NFL-showcase

December 14, 2023

0.1 Clustering NFL Data

- Here is a demo on clustering data and identifying important factors. the example is focused on the National Footbal League (NFL) data provided by the yellowbrick database
- The dataset is comprised of statistics on all eligible receivers from the 2018 NFL regular season.

[1]:
```
import sklearn as sk
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import hashlib
```

[2]:
```
from yellowbrick.datasets import load_nfl

nfl = load_nfl(return_dataset=True, data_home='.')
```

[3]:
```
print(nfl.README)
```

```
# NFL Receiver Statistics from the 2018 Regular Season

**Downloaded from Pro-Football-Reference on June 18, 2019.**

- Multivariate Data Set
- 494 Instances
- 20 attributes
- Well suited for _clustering_ tasks
- [https://www.pro-football-
reference.com/years/2018/receiving.htm](https://www.pro-football-
reference.com/years/2018/receiving.htm)

## Abstract

This dataset is comprised of statistics on all eligible receivers from the 2018
NFL regular season.

## Description
```

The dataset consists of an aggregate of all relevant statistics for eligible receivers that played in at least 1 game and had at least 1 target throughout the season. This is not limited to players specifically designated as wide-receivers, but may include other positions such as running-backs and tight-ends.

Attributes

- Player : player name
- Id : PFR player id
- Tm : team
- Age : age
- G : games count
- GS : games started count
- Tgt : number of targets
- Rec : number of receptions
- Ctch_Rate : catch rate (Rec / Tgt)
- Yds : total yards
- Y/R : yards per reception
- TD : touchdowns
- Lng : longest catch
- Y/Tgt : yards per target
- R/G : receptions per game
- Y/G : yards per game
- Fmb : number of fumbles
- ProBowl : 1/0 indicator of making the Pro Bowl
- FirstTeamAllPro : 1/0 indicator of making First Team All Pro
- C_pos : 1/0 indicator of being a Center
- CB_pos : 1/0 indicator of being a Cornerback
- DT_pos : 1/0 indicator of being a Defensive Tackle
- FB_pos : 1/0 indicator of being a Fullback
- QB_pos : 1/0 indicator of being a Quarterback
- RB_pos : 1/0 indicator of being a Runningback
- T_pos : 1/0 indicator of being a Tackle
- TE_pos : 1/0 indicator of being a Tightend
- WR_pos : 1/0 indicator of being a Wide Receiver

Citation

Redistributed with the permission of Sports Reference LLC on June 11, 2019 via email.

Sports Reference LLC, "2018 NFL Receiving," Pro-Football-Reference.com - Pro Football Statistics and History.
[Online]. Available: https://www.pro-football-reference.com/years/2018/receiving.htm. [Accessed: 18-Jun-2019]

- Convert the data to a `DataFrame`

[43]:
```
# Chk for nan, clean the data
df.isnull().sum().sum()
```

[43]:
```
0
```

[4]:
```
df = nfl.to_dataframe()
df
```

[4]:

	Rk	Player	Id	Tm	Age	G	GS	Tgt	Rec	Ctch_Rate	\
0	1	Michael Thomas	ThomMi05	NOR	25	16	16	147	125	0.850	
1	2	Zach Ertz	ErtzZa00	PHI	28	16	16	156	116	0.744	
2	3	DeAndre Hopkins	HopkDe00	HOU	26	16	16	163	115	0.706	
3	4	Julio Jones	JoneJu02	ATL	29	16	16	170	113	0.665	
4	5	Adam Thielen	ThieAd00	MIN	28	16	16	153	113	0.739	
..	…	…	…	…	…	…	…	…	…	…	
489	490	Tim White	WhitTi00	BAL	24	3	0	1	1	1.000	
490	491	Jonathan Williams	WillJo07	NOR	24	3	0	1	1	1.000	
491	492	Kyle Williams	WillKy20	BUF	35	16	16	1	1	1.000	
492	493	Russell Wilson	WilsRu00	SEA	30	16	16	1	1	1.000	
493	494	Brandon Zylstra	ZylsBr00	MIN	25	16	0	2	1	0.500	

	…	FirstTeamAllPro	C_pos	CB_pos	DT_pos	FB_pos	QB_pos	RB_pos	\
0	…	1	0	0	0	0	0	0	
1	…	0	0	0	0	0	0	0	
2	…	1	0	0	0	0	0	0	
3	…	0	0	0	0	0	0	0	
4	…	0	0	0	0	0	0	0	
..	…	…	…	…	…	…	…	…	
489	…	0	0	0	0	0	0	0	
490	…	0	0	0	0	0	0	0	
491	…	0	0	0	1	0	0	0	
492	…	0	0	0	0	0	1	0	
493	…	0	0	0	0	0	0	0	

	T_pos	TE_pos	WR_pos
0	0	0	1
1	0	1	0
2	0	0	1
3	0	0	1
4	0	0	1
..	…	…	…
489	0	0	0
490	0	0	0
491	0	0	0
492	0	0	0
493	0	0	0

```
[494 rows x 29 columns]
```

- Encrypt the name data

[5]:
```
def hash_name(name):
    return hashlib.sha256(name.encode()).hexdigest()

# Apply the hash function to the Player column
if 'Player' in df.columns:
    df['Player'] = df['Player'].apply(hash_name)

df.drop('Id', axis=1, inplace=True)
# Display the DataFrame
df.head()
```

[5]:

	Rk	Player	Tm	Age	G	GS	\
0	1	36d1dcc21cd041c140d88353146309d21f2e424a1301aa…	NOR	25	16	16	
1	2	baaecde2587e1c4ea83eb9f39116294aa6b21473c925a1…	PHI	28	16	16	
2	3	9f819c9d9d341c304ae42066a46bc72b05c88ed8329393…	HOU	26	16	16	
3	4	6e53c591b71bbe53a49c0967b53f1e18d9fbe4f13d8aa3…	ATL	29	16	16	
4	5	eee5b9da6d68f761071ec8cf370274de901cb5cbd3addf…	MIN	28	16	16	

	Tgt	Rec	Ctch_Rate	Yds	…	FirstTeamAllPro	C_pos	CB_pos	DT_pos	\
0	147	125	0.850	1405	…	1	0	0	0	
1	156	116	0.744	1163	…	0	0	0	0	
2	163	115	0.706	1572	…	1	0	0	0	
3	170	113	0.665	1677	…	0	0	0	0	
4	153	113	0.739	1373	…	0	0	0	0	

	FB_pos	QB_pos	RB_pos	T_pos	TE_pos	WR_pos
0	0	0	0	0	0	1
1	0	0	0	0	1	0
2	0	0	0	0	0	1
3	0	0	0	0	0	1
4	0	0	0	0	0	1

```
[5 rows x 28 columns]
```

- Differences in variance affect k-means clustering, so we'll investigate the variance among columns.

