype=bool)
for i in range(corr.shape[0]):
    for j in range(i+1, corr.shape[0]):
```

```
        if corr.iloc[i,j] >= 0.9:
            if columns[j]:
                columns[j] = False
selected_columns = X.columns[columns]
X = X[selected_columns]
X
```

[10]:

	Crossing	Finishing	HeadingAccuracy	ShortPassing	Volleys	Dribbling	\
0	88	95	70	92	88	97	
1	84	94	89	83	87	89	
2	87	87	62	87	87	96	
3	53	52	87	79	45	70	
4	13	11	15	43	13	12	
…	…	…	…	…	…	…	
19650	42	15	42	37	25	38	
19651	38	25	46	48	28	43	
19652	12	9	10	22	8	9	
19653	38	29	42	56	30	40	
19654	24	42	45	35	30	47	

	Curve	FKAccuracy	LongPassing	Acceleration	…	Balance	ShotPower	\
0	93	94	92	91	…	95	86	
1	81	76	77	88	…	71	95	
2	88	89	81	94	…	84	80	
3	60	70	83	74	…	53	81	
4	13	14	40	43	…	49	59	
…	…	…	…	…	…	…	…	
19650	32	25	30	68	…	60	30	
19651	40	40	45	66	…	50	38	
19652	12	8	15	25	…	30	34	
19653	38	32	53	55	…	54	40	
19654	32	30	33	55	…	43	43	

	Jumping	Stamina	Strength	LongShots	Aggression	Interceptions	\
0	68	75	68	94	48	40	
1	95	85	78	93	63	29	
2	61	81	49	85	51	36	
3	90	75	92	64	83	90	
4	78	41	78	12	34	19	
…	…	…	…	…	…	…	
19650	70	53	41	15	40	48	
19651	60	55	45	30	50	40	
19652	40	25	50	9	25	10	
19653	61	34	60	25	56	45	
19654	33	48	53	37	33	25	

	Vision	Penalties

```
0          94         75
1          82         85
2          90         92
3          65         62
4          65         11
…         …          …
19650      23         31
19651      46         37
19652      37          8
19653      38         40
19654      36         43

[19600 rows x 22 columns]
```

3.5 Splitting Data

[11]:
```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.25,␣
↪random_state=123)
```

3.6 Building Decision Tree Model

[12]:
```
# Create Decision Tree classifer object
clf = DecisionTreeClassifier(max_leaf_nodes = 15)

# Train Decision Tree Classifer
clf = clf.fit(X_train,y_train)

#Predict the response for test dataset
y_pred = clf.predict(X_test)
```

3.7 Evaluating Model

[13]:
```
print(classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

         CAM       0.37      0.82      0.51       582
          CB       0.79      0.86      0.82       973
         CDM       0.41      0.52      0.46       383
          CF       0.00      0.00      0.00        14
          CM       0.46      0.27      0.34       312
          GK       0.99      0.98      0.99       515
          LB       0.22      0.61      0.32       231
          LM       0.00      0.00      0.00       239
          LW       0.00      0.00      0.00        40
         LWB       0.00      0.00      0.00        70
          RB       0.00      0.00      0.00       300
          RM       0.00      0.00      0.00       414
```

```
          RW       0.00      0.00      0.00        69
         RWB       0.00      0.00      0.00        60
          ST       0.80      0.85      0.82       698

    accuracy                           0.58      4900
   macro avg       0.27      0.33      0.28      4900
weighted avg       0.49      0.58      0.52      4900
```

```
C:\Users\FORGE-15 I7\Anaconda3\lib\site-
packages\sklearn\metrics\_classification.py:1221: UndefinedMetricWarning:
Precision and F-score are ill-defined and being set to 0.0 in labels with no
predicted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

[14]:
```
print("Accuracy:", metrics.accuracy_score(y_test, y_pred))
```

```
Accuracy: 0.5791836734693877
```

3.8 Visualizing Decision Trees

[15]:
```
import os
os.environ["PATH"] += os.pathsep + r'C:\Users\FORGE-15␣
↪I7\Anaconda3\pkgs\graphviz-2.38-hfd603c8_2\Library\bin\graphviz'
```