[8]:
```
df.describe()
```

[8]:

	Rk	Age	G	GS	Tgt	Rec	\
count	494.000000	494.000000	494.000000	494.000000	494.000000	494.000000	
mean	247.500000	26.028340	12.012146	5.682186	34.692308	23.202429	
std	142.749781	3.232569	4.353527	5.339414	37.216793	25.217502	
min	1.000000	21.000000	1.000000	0.000000	1.000000	1.000000	

```
25%    124.250000   24.000000    9.000000    1.000000    6.000000    4.000000
50%    247.500000   25.000000   14.000000    4.000000   23.000000   14.000000
75%    370.750000   28.000000   16.000000   10.000000   49.000000   34.000000
max    494.000000   41.000000   16.000000   16.000000  170.000000  125.000000

        Ctch_Rate          Yds          Y/R           TD  …  FirstTeamAllPro  \
count  494.000000   494.000000  494.000000  494.000000  …       494.000000
mean     0.701964   263.698381   10.523077    1.714575  …         0.014170
std      0.162884   317.245031    5.865255    2.402144  …         0.118311
min      0.200000   -11.000000  -11.000000    0.000000  …         0.000000
25%      0.600000    38.000000    7.700000    0.000000  …         0.000000
50%      0.688000   144.500000   10.000000    1.000000  …         0.000000
75%      0.786500   376.250000   12.875000    2.000000  …         0.000000
max      1.000000  1677.000000   66.000000   15.000000  …         1.000000

            C_pos       CB_pos       DT_pos       FB_pos       QB_pos      RB_pos  \
count  494.000000  494.000000  494.000000  494.000000  494.000000  494.00000
mean     0.004049    0.004049    0.002024    0.038462    0.026316    0.15587
std      0.063564    0.063564    0.044992    0.192503    0.160235    0.36310
min      0.000000    0.000000    0.000000    0.000000    0.000000    0.00000
25%      0.000000    0.000000    0.000000    0.000000    0.000000    0.00000
50%      0.000000    0.000000    0.000000    0.000000    0.000000    0.00000
75%      0.000000    0.000000    0.000000    0.000000    0.000000    0.00000
max      1.000000    1.000000    1.000000    1.000000    1.000000    1.00000

            T_pos       TE_pos       WR_pos
count  494.000000  494.000000  494.000000
mean     0.010121    0.220648    0.336032
std      0.100196    0.415104    0.472829
min      0.000000    0.000000    0.000000
25%      0.000000    0.000000    0.000000
50%      0.000000    0.000000    0.000000
75%      0.000000    0.000000    1.000000
max      1.000000    1.000000    1.000000

[8 rows x 26 columns]
```

- The variance varies a lot, so we'll employ `StandardScaler`.

[48]:
```python
from sklearn.preprocessing import StandardScaler

# Exclude the 'Player' and 'Tm' columns for scaling
columns_to_scale = df.columns.drop(['Player', 'Tm', 'Rk'])
scaler = StandardScaler()

# Scale only the columns that are not 'Player' and 'Tm'
scaled_columns = scaler.fit_transform(df[columns_to_scale])
```

```
# Create a new DataFrame from the scaled data
scaled_df = pd.DataFrame(scaled_columns, index=df.index,␣
 ↪columns=columns_to_scale)

# Add the unscaled 'Player' and 'Tm' columns back to the DataFrame
# scaled_df['Player'] = df['Player']
# scaled_df['Tm'] = df['Tm']
# scaled_df['Rk'] = df['Rk']

# # Reorder the columns if needed
# column_order = ['Rk','Player', 'Tm'] + [col for col in df.columns if col not␣
 ↪in ['Rk','Player', 'Tm']]
# scaled_df = scaled_df[column_order]

# Display the scaled DataFrame
scaled_df.head()
```

```
C:\Users\tanagnos\anaconda3\envs\PDS\Lib\site-
packages\sklearn\utils\validation.py:767: FutureWarning: is_sparse is deprecated
and will be removed in a future version. Check `isinstance(dtype,
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pd.SparseDtype)` instead.
```

```
  if is_sparse(pd_dtype) or not is_extension_array_dtype(pd_dtype):
```

[48]:

	Age	G	GS	Tgt	Rec	Ctch_Rate	Yds	\
0	-0.318441	0.916934	1.934346	3.020721	4.040874	0.909766	3.601187	
1	0.610554	0.916934	1.934346	3.262792	3.683618	0.258337	2.837596	
2	-0.008776	0.916934	1.934346	3.451070	3.643923	0.024806	4.128127	
3	0.920219	0.916934	1.934346	3.639348	3.564532	-0.227162	4.459437	
4	0.610554	0.916934	1.934346	3.182102	3.564532	0.227609	3.500216	

	Y/R	TD	Lng	…	FirstTeamAllPro	C_pos	CB_pos	\
0	0.115529	3.035959	2.034711	…	8.340949	-0.063758	-0.063758	
1	-0.089273	2.619242	0.162378	…	-0.119890	-0.063758	-0.063758	
2	0.542200	3.869393	0.901457	…	8.340949	-0.063758	-0.063758	
3	0.729936	2.619242	1.344904	…	-0.119890	-0.063758	-0.063758	
4	0.286198	3.035959	1.837624	…	-0.119890	-0.063758	-0.063758	