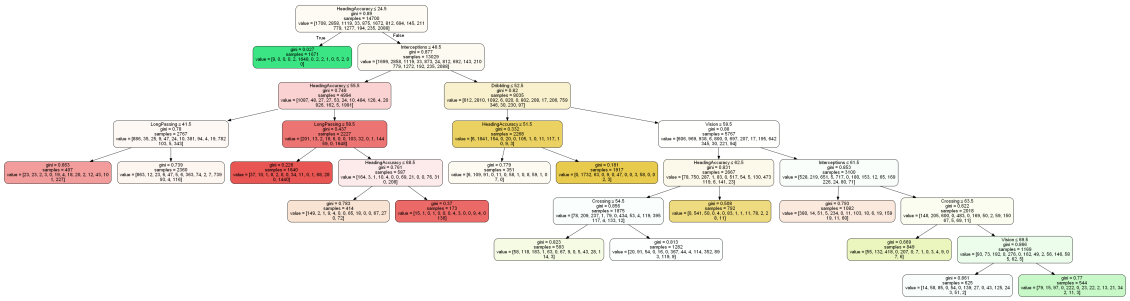
[16]:
```
from sklearn.tree import export_graphviz
from io import StringIO
from IPython.display import Image
import pydotplus

# Create DOT data
dot_data = StringIO()
export_graphviz(clf,
                out_file=dot_data,
                filled=True,
                rounded=True,
                special_characters=True,
                feature_names = X.columns)

# Draw graph
graph = pydotplus.graph_from_dot_data(dot_data.getvalue())

# Output
graph.write_png('decision_tree.png')
Image(graph.create_png())
```

[16]:



To show png file created in markdown: > *[alt text] (decision_tree.png ``Decision Tree'')*

1.2 Question 4

There will be a football player awarded as ``Player of The Year'' every year. The player is selected through majority votes from authorized parties. There will be five top players nominated for this award. Each party can vote up to maximun three different players in favor.

4.1 mporting required libraries

[17]:
```
import random
from mlxtend.frequent_patterns import apriori, association_rules, fpgrowth
# from apyori import apriori
```

4.2 Creating a list from dataset

[18]:
```
# Select top players
topPlayers = df.sort_values('overall_rating', ascending = False)['name'].
 ↪head(5).tolist()
topPlayers
```

[18]:
```
['Lionel Andrés Messi Cuccittini',
 'Cristiano Ronaldo dos Santos Aveir',
 'Neymar da Silva Santos Júnior',
 'Virgil van Dijk',
 'Jan Oblak']
```