	DT_pos	FB_pos	QB_pos	RB_pos	T_pos	TE_pos	WR_pos
0	-0.045038	-0.2	-0.164399	-0.429712	-0.101118	-0.532087	1.405668
1	-0.045038	-0.2	-0.164399	-0.429712	-0.101118	1.879391	-0.711405
2	-0.045038	-0.2	-0.164399	-0.429712	-0.101118	-0.532087	1.405668
3	-0.045038	-0.2	-0.164399	-0.429712	-0.101118	-0.532087	1.405668
4	-0.045038	-0.2	-0.164399	-0.429712	-0.101118	-0.532087	1.405668

[5 rows x 25 columns]

[49]:
```
scaled_df.describe()
```

[49]:

	Age	G	GS	Tgt	Rec	\
count	4.940000e+02	4.940000e+02	4.940000e+02	4.940000e+02	494.000000	
mean	1.006842e-16	2.301353e-16	2.876691e-17	-1.150676e-16	0.000000	
std	1.001014e+00	1.001014e+00	1.001014e+00	1.001014e+00	1.001014	
min	-1.557101e+00	-2.532041e+00	-1.065275e+00	-9.062162e-01	-0.881330	
25%	-6.281061e-01	-6.925876e-01	-8.777991e-01	-7.717321e-01	-0.762244	
50%	-3.184410e-01	4.570706e-01	-3.153701e-01	-3.144860e-01	-0.365292	
75%	6.105543e-01	9.169339e-01	8.094879e-01	3.848315e-01	0.428612	
max	4.636201e+00	9.169339e-01	1.934346e+00	3.639348e+00	4.040874	

	Ctch_Rate	Yds	Y/R	TD	Lng	\
count	4.940000e+02	494.000000	4.940000e+02	4.940000e+02	4.940000e+02	
mean	2.301353e-16	0.000000	2.876691e-17	5.753382e-17	5.753382e-17	
std	1.001014e+00	1.001014	1.001014e+00	1.001014e+00	1.001014e+00	
min	-3.084844e+00	-0.866765	-3.673309e+00	-7.144922e-01	-2.054859e+00	
25%	-6.266226e-01	-0.712154	-4.818101e-01	-7.144922e-01	-7.245168e-01	
50%	-8.581384e-02	-0.376111	-8.927271e-02	-2.977754e-01	-2.317975e-01	
75%	5.195233e-01	0.355138	4.013990e-01	1.189414e-01	6.058253e-01	
max	1.831599e+00	4.459437	9.468158e+00	5.536260e+00	3.266509e+00	

	…	FirstTeamAllPro	C_pos	CB_pos	DT_pos	\

```
count  …     4.940000e+02  4.940000e+02  4.940000e+02  4.940000e+02
mean   …    -6.472555e-17  3.595864e-18  5.393796e-18 -1.797932e-17
std    …     1.001014e+00  1.001014e+00  1.001014e+00  1.001014e+00
min    …    -1.198904e-01 -6.375767e-02 -6.375767e-02 -4.503773e-02
25%    …    -1.198904e-01 -6.375767e-02 -6.375767e-02 -4.503773e-02
50%    …    -1.198904e-01 -6.375767e-02 -6.375767e-02 -4.503773e-02
75%    …    -1.198904e-01 -6.375767e-02 -6.375767e-02 -4.503773e-02
max    …     8.340949e+00  1.568439e+01  1.568439e+01  2.220360e+01

             FB_pos        QB_pos        RB_pos         T_pos        TE_pos  \
count  4.940000e+02  4.940000e+02  4.940000e+02  4.940000e+02  4.940000e+02
mean  -1.438346e-17  4.315037e-17 -1.438346e-17 -5.034210e-17 -2.876691e-17
std    1.001014e+00  1.001014e+00  1.001014e+00  1.001014e+00  1.001014e+00
min   -2.000000e-01 -1.643990e-01 -4.297119e-01 -1.011185e-01 -5.320873e-01
25%   -2.000000e-01 -1.643990e-01 -4.297119e-01 -1.011185e-01 -5.320873e-01
50%   -2.000000e-01 -1.643990e-01 -4.297119e-01 -1.011185e-01 -5.320873e-01
75%   -2.000000e-01 -1.643990e-01 -4.297119e-01 -1.011185e-01 -5.320873e-01
max    5.000000e+00  6.082763e+00  2.327141e+00  9.889388e+00  1.879391e+00

             WR_pos
count  4.940000e+02
mean   1.150676e-16
std    1.001014e+00
min   -7.114053e-01
25%   -7.114053e-01
50%   -7.114053e-01
75%    1.405668e+00
max    1.405668e+00

[8 rows x 25 columns]
```

- We are gonna use the elbow method to give us a first indication on the number of clusters.

[50]:
```
from yellowbrick.cluster import KElbowVisualizer
from sklearn.cluster import KMeans

plt.figure(figsize=(6, 4))
kmeans = KMeans(random_state=0)
visualizer = KElbowVisualizer(kmeans, k=(1,11))

visualizer.fit(scaled_df)
_ = visualizer.show()
```

```
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pd.SparseDtype)` instead.
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C:\Users\tanagnos\anaconda3\envs\PDS\Lib\site-
packages\sklearn\cluster\_kmeans.py:870: FutureWarning: The default value of
`n_init` will change from 10 to 'auto' in 1.4. Set the value of `n_init`
explicitly to suppress the warning
  warnings.warn(
C:\Users\tanagnos\anaconda3\envs\PDS\Lib\site-
packages\sklearn\cluster\_kmeans.py:1382: UserWarning: KMeans is known to have a
memory leak on Windows with MKL, when there are less chunks than available
threads. You can avoid it by setting the environment variable OMP_NUM_THREADS=2.
  warnings.warn(
C:\Users\tanagnos\anaconda3\envs\PDS\Lib\site-
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```

```
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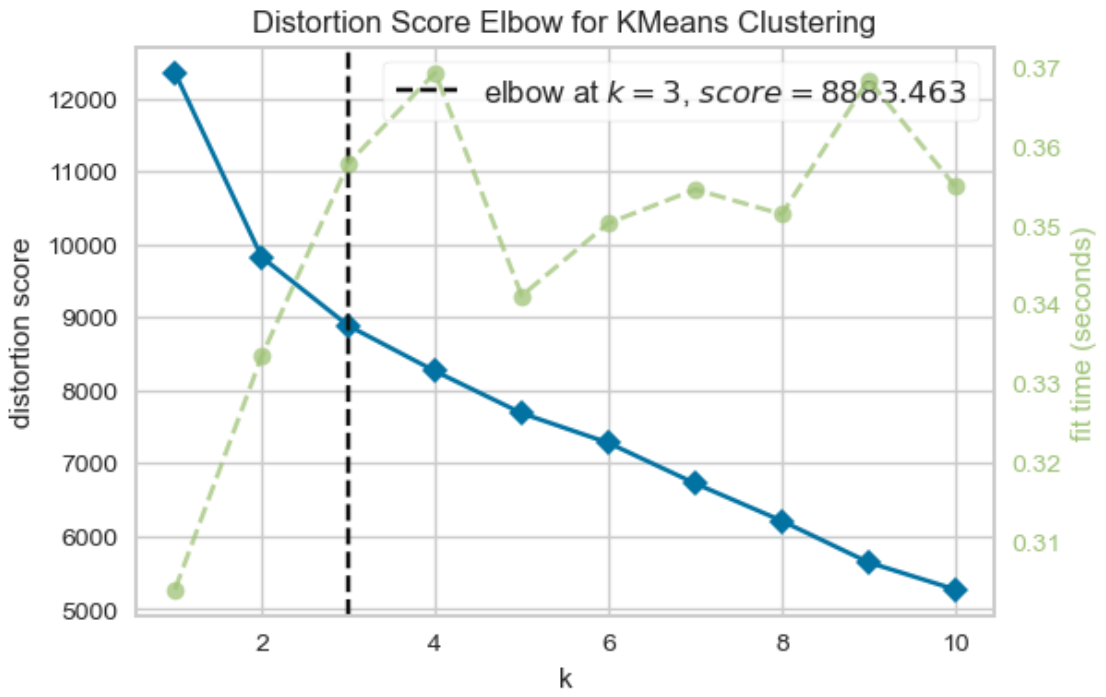

- We'll also check with the silhouette method.

[51]:
```
from yellowbrick.cluster import SilhouetteVisualizer

plt.figure(figsize=(2.5 * 4,  1.75 * 8))

scores = {}
for n_clusters in range(2, 10):
    plt.subplot(4, 2, n_clusters - 1)
    kmeans = KMeans(n_clusters, random_state=42)
    visualizer = SilhouetteVisualizer(kmeans, colors='yellowbrick')
    visualizer.fit(scaled_df)
    scores[n_clusters] = visualizer.silhouette_score_
    plt.title(f'clusters: {n_clusters} score: {visualizer.silhouette_score_}')
```

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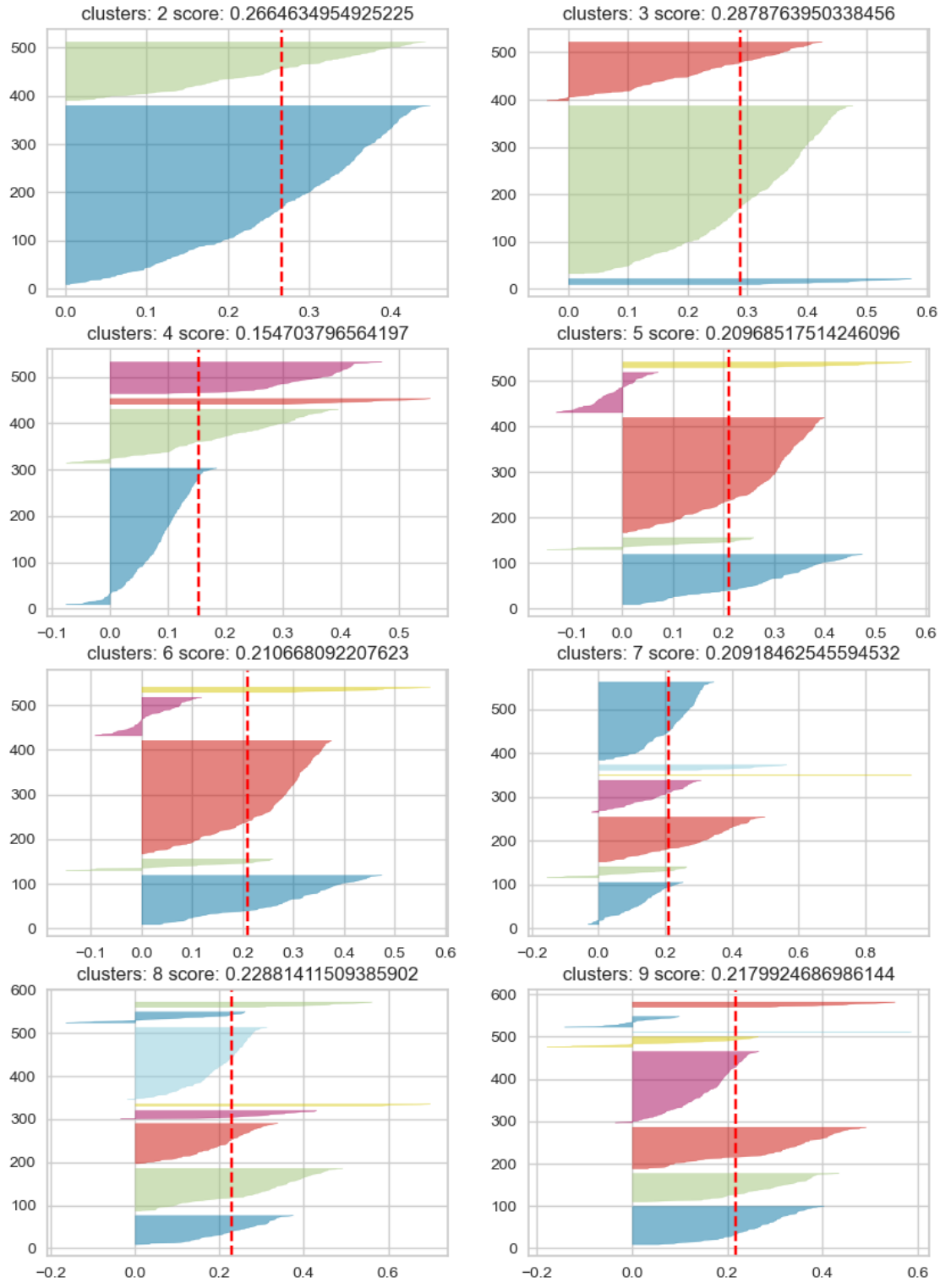