[19]:
```
voteList = []

for i in range(100):
    # Sampling with replacement
    sampling = random.sample(topPlayers, k = random.randint(1, 3))
    print("Vote: ", sampling)
    voteList.append(sampling)
```

```
Vote:  ['Virgil van Dijk']
Vote:  ['Jan Oblak']
Vote:  ['Virgil van Dijk']
Vote:  ['Jan Oblak', 'Cristiano Ronaldo dos Santos Aveir']
Vote:  ['Lionel Andrés Messi Cuccittini']
Vote:  ['Neymar da Silva Santos Júnior']
Vote:  ['Lionel Andrés Messi Cuccittini']
Vote:  ['Virgil van Dijk']
Vote:  ['Neymar da Silva Santos Júnior', 'Cristiano Ronaldo dos Santos Aveir']
Vote:  ['Neymar da Silva Santos Júnior']
Vote:  ['Neymar da Silva Santos Júnior', 'Jan Oblak', 'Cristiano Ronaldo dos
Santos Aveir']
Vote:  ['Lionel Andrés Messi Cuccittini']
Vote:  ['Lionel Andrés Messi Cuccittini', 'Cristiano Ronaldo dos Santos Aveir']
Vote:  ['Neymar da Silva Santos Júnior', 'Virgil van Dijk', 'Lionel Andrés Messi
Cuccittini']
Vote:  ['Virgil van Dijk', 'Lionel Andrés Messi Cuccittini']
Vote:  ['Virgil van Dijk', 'Cristiano Ronaldo dos Santos Aveir']
Vote:  ['Jan Oblak']
Vote:  ['Lionel Andrés Messi Cuccittini', 'Cristiano Ronaldo dos Santos Aveir']
Vote:  ['Jan Oblak']
Vote:  ['Jan Oblak', 'Lionel Andrés Messi Cuccittini', 'Neymar da Silva Santos
Júnior']
Vote:  ['Virgil van Dijk', 'Cristiano Ronaldo dos Santos Aveir', 'Neymar da
Silva Santos Júnior']
Vote:  ['Neymar da Silva Santos Júnior', 'Cristiano Ronaldo dos Santos Aveir',
'Virgil van Dijk']
Vote:  ['Jan Oblak']
Vote:  ['Jan Oblak']
Vote:  ['Neymar da Silva Santos Júnior']
Vote:  ['Cristiano Ronaldo dos Santos Aveir', 'Virgil van Dijk', 'Lionel Andrés
Messi Cuccittini']
Vote:  ['Lionel Andrés Messi Cuccittini', 'Neymar da Silva Santos Júnior',
'Virgil van Dijk']
Vote:  ['Neymar da Silva Santos Júnior', 'Lionel Andrés Messi Cuccittini', 'Jan
Oblak']
Vote:  ['Lionel Andrés Messi Cuccittini', 'Cristiano Ronaldo dos Santos Aveir',
'Neymar da Silva Santos Júnior']
Vote:  ['Lionel Andrés Messi Cuccittini']
Vote:  ['Lionel Andrés Messi Cuccittini', 'Cristiano Ronaldo dos Santos Aveir',
'Neymar da Silva Santos Júnior']
Vote:  ['Neymar da Silva Santos Júnior']
Vote:  ['Virgil van Dijk', 'Lionel Andrés Messi Cuccittini', 'Jan Oblak']
Vote:  ['Lionel Andrés Messi Cuccittini', 'Virgil van Dijk', 'Cristiano Ronaldo
dos Santos Aveir']
Vote:  ['Lionel Andrés Messi Cuccittini']
Vote:  ['Cristiano Ronaldo dos Santos Aveir']
Vote:  ['Lionel Andrés Messi Cuccittini', 'Neymar da Silva Santos Júnior']
```

```
Vote:  ['Cristiano Ronaldo dos Santos Aveir', 'Jan Oblak', 'Lionel Andrés Messi
Cuccittini']
Vote:  ['Neymar da Silva Santos Júnior', 'Virgil van Dijk', 'Cristiano Ronaldo
dos Santos Aveir']
Vote:  ['Lionel Andrés Messi Cuccittini']
Vote:  ['Lionel Andrés Messi Cuccittini']
Vote:  ['Jan Oblak', 'Neymar da Silva Santos Júnior', 'Virgil van Dijk']
Vote:  ['Cristiano Ronaldo dos Santos Aveir']
Vote:  ['Jan Oblak', 'Cristiano Ronaldo dos Santos Aveir', 'Virgil van Dijk']
Vote:  ['Cristiano Ronaldo dos Santos Aveir']
Vote:  ['Virgil van Dijk', 'Cristiano Ronaldo dos Santos Aveir', 'Neymar da
Silva Santos Júnior']
Vote:  ['Neymar da Silva Santos Júnior']
Vote:  ['Virgil van Dijk']
Vote:  ['Cristiano Ronaldo dos Santos Aveir', 'Virgil van Dijk']
Vote:  ['Cristiano Ronaldo dos Santos Aveir', 'Neymar da Silva Santos Júnior']
Vote:  ['Virgil van Dijk', 'Lionel Andrés Messi Cuccittini']