[52]:
```
sorted(scores.items(), key=lambda kv: kv[1], reverse=True)
```

[52]:
```
[(3, 0.2878763950338456),
 (2, 0.2664634954925225),
 (8, 0.22881411509385902),
 (9, 0.2179924686986144),
 (6, 0.210668092207623),
 (5, 0.20968517514246096),
 (7, 0.20918462545594532),
 (4, 0.154703796564197)]
```

- The elbow method indicates 3 clusters, the silhouette scores goes for 3, so let's try with 3.

[53]:
```
kmeans = KMeans(n_clusters=3, random_state=0)
kmeans.fit(scaled_df)
```

```
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and will be removed in a future version. Check `isinstance(dtype,
pd.SparseDtype)` instead.
  if is_sparse(pd_dtype):
C:\Users\tanagnos\anaconda3\envs\PDS\Lib\site-
packages\sklearn\utils\validation.py:614: FutureWarning: is_sparse is deprecated
and will be removed in a future version. Check `isinstance(dtype,
pd.SparseDtype)` instead.
  if is_sparse(pd_dtype) or not is_extension_array_dtype(pd_dtype):
C:\Users\tanagnos\anaconda3\envs\PDS\Lib\site-
packages\sklearn\cluster\_kmeans.py:870: FutureWarning: The default value of
`n_init` will change from 10 to 'auto' in 1.4. Set the value of `n_init`
explicitly to suppress the warning
  warnings.warn(
C:\Users\tanagnos\anaconda3\envs\PDS\Lib\site-
packages\sklearn\cluster\_kmeans.py:1382: UserWarning: KMeans is known to have a
memory leak on Windows with MKL, when there are less chunks than available
threads. You can avoid it by setting the environment variable OMP_NUM_THREADS=2.
  warnings.warn(
```

[53]:
```
KMeans(n_clusters=3, random_state=0)
```

- In order to visualize the clusters we can perform PCA on two principal components.
- We'll project the clusters on these two, and plot the results.

[54]:
```
from sklearn.decomposition import PCA

pca = PCA(n_components=3)
```

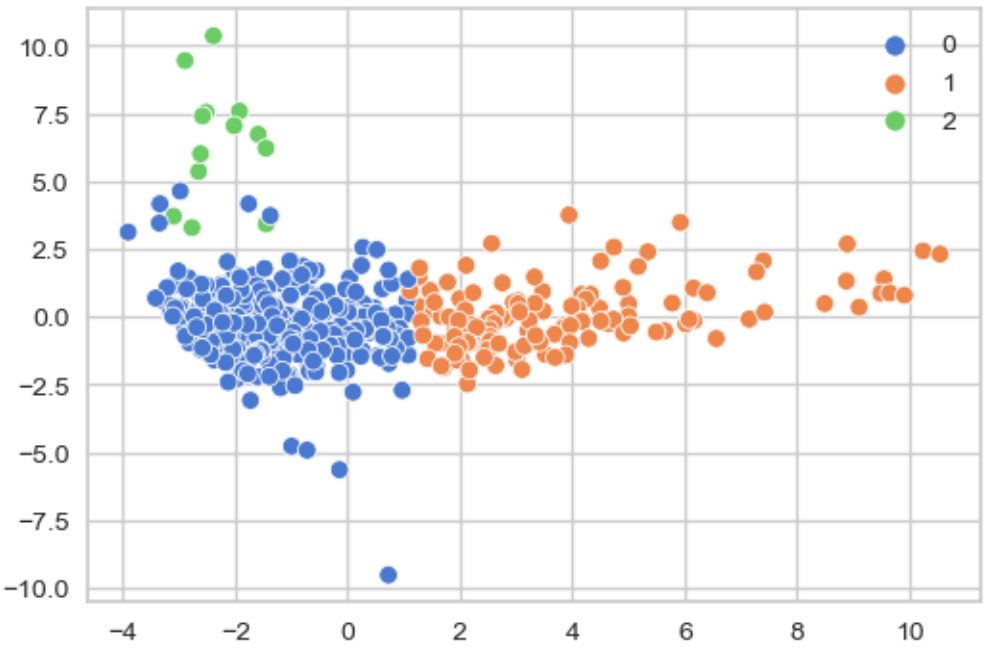
```
X = pca.fit_transform(scaled_df)
pca.explained_variance_ratio_
```

```
C:\Users\tanagnos\anaconda3\envs\PDS\Lib\site-
packages\sklearn\utils\validation.py:767: FutureWarning: is_sparse is deprecated
and will be removed in a future version. Check `isinstance(dtype,
pd.SparseDtype)` instead.
  if not hasattr(array, "sparse") and array.dtypes.apply(is_sparse).any():
C:\Users\tanagnos\anaconda3\envs\PDS\Lib\site-
packages\sklearn\utils\validation.py:605: FutureWarning: is_sparse is deprecated
and will be removed in a future version. Check `isinstance(dtype,
pd.SparseDtype)` instead.
  if is_sparse(pd_dtype):
C:\Users\tanagnos\anaconda3\envs\PDS\Lib\site-
packages\sklearn\utils\validation.py:614: FutureWarning: is_sparse is deprecated
and will be removed in a future version. Check `isinstance(dtype,
pd.SparseDtype)` instead.
  if is_sparse(pd_dtype) or not is_extension_array_dtype(pd_dtype):
```

[54]:
```
array([0.29226849, 0.11296978, 0.06497883])
```

[55]:
```
plt.figure(figsize=(6, 4))
_ = sns.scatterplot(x=X[:, 0], y=X[:, 1], hue=kmeans.labels_,
                    palette=sns.color_palette('muted', n_colors=3))
```

```
C:\Users\tanagnos\anaconda3\envs\PDS\Lib\site-packages\seaborn\_oldcore.py:1498:
FutureWarning: is_categorical_dtype is deprecated and will be removed in a
future version. Use isinstance(dtype, CategoricalDtype) instead
  if pd.api.types.is_categorical_dtype(vector):
C:\Users\tanagnos\anaconda3\envs\PDS\Lib\site-packages\seaborn\_oldcore.py:1498:
FutureWarning: is_categorical_dtype is deprecated and will be removed in a
future version. Use isinstance(dtype, CategoricalDtype) instead
  if pd.api.types.is_categorical_dtype(vector):
C:\Users\tanagnos\anaconda3\envs\PDS\Lib\site-packages\seaborn\_oldcore.py:1498:
FutureWarning: is_categorical_dtype is deprecated and will be removed in a
future version. Use isinstance(dtype, CategoricalDtype) instead
  if pd.api.types.is_categorical_dtype(vector):
C:\Users\tanagnos\anaconda3\envs\PDS\Lib\site-packages\seaborn\_oldcore.py:1498:
FutureWarning: is_categorical_dtype is deprecated and will be removed in a
future version. Use isinstance(dtype, CategoricalDtype) instead
  if pd.api.types.is_categorical_dtype(vector):
```



- To visualize PCA, we mae use of a *biplot*.
- A biplot plots the data on the components we have found.
- It also displays vectors that show how much each of the original features contributes to each principal component.
- The left and bottom axes of a biplot are the principal components.
- The right and top axes of a biplot show the contributions of the original features to the components, i.e., the loadings.

[56]:
```
from math import ceil

# based on https://stackoverflow.com/questions/39216897/
 ↪plot-pca-loadings-and-loading-in-biplot-in-sklearn-like-rs-autoplot
def biplot(score, coeff, text, labels=None):
    fig = plt.figure(figsize=(10, 8))
    ax1 = fig.add_subplot(111, label='pcas')
    ax2 = fig.add_subplot(111, label='loading vectors', frame_on=False)
    ax2.xaxis.tick_top()
    ax2.yaxis.tick_right()
    xs = score[:, 0]
    ys = score[:, 1]
    n = coeff.shape[0]

    # draw scatterplot
    ax1.scatter(xs, ys, fc='k')
```

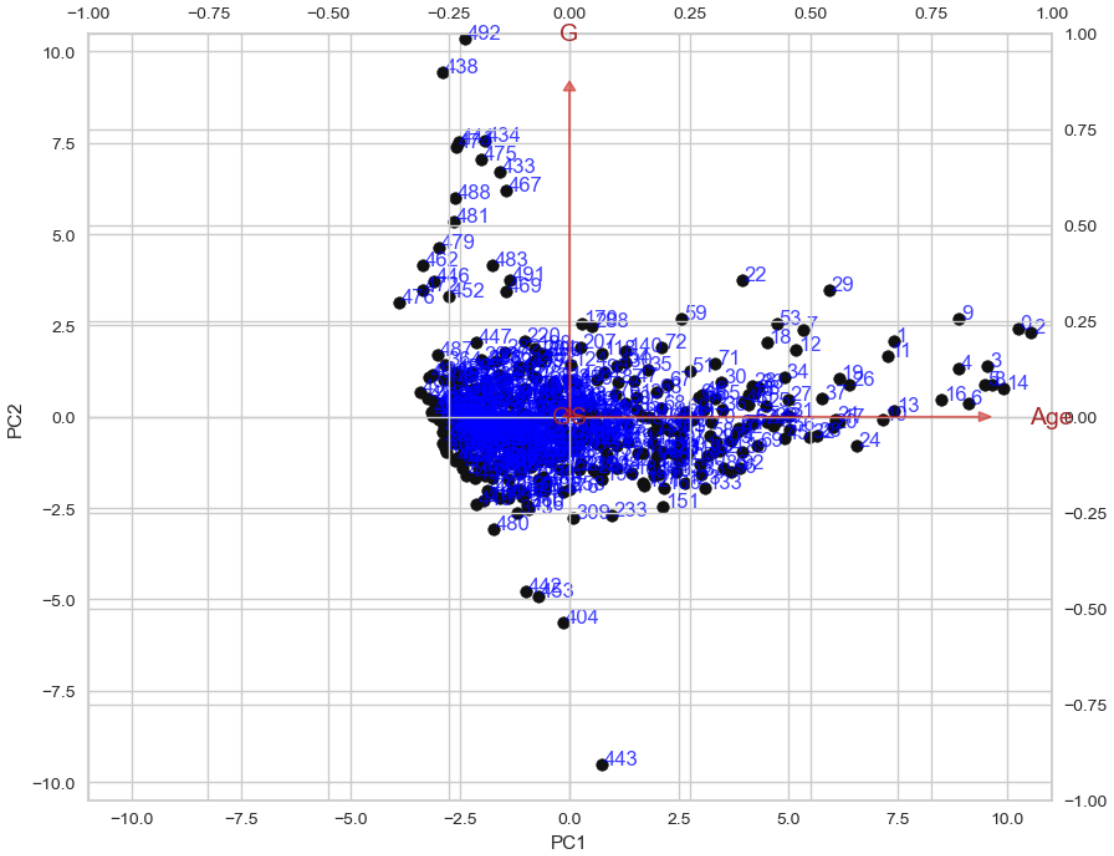
```
    for i, txt in enumerate(text):
        ax1.text(xs[i] + 0.05, ys[i], txt,
                    fontsize=12,
                    alpha=0.75,
                    c='blue')

    # draw loading vectors
    for i in range(n):
        ax2.arrow(0, 0, coeff[i,0] * 0.85, coeff[i,1] * 0.85,
                  lw=1,
                  color = 'r',alpha = 0.5, head_width=0.025, head_length=0.025)
        if labels is None:
            ax2.text(coeff[i,0], coeff[i,1], "Var"+str(i+1),
                     color = 'g', ha = 'center', va = 'center')
        else:
            ax2.text(coeff[i,0], coeff[i,1],
                     labels[i], color = 'brown', ha = 'center', va = 'center',
                     fontsize=14)

    xmax = max(xs.min(), xs.max(), key=abs)
    xlim = 0.5 * ceil(2.0 * xmax)
    ax1.set_xlim(-xlim, xlim)
    ymax = max(ys.min(), ys.max(), key=abs)
    ylim = 0.5 * ceil(2.0 * ymax)
    ax1.set_ylim(-ylim, ylim)
    ax1.axhline(0, linestyle=':', color='k', lw=0.5) # horizontal lines
    ax1.axvline(0, linestyle=':', color='k', lw=0.5) # vertical lines
    ax1.set_xlabel("PC1")
    ax1.set_ylabel("PC2")
    ax2.set_xlim(-1, 1)
    ax2.set_ylim(-1, 1)
```