Vote:  ['Jan Oblak', 'Neymar da Silva Santos Júnior']
Vote:  ['Cristiano Ronaldo dos Santos Aveir', 'Neymar da Silva Santos Júnior']
Vote:  ['Neymar da Silva Santos Júnior', 'Virgil van Dijk', 'Cristiano Ronaldo
dos Santos Aveir']
Vote:  ['Lionel Andrés Messi Cuccittini', 'Virgil van Dijk', 'Neymar da Silva
Santos Júnior']
Vote:  ['Jan Oblak', 'Cristiano Ronaldo dos Santos Aveir', 'Lionel Andrés Messi
Cuccittini']
Vote:  ['Neymar da Silva Santos Júnior']
Vote:  ['Lionel Andrés Messi Cuccittini', 'Jan Oblak']
Vote:  ['Cristiano Ronaldo dos Santos Aveir', 'Neymar da Silva Santos Júnior',
'Lionel Andrés Messi Cuccittini']
Vote:  ['Cristiano Ronaldo dos Santos Aveir', 'Jan Oblak', 'Neymar da Silva
Santos Júnior']
Vote:  ['Virgil van Dijk']
Vote:  ['Jan Oblak', 'Virgil van Dijk', 'Lionel Andrés Messi Cuccittini']
Vote:  ['Neymar da Silva Santos Júnior', 'Jan Oblak']
Vote:  ['Jan Oblak']
Vote:  ['Neymar da Silva Santos Júnior', 'Jan Oblak', 'Virgil van Dijk']
Vote:  ['Neymar da Silva Santos Júnior', 'Cristiano Ronaldo dos Santos Aveir']
Vote:  ['Cristiano Ronaldo dos Santos Aveir', 'Virgil van Dijk']
Vote:  ['Virgil van Dijk', 'Jan Oblak']
Vote:  ['Lionel Andrés Messi Cuccittini', 'Jan Oblak', 'Cristiano Ronaldo dos
Santos Aveir']
Vote:  ['Jan Oblak', 'Neymar da Silva Santos Júnior', 'Cristiano Ronaldo dos
Santos Aveir']
Vote:  ['Jan Oblak', 'Lionel Andrés Messi Cuccittini']
Vote:  ['Neymar da Silva Santos Júnior']
Vote:  ['Jan Oblak', 'Cristiano Ronaldo dos Santos Aveir']
Vote:  ['Lionel Andrés Messi Cuccittini']
Vote:  ['Jan Oblak', 'Cristiano Ronaldo dos Santos Aveir', 'Lionel Andrés Messi
```

```
Cuccittini']
Vote:  ['Lionel Andrés Messi Cuccittini']
Vote:  ['Virgil van Dijk']
Vote:  ['Jan Oblak']
Vote:  ['Jan Oblak']
Vote:  ['Jan Oblak', 'Virgil van Dijk', 'Lionel Andrés Messi Cuccittini']
Vote:  ['Jan Oblak', 'Virgil van Dijk', 'Cristiano Ronaldo dos Santos Aveir']
Vote:  ['Cristiano Ronaldo dos Santos Aveir', 'Neymar da Silva Santos Júnior',
'Lionel Andrés Messi Cuccittini']
Vote:  ['Cristiano Ronaldo dos Santos Aveir']
Vote:  ['Jan Oblak', 'Cristiano Ronaldo dos Santos Aveir']
Vote:  ['Virgil van Dijk']
Vote:  ['Lionel Andrés Messi Cuccittini', 'Jan Oblak']
Vote:  ['Virgil van Dijk', 'Neymar da Silva Santos Júnior', 'Cristiano Ronaldo
dos Santos Aveir']
Vote:  ['Neymar da Silva Santos Júnior', 'Cristiano Ronaldo dos Santos Aveir',
'Jan Oblak']
Vote:  ['Neymar da Silva Santos Júnior', 'Cristiano Ronaldo dos Santos Aveir',
'Lionel Andrés Messi Cuccittini']
Vote:  ['Neymar da Silva Santos Júnior', 'Lionel Andrés Messi Cuccittini', 'Jan
Oblak']
Vote:  ['Neymar da Silva Santos Júnior', 'Virgil van Dijk', 'Jan Oblak']
Vote:  ['Cristiano Ronaldo dos Santos Aveir', 'Jan Oblak', 'Lionel Andrés Messi
Cuccittini']
Vote:  ['Neymar da Silva Santos Júnior', 'Cristiano Ronaldo dos Santos Aveir']
Vote:  ['Neymar da Silva Santos Júnior', 'Lionel Andrés Messi Cuccittini', 'Jan
Oblak']
Vote:  ['Lionel Andrés Messi Cuccittini', 'Neymar da Silva Santos Júnior',
'Virgil van Dijk']
Vote:  ['Virgil van Dijk', 'Cristiano Ronaldo dos Santos Aveir']
Vote:  ['Jan Oblak']
Vote:  ['Cristiano Ronaldo dos Santos Aveir', 'Virgil van Dijk']
Vote:  ['Virgil van Dijk']
Vote:  ['Neymar da Silva Santos Júnior', 'Lionel Andrés Messi Cuccittini',
'Cristiano Ronaldo dos Santos Aveir']
```