[57]:
```
X_proj = pca.fit_transform(X)

biplot(X_proj,
       pca.components_.T,
       scaled_df.index,
       scaled_df.columns)
```



From the biplot it's clear that age (`Age`) and the number of games (`G`) played significantly impact the variance in the dataset, as indicated by their prominence in the principal component axes. Reasonable result highlighting the experience and fitness.

- Visualize the clusters is with *radar plots*.
- We'll write a function to plot them.

[28]:
```
def radar_factory(keys, values, axes=None, fontsize=10, figsize=(5, 5)):

    import math

    if axes is None:
        # Initialise the spider plot.
        plt.figure(figsize=figsize)
        ax = plt.subplot(111, polar=True)
    else:
        ax = axes

    num_categories = len(keys)
```

```
    # What will be the angle of each axis in the plot?
    # We divide the plot / number of variables + 1.
    # We add one because we want to do a complete circle.
    angles = np.arange(num_categories + 1)
    angles = angles / num_categories * 2 * np.pi
    angles[-1] = angles[0]

    # We want the first axis to be on top.
    ax.set_theta_offset(np.pi / 2)
    # Theta direction is -1 clockwise,
    # and 1 counterclockwise
    ax.set_theta_direction(-1)

    # Draw one axis per variable and add x labels
    ax.tick_params(labelsize=fontsize)
    ax.set_xticks(angles[:-1])
    ax.set_xticklabels(keys)

    # Draw y labels
    ax.set_rlabel_position(0)
    max_y = max(values)
    min_y = min(values)

    values.append(values[0])
    ax.plot(list(angles), values,
            linewidth=1, linestyle='solid')

    ax.fill(angles, values, 'b', alpha=0.1)
    yticks = ax.get_yticks()
    ax.set_yticklabels([])
    ylims = ax.get_ylim()
    ax.set_ylim(min(yticks[0], ylims[0]),
                max(yticks[-1], ylims[1]))
```

- Now we'll use a radar plot to project the centroid of each cluster in all dimensions.
- To make all dimensions comparable and all radar plots comparable, we'll scale all centroids between zero and one.

[58]:
```
matrix_scaler = lambda a: (a - a.min()) / (a.max() - a.min())
cluster_centers = matrix_scaler(kmeans.cluster_centers_)
```

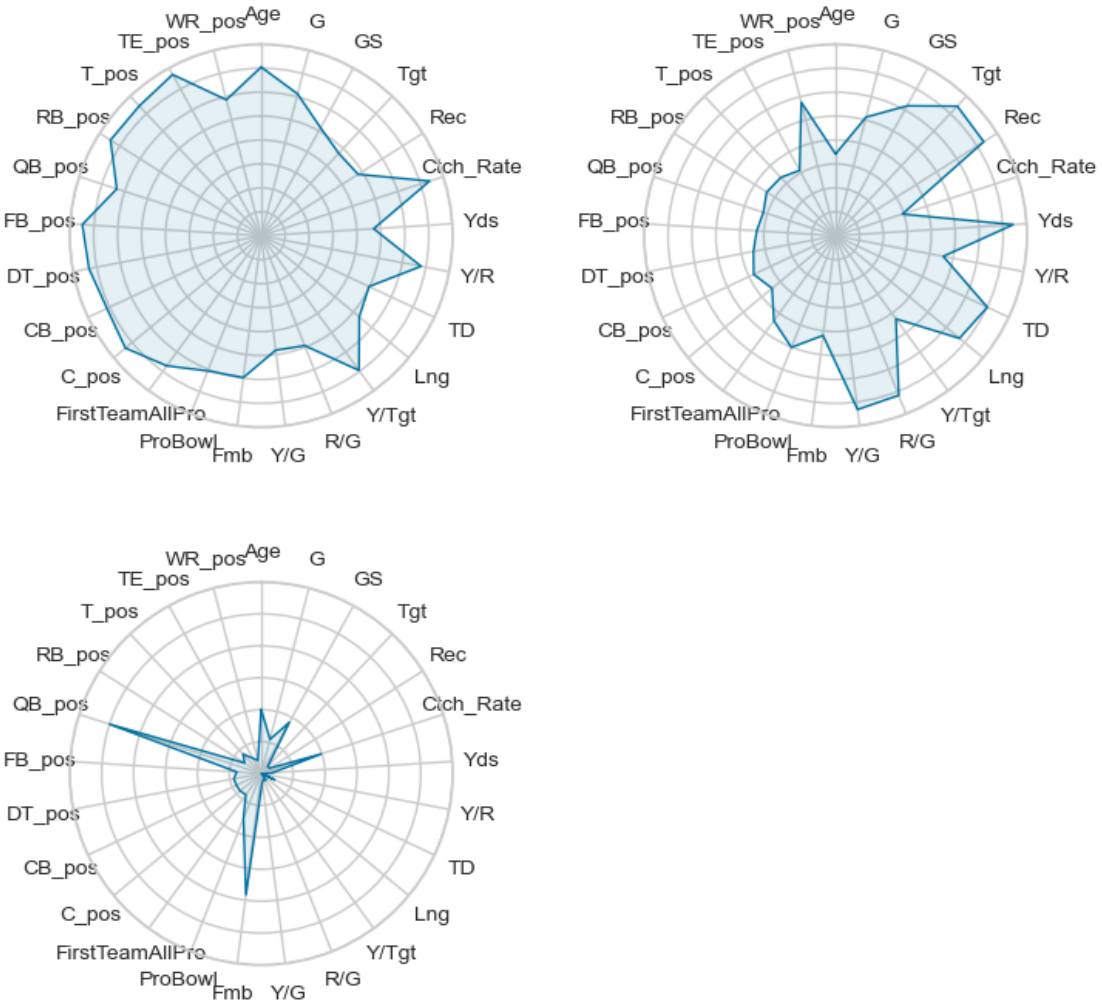
- It seems that this cluster contains players that have position indicators on.
- Indeed, as we can see, these indicators are not mutually exclusive as one might expect.

[59]:
```
df.loc[:, 'C_pos':'WR_pos'].sum(axis=1).value_counts()
```

[59]:
```
1    354
0    121
2     17
3      2
Name: count, dtype: int64
```

- Or we can plot all the clusters together.

[60]:
```
plt.figure(figsize=(2 * 4, 2 * 4))
plt.subplots_adjust(hspace=0.3, wspace=0.5)
for i, cs in enumerate(cluster_centers):
    ax = plt.subplot(2, 2, i + 1, polar=True)
    radar_factory(scaled_df.columns, list(cs), axes=ax)
```



1 NFL Player Performance Radar Charts

The provided image showcases three radar charts representing multivariate data on NFL player performance across a variety of attributes. Each chart likely corresponds to different player positions or group comparisons, with each axis or spoke representing distinct performance metrics.

1.1 Key Attributes on Radar Charts

- `Age`: The player's age, an indicator of experience or physical prime.
- `G` (Games Count): The total number of games played, indicating durability and experience.
- `GS` (Games Started Count): How often the player is in the starting lineup, signifying importance to the team.
- `Tgt` (Number of Targets): Frequency the player is targeted in the passing game, showing involvement in the offensive strategy.
- `Rec` (Number of Receptions): Successful catches, a direct indicator of productivity in the passing game.
- `Ctch_Rate` (Catch Rate): Efficiency metric representing the percentage of receptions per target.
- `Yds` (Total Yards): Cumulative distance covered on successful plays, a measure of offensive production.
- `Y/R` (Yards per Reception): Average yards gained per reception, a measure of effectiveness and big-play capability.
- `TD` (Touchdowns): The number of touchdowns scored, a critical measure of scoring impact.
- `Lng` (Longest Catch): Longest single catch, indicative of big-play ability.
- `Y/Tgt` (Yards per Target): Average yards gained per target, an efficiency metric.
- `R/G` (Receptions per Game): Consistency metric showing average receptions per game.
- `Y/G` (Yards per Game): Average yards gained per game, indicating game-by-game impact.
- `Fmb` (Number of Fumbles): Ball security metric representing the number of times the player fumbled.
- `ProBowl`: Binary indicator of whether the player made the Pro Bowl, reflecting recognition and elite status.
- `FirstTeamAllPro`: Binary indicator of making the First Team All-Pro, denoting top-tier player performance.
- Position Indicators: Binary attributes such as `WR_pos`, `RB_pos`, `QB_pos`, etc., identifying the player's primary field position.

1.2 Usage and Interpretation

These radar charts are instrumental for coaches, scouts, and analysts for:

- **Performance Assessment**: Evaluating strengths and weaknesses in multiple areas.
- **Player Comparison**: Visually comparing players within or across positions.
- **Game Strategy Development**: Utilizing player profiles for planning game tactics.
- **Recruitment and Drafting**: Informing decisions during player selection processes.

1.3 Further progress of the project. Predicting NFL Game Outcomes, Player Injury Risks, and Performance

1.3.1 1. Predicting Game Outcomes

Analyzing historical data to identify factors influencing game outcomes.

Data Collection and Preprocessing

- Gather historical game scores, player and team stats, weather, and location.
- Handle missing values, encode categorical variables, and normalize features.

Feature Engineering

- Develop new features like team averages, player performance metrics, and home advantage.
- Time-based features: trends in team performance or player fitness.

Model Selection and Training

- Use models like logistic regression, random forests, or neural networks.
- Train on historical data to predict outcomes.
- Cross-validate to assess and tune the model.

Evaluation and Prediction

- Evaluate using accuracy, precision, recall, or AUC-ROC.
- Predict future game outcomes.

1.3.2 2. Predicting Player Injury Risks

Analyzing player data to identify factors increasing injury likelihood.

Data Collection and Preprocessing

- Collect data on player injuries, conditions, and health history.
- Ensure data consistency and completeness.

Feature Engineering

- Features related to activities, play style, game conditions, and training.
- Player-specific factors: age, previous injuries, recovery.

Model Selection and Training

- Suitable models for risk assessment (logistic regression, survival models).
- Train to predict injury probability.

Evaluation and Prediction

- Validate with historical data.
- Assess current players' injury risks.

1.3.3 3. Predicting Player Performance

Analyzing individual player stats and other influencing factors.

Data Collection and Preprocessing

- Collect performance metrics, physical and health data, training info.
- Process data for quality and relevance.

Feature Engineering

- Features encapsulating skills, condition, and game context.
- Team dynamics and opposition strength.

Model Selection and Training

- Regression, time series, or machine learning algorithms.
- Train on historical data for future performance predictions.

Evaluation and Prediction

- Evaluate accuracy with known performance data.
- Predict future player performance.

1.3.4 Incorporating Big Data

- **Enhanced Analysis:** Utilize large and varied datasets for comprehensive analysis.
- **Real-time Insights:** Leverage real-time data processing for current insights.
- **Predictive Accuracy:** Improve predictive accuracy with larger datasets.

1.3.5 General Considerations

- **Data Quality:** Emphasize accurate and relevant data.
- **Model Complexity:** Balance between complexity and resources.
- **Ethical Considerations:** Consider privacy in injury predictions.
- **Continuous Improvement:** Regularly update models with new data.