[20]:
```
voteList
```

[20]:
```
[['Virgil van Dijk'],
 ['Jan Oblak'],
 ['Virgil van Dijk'],
 ['Jan Oblak', 'Cristiano Ronaldo dos Santos Aveir'],
 ['Lionel Andrés Messi Cuccittini'],
 ['Neymar da Silva Santos Júnior'],
 ['Lionel Andrés Messi Cuccittini'],
 ['Virgil van Dijk'],
 ['Neymar da Silva Santos Júnior', 'Cristiano Ronaldo dos Santos Aveir'],
```

```
['Neymar da Silva Santos Júnior'],
['Neymar da Silva Santos Júnior',
 'Jan Oblak',
 'Cristiano Ronaldo dos Santos Aveir'],
['Lionel Andrés Messi Cuccittini'],
['Lionel Andrés Messi Cuccittini', 'Cristiano Ronaldo dos Santos Aveir'],
['Neymar da Silva Santos Júnior',
 'Virgil van Dijk',
 'Lionel Andrés Messi Cuccittini'],
['Virgil van Dijk', 'Lionel Andrés Messi Cuccittini'],
['Virgil van Dijk', 'Cristiano Ronaldo dos Santos Aveir'],
['Jan Oblak'],
['Lionel Andrés Messi Cuccittini', 'Cristiano Ronaldo dos Santos Aveir'],
['Jan Oblak'],
['Jan Oblak',
 'Lionel Andrés Messi Cuccittini',
 'Neymar da Silva Santos Júnior'],
['Virgil van Dijk',
 'Cristiano Ronaldo dos Santos Aveir',
 'Neymar da Silva Santos Júnior'],
['Neymar da Silva Santos Júnior',
 'Cristiano Ronaldo dos Santos Aveir',
 'Virgil van Dijk'],
['Jan Oblak'],
['Jan Oblak'],
['Neymar da Silva Santos Júnior'],
['Cristiano Ronaldo dos Santos Aveir',
 'Virgil van Dijk',
 'Lionel Andrés Messi Cuccittini'],
['Lionel Andrés Messi Cuccittini',
 'Neymar da Silva Santos Júnior',
 'Virgil van Dijk'],
['Neymar da Silva Santos Júnior',
 'Lionel Andrés Messi Cuccittini',
 'Jan Oblak'],
['Lionel Andrés Messi Cuccittini',
 'Cristiano Ronaldo dos Santos Aveir',
 'Neymar da Silva Santos Júnior'],
['Lionel Andrés Messi Cuccittini'],
['Lionel Andrés Messi Cuccittini',
 'Cristiano Ronaldo dos Santos Aveir',
 'Neymar da Silva Santos Júnior'],
['Neymar da Silva Santos Júnior'],
['Virgil van Dijk', 'Lionel Andrés Messi Cuccittini', 'Jan Oblak'],
['Lionel Andrés Messi Cuccittini',
 'Virgil van Dijk',
 'Cristiano Ronaldo dos Santos Aveir'],
```

```
['Lionel Andrés Messi Cuccittini'],
['Cristiano Ronaldo dos Santos Aveir'],
['Lionel Andrés Messi Cuccittini', 'Neymar da Silva Santos Júnior'],
['Cristiano Ronaldo dos Santos Aveir',
 'Jan Oblak',
 'Lionel Andrés Messi Cuccittini'],
['Neymar da Silva Santos Júnior',
 'Virgil van Dijk',
 'Cristiano Ronaldo dos Santos Aveir'],
['Lionel Andrés Messi Cuccittini'],
['Lionel Andrés Messi Cuccittini'],
['Jan Oblak', 'Neymar da Silva Santos Júnior', 'Virgil van Dijk'],
['Cristiano Ronaldo dos Santos Aveir'],
['Jan Oblak', 'Cristiano Ronaldo dos Santos Aveir', 'Virgil van Dijk'],
['Cristiano Ronaldo dos Santos Aveir'],
['Virgil van Dijk',
 'Cristiano Ronaldo dos Santos Aveir',
 'Neymar da Silva Santos Júnior'],
['Neymar da Silva Santos Júnior'],
['Virgil van Dijk'],
['Cristiano Ronaldo dos Santos Aveir', 'Virgil van Dijk'],
['Cristiano Ronaldo dos Santos Aveir', 'Neymar da Silva Santos Júnior'],
['Virgil van Dijk', 'Lionel Andrés Messi Cuccittini'],
['Jan Oblak', 'Neymar da Silva Santos Júnior'],
['Cristiano Ronaldo dos Santos Aveir', 'Neymar da Silva Santos Júnior'],
['Neymar da Silva Santos Júnior',
 'Virgil van Dijk',
 'Cristiano Ronaldo dos Santos Aveir'],
['Lionel Andrés Messi Cuccittini',
 'Virgil van Dijk',
 'Neymar da Silva Santos Júnior'],
['Jan Oblak',
 'Cristiano Ronaldo dos Santos Aveir',
 'Lionel Andrés Messi Cuccittini'],
['Neymar da Silva Santos Júnior'],
['Lionel Andrés Messi Cuccittini', 'Jan Oblak'],
['Cristiano Ronaldo dos Santos Aveir',
 'Neymar da Silva Santos Júnior',
 'Lionel Andrés Messi Cuccittini'],
['Cristiano Ronaldo dos Santos Aveir',
 'Jan Oblak',
 'Neymar da Silva Santos Júnior'],
['Virgil van Dijk'],
['Jan Oblak', 'Virgil van Dijk', 'Lionel Andrés Messi Cuccittini'],
['Neymar da Silva Santos Júnior', 'Jan Oblak'],
['Jan Oblak'],
['Neymar da Silva Santos Júnior', 'Jan Oblak', 'Virgil van Dijk'],
```

```
['Neymar da Silva Santos Júnior', 'Cristiano Ronaldo dos Santos Aveir'],
['Cristiano Ronaldo dos Santos Aveir', 'Virgil van Dijk'],
['Virgil van Dijk', 'Jan Oblak'],
['Lionel Andrés Messi Cuccittini',
 'Jan Oblak',
 'Cristiano Ronaldo dos Santos Aveir'],
['Jan Oblak',
 'Neymar da Silva Santos Júnior',
 'Cristiano Ronaldo dos Santos Aveir'],
['Jan Oblak', 'Lionel Andrés Messi Cuccittini'],
['Neymar da Silva Santos Júnior'],
['Jan Oblak', 'Cristiano Ronaldo dos Santos Aveir'],
['Lionel Andrés Messi Cuccittini'],
['Jan Oblak',
 'Cristiano Ronaldo dos Santos Aveir',
 'Lionel Andrés Messi Cuccittini'],
['Lionel Andrés Messi Cuccittini'],
['Virgil van Dijk'],
['Jan Oblak'],
['Jan Oblak'],
['Jan Oblak', 'Virgil van Dijk', 'Lionel Andrés Messi Cuccittini'],
['Jan Oblak', 'Virgil van Dijk', 'Cristiano Ronaldo dos Santos Aveir'],
['Cristiano Ronaldo dos Santos Aveir',
 'Neymar da Silva Santos Júnior',
 'Lionel Andrés Messi Cuccittini'],
['Cristiano Ronaldo dos Santos Aveir'],
['Jan Oblak', 'Cristiano Ronaldo dos Santos Aveir'],
['Virgil van Dijk'],
['Lionel Andrés Messi Cuccittini', 'Jan Oblak'],
['Virgil van Dijk',
 'Neymar da Silva Santos Júnior',
 'Cristiano Ronaldo dos Santos Aveir'],
['Neymar da Silva Santos Júnior',
 'Cristiano Ronaldo dos Santos Aveir',
 'Jan Oblak'],
['Neymar da Silva Santos Júnior',
 'Cristiano Ronaldo dos Santos Aveir',
 'Lionel Andrés Messi Cuccittini'],
['Neymar da Silva Santos Júnior',
 'Lionel Andrés Messi Cuccittini',
 'Jan Oblak'],
['Neymar da Silva Santos Júnior', 'Virgil van Dijk', 'Jan Oblak'],
['Cristiano Ronaldo dos Santos Aveir',
 'Jan Oblak',
 'Lionel Andrés Messi Cuccittini'],
['Neymar da Silva Santos Júnior', 'Cristiano Ronaldo dos Santos Aveir'],
['Neymar da Silva Santos Júnior',
```

```
 'Lionel Andrés Messi Cuccittini',
 'Jan Oblak'],
['Lionel Andrés Messi Cuccittini',
 'Neymar da Silva Santos Júnior',
 'Virgil van Dijk'],
['Virgil van Dijk', 'Cristiano Ronaldo dos Santos Aveir'],
['Jan Oblak'],
['Cristiano Ronaldo dos Santos Aveir', 'Virgil van Dijk'],
['Virgil van Dijk'],
['Neymar da Silva Santos Júnior',
 'Lionel Andrés Messi Cuccittini',
 'Cristiano Ronaldo dos Santos Aveir']]
```

[21]:
```
import collections

counter = collections.Counter(x for clist in voteList for x in clist)
pd.DataFrame.from_dict(counter, orient='index').reset_index().
↪rename(columns={"index": "Player",
                                                                    0:
↪ "Votes"})
```

[21]:

	Player	Votes
0	Virgil van Dijk	36
1	Jan Oblak	39
2	Cristiano Ronaldo dos Santos Aveir	44
3	Lionel Andrés Messi Cuccittini	41
4	Neymar da Silva Santos Júnior	42

4.3 Convert list to dataframe with boolean values

[22]:
```
df_vote = pd.DataFrame(voteList).stack().str.get_dummies().sum(level=0)
df_vote
```

[22]:

	Cristiano Ronaldo dos Santos Aveir	Jan Oblak	\
0	0	0	
1	0	1	
2	0	0	
3	1	1	
4	0	0	
..	…	…	
95	1	0	
96	0	1	
97	1	0	
98	0	0	
99	1	0	

	Lionel Andrés Messi Cuccittini	Neymar da Silva Santos Júnior	\

```
0                                0                                0
1                                0                                0
2                                0                                0
3                                0                                0
4                                1                                0
..                             …                                …
95                               0                                0
96                               0                                0
97                               0                                0
98                               0                                0
99                               1                                1

    Virgil van Dijk
0                 1
1                 0
2                 1
3                 0
4                 0
..              …
95                1
96                0
97                1
98                1
99                0

[100 rows x 5 columns]
```

4.4 Find frequently occurring itemsets using Apriori Algorithm

[23]:
```
apriori_itemsets = apriori(df_vote, min_support=0.02, use_colnames=True)
apriori_itemsets
```

[23]:
```
    support                                        itemsets
0      0.44              (Cristiano Ronaldo dos Santos Aveir)
1      0.39                                   (Jan Oblak)
2      0.41                  (Lionel Andrés Messi Cuccittini)
3      0.42                   (Neymar da Silva Santos Júnior)
4      0.36                                (Virgil van Dijk)
5      0.14    (Jan Oblak, Cristiano Ronaldo dos Santos Aveir)
6      0.15  (Lionel Andrés Messi Cuccittini, Cristiano Ron…
7      0.21  (Neymar da Silva Santos Júnior, Cristiano Rona…
8      0.15  (Virgil van Dijk, Cristiano Ronaldo dos Santos…
9      0.15        (Lionel Andrés Messi Cuccittini, Jan Oblak)
10     0.13         (Neymar da Silva Santos Júnior, Jan Oblak)
11     0.09                      (Virgil van Dijk, Jan Oblak)
12     0.15  (Neymar da Silva Santos Júnior, Lionel Andrés …
13     0.11  (Virgil van Dijk, Lionel Andrés Messi Cuccittini)
```

```
14     0.13   (Neymar da Silva Santos Júnior, Virgil van Dijk)
15     0.05  (Lionel Andrés Messi Cuccittini, Jan Oblak, Cr…
16     0.04  (Neymar da Silva Santos Júnior, Jan Oblak, Cri…
17     0.02  (Virgil van Dijk, Jan Oblak, Cristiano Ronaldo…
18     0.06  (Neymar da Silva Santos Júnior, Lionel Andrés …
19     0.02  (Virgil van Dijk, Lionel Andrés Messi Cuccitti…
20     0.06  (Neymar da Silva Santos Júnior, Virgil van Dij…
21     0.04  (Neymar da Silva Santos Júnior, Lionel Andrés …
22     0.03  (Virgil van Dijk, Lionel Andrés Messi Cuccitti…
23     0.03  (Neymar da Silva Santos Júnior, Virgil van Dij…
24     0.04  (Neymar da Silva Santos Júnior, Virgil van Dij…
```

4.5 Find frequently occurring itemsets using F-P Growth

[24]:
```
fpgrowth_itemsets = fpgrowth(df_vote, min_support=0.02, use_colnames=True)
fpgrowth_itemsets
```

[24]:
```
    support                                          itemsets
0      0.36                                  (Virgil van Dijk)
1      0.39                                       (Jan Oblak)
2      0.44                (Cristiano Ronaldo dos Santos Aveir)
3      0.41                    (Lionel Andrés Messi Cuccittini)
4      0.42                     (Neymar da Silva Santos Júnior)
5      0.13   (Neymar da Silva Santos Júnior, Virgil van Dijk)
6      0.11  (Virgil van Dijk, Lionel Andrés Messi Cuccittini)
7      0.15  (Virgil van Dijk, Cristiano Ronaldo dos Santos…
8      0.09                        (Virgil van Dijk, Jan Oblak)
9      0.06  (Neymar da Silva Santos Júnior, Virgil van Dij…
10     0.04  (Neymar da Silva Santos Júnior, Virgil van Dij…
11     0.02  (Virgil van Dijk, Lionel Andrés Messi Cuccitti…
12     0.03  (Virgil van Dijk, Lionel Andrés Messi Cuccitti…
13     0.03  (Neymar da Silva Santos Júnior, Virgil van Dij…
14     0.02  (Virgil van Dijk, Jan Oblak, Cristiano Ronaldo…
15     0.14    (Jan Oblak, Cristiano Ronaldo dos Santos Aveir)
16     0.13         (Neymar da Silva Santos Júnior, Jan Oblak)
17     0.15        (Lionel Andrés Messi Cuccittini, Jan Oblak)
18     0.05  (Lionel Andrés Messi Cuccittini, Jan Oblak, Cr…
19     0.04  (Neymar da Silva Santos Júnior, Jan Oblak, Cri…
20     0.04  (Neymar da Silva Santos Júnior, Lionel Andrés …
21     0.15  (Lionel Andrés Messi Cuccittini, Cristiano Ron…
22     0.15  (Neymar da Silva Santos Júnior, Lionel Andrés …
23     0.06  (Neymar da Silva Santos Júnior, Lionel Andrés …
24     0.21  (Neymar da Silva Santos Júnior, Cristiano Rona…
```

4.6 Mine the Association Rules

[25]:
```
apriori_rules = association_rules(apriori_itemsets, metric="lift",␣
↪min_threshold=1)
apriori_rules
```

[25]:

	antecedents	consequents	antecedent support	consequent support	support	confidence	lift	leverage	conviction
0	(Neymar da Silva Santos Júnior)	(Cristiano Ronaldo dos Santos Aveir)	0.42	0.44	0.21	0.500000	1.136364	0.0252	1.120000
1	(Cristiano Ronaldo dos Santos Aveir)	(Neymar da Silva Santos Júnior)	0.44	0.42	0.21	0.477273	1.136364	0.0252	1.109565
2	(Neymar da Silva Santos Júnior, Virgil van Dijk)	(Cristiano Ronaldo dos Santos Aveir)	0.13	0.44	0.06	0.461538	1.048951	0.0028	1.040000
3	(Cristiano Ronaldo dos Santos Aveir)	(Neymar da Silva Santos Júnior, Virgil van Dijk)	0.44	0.13	0.06	0.136364	1.048951	0.0028	1.007368

[26]:
```
fpgrowth_rules = association_rules(fpgrowth_itemsets, metric="lift",␣
↪min_threshold=1)
fpgrowth_rules
```

[26]:

	antecedents	consequents	antecedent support	consequent support	support	confidence	lift	leverage	conviction
0	(Neymar da Silva Santos Júnior, Virgil van Dijk)	(Cristiano Ronaldo dos Santos Aveir)	0.13	0.44	0.06	0.461538	1.048951	0.0028	1.040000
1	(Cristiano Ronaldo dos Santos Aveir)	(Neymar da Silva Santos Júnior, Virgil van Dijk)	0.44	0.13	0.06	0.136364	1.048951	0.0028	1.007368
2	(Neymar da Silva Santos Júnior)	(Cristiano Ronaldo dos Santos Aveir)	0.42	0.44	0.21	0.500000	1.136364	0.0252	1.120000
3	(Cristiano Ronaldo dos Santos Aveir)	(Neymar da Silva Santos Júnior)	0.44	0.42	0.21	0.477273	1.136364	0.0252	1.109565

1.3 References

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FP Growth - YouTube: FP Growth method with an example - mlxtend: Frequent Itemsets via the FP-Growth Algorithm - Frequent Pattern (FP) Growth Algorithm In Data Mining

[ ]: