KNN_NBA_Regression

January 24, 2021

[50]:
```
import pandas as pd
from sklearn.model_selection import␣
↪train_test_split,GridSearchCV,RandomizedSearchCV
from sklearn.neighbors import KNeighborsRegressor
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.decomposition import PCA
import warnings
warnings.filterwarnings(action='ignore')
```

[4]:
```
df_nba=pd.read_csv('nba_2013.csv')
```

[5]:
```
df_nba.head()
```

[5]:
```
            player pos  age bref_team_id   g  gs    mp   fg  fga    fg.  …  \
0      Quincy Acy  SF   23          TOT  63   0   847   66   141  0.468  …
1    Steven Adams   C   20          OKC  81  20  1197   93   185  0.503  …
2     Jeff Adrien  PF   27          TOT  53  12   961  143   275  0.520  …
3   Arron Afflalo  SG   28          ORL  73  73  2552  464  1011  0.459  …
4   Alexis Ajinca   C   25          NOP  56  30   951  136   249  0.546  …

   drb  trb  ast  stl  blk  tov   pf   pts     season  season_end
0  144  216   28   23   26   30  122   171  2013-2014        2013
1  190  332   43   40   57   71  203   265  2013-2014        2013
2  204  306   38   24   36   39  108   362  2013-2014        2013
3  230  262  248   35    3  146  136  1330  2013-2014        2013
4  183  277   40   23   46   63  187   328  2013-2014        2013

[5 rows x 31 columns]
```

0.0.1 Basics Dataframe Statistics

[7]:
```
df_nba.describe().T
```

[7]:
```
            count       mean        std   min        25%        50%  \
age         481.0  26.509356   4.198265  19.0  23.000000  26.000000
```

g	481.0	53.253638	25.322711	1.0	32.000000	61.000000
gs	481.0	25.571726	29.658465	0.0	0.000000	10.000000
mp	481.0	1237.386694	897.258840	1.0	388.000000	1141.000000
fg	481.0	192.881497	171.832793	0.0	47.000000	146.000000
fga	481.0	424.463617	368.850833	0.0	110.000000	332.000000
fg.	479.0	0.436436	0.098672	0.0	0.400500	0.438000
x3p	481.0	39.613306	50.855639	0.0	0.000000	16.000000
x3pa	481.0	110.130977	132.751732	0.0	3.000000	48.000000
x3p.	414.0	0.285111	0.157633	0.0	0.234355	0.330976
x2p	481.0	153.268191	147.223161	0.0	31.000000	110.000000
x2pa	481.0	314.332640	294.174554	0.0	67.000000	227.000000
x2p.	478.0	0.466947	0.104448	0.0	0.434719	0.474475
efg.	479.0	0.480752	0.099552	0.0	0.451000	0.488000
ft	481.0	91.205821	103.667725	0.0	16.000000	53.000000
fta	481.0	120.642412	131.240639	0.0	22.000000	73.000000
ft.	461.0	0.722419	0.160166	0.0	0.654000	0.751000
orb	481.0	55.810811	62.101191	0.0	12.000000	35.000000
drb	481.0	162.817048	145.348116	0.0	43.000000	135.000000
trb	481.0	218.627859	200.356507	0.0	55.000000	168.000000
ast	481.0	112.536383	131.019557	0.0	20.000000	65.000000
stl	481.0	39.280665	34.783590	0.0	9.000000	32.000000
blk	481.0	24.103950	30.875381	0.0	4.000000	14.000000
tov	481.0	71.862786	62.701690	0.0	21.000000	58.000000
pf	481.0	105.869023	71.213627	0.0	44.000000	104.000000
pts	481.0	516.582121	470.422228	0.0	115.000000	401.000000
season_end	481.0	2013.000000	0.000000	2013.0	2013.000000	2013.000000

	75%	max
age	29.000000	39.0
g	76.000000	83.0
gs	54.000000	82.0
mp	2016.000000	3122.0
fg	307.000000	849.0
fga	672.000000	1688.0
fg.	0.479500	1.0
x3p	68.000000	261.0
x3pa	193.000000	615.0
x3p.	0.375000	1.0
x2p	230.000000	706.0
x2pa	459.000000	1408.0
x2p.	0.513729	1.0
efg.	0.526000	1.0
ft	126.000000	703.0
fta	179.000000	805.0
ft.	0.821000	1.0
orb	73.000000	440.0
drb	230.000000	783.0

```
trb          310.000000  1114.0
ast          152.000000   721.0
stl           60.000000   191.0
blk           32.000000   219.0
tov          108.000000   295.0
pf           158.000000   273.0
pts          821.000000  2593.0
season_end  2013.000000  2013.0
```

[8]:
```python
df_nba.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 481 entries, 0 to 480
Data columns (total 31 columns):
 #   Column        Non-Null Count  Dtype
---  ------        --------------  -----
 0   player        481 non-null    object
 1   pos           481 non-null    object
 2   age           481 non-null    int64
 3   bref_team_id  481 non-null    object
 4   g             481 non-null    int64
 5   gs            481 non-null    int64
 6   mp            481 non-null    int64
 7   fg            481 non-null    int64
 8   fga           481 non-null    int64
 9   fg.           479 non-null    float64
 10  x3p           481 non-null    int64
 11  x3pa          481 non-null    int64
 12  x3p.          414 non-null    float64
 13  x2p           481 non-null    int64
 14  x2pa          481 non-null    int64
 15  x2p.          478 non-null    float64
 16  efg.          479 non-null    float64
 17  ft            481 non-null    int64
 18  fta           481 non-null    int64
 19  ft.           461 non-null    float64
 20  orb           481 non-null    int64
 21  drb           481 non-null    int64
 22  trb           481 non-null    int64
 23  ast           481 non-null    int64
 24  stl           481 non-null    int64
 25  blk           481 non-null    int64
 26  tov           481 non-null    int64
 27  pf            481 non-null    int64
 28  pts           481 non-null    int64
 29  season        481 non-null    object
 30  season_end    481 non-null    int64
```

```
dtypes: float64(5), int64(22), object(4)
memory usage: 109.0+ KB
```

[11]:
```
row,col=df_nba.shape
print('No of Data points: ',row)
print('No of Features: ',col)
```

```
No of Data points:  481
No of Features:  31
```

Getting idea of No of NULL values in each feature

[12]:
```
df_nba.isna().sum()
```

[12]:
```
player          0
pos             0
age             0
bref_team_id    0
g               0
gs              0
mp              0
fg              0
fga             0
fg.             2
x3p             0
x3pa            0
x3p.           67
x2p             0
x2pa            0
x2p.            3
efg.            2
ft              0
fta             0
ft.            20
orb             0
drb             0
trb             0
ast             0
stl             0
blk             0
tov             0
pf              0
pts             0
season          0
season_end      0
dtype: int64
```

Percentage of NULL values.

[13]:
```
df_nba.isna().sum()/row * 100
```

[13]:
```
player           0.000000
pos              0.000000
age              0.000000
bref_team_id     0.000000
g                0.000000
gs               0.000000
mp               0.000000
fg               0.000000
fga              0.000000
fg.              0.415800
x3p              0.000000
x3pa             0.000000
x3p.            13.929314
x2p              0.000000
x2pa             0.000000
x2p.             0.623701
efg.             0.415800
ft               0.000000
fta              0.000000
ft.              4.158004
orb              0.000000
drb              0.000000
trb              0.000000
ast              0.000000
stl              0.000000
blk              0.000000
tov              0.000000
pf               0.000000
pts              0.000000
season           0.000000
season_end       0.000000
dtype: float64
```

0.0.2 EDA

Feature: pos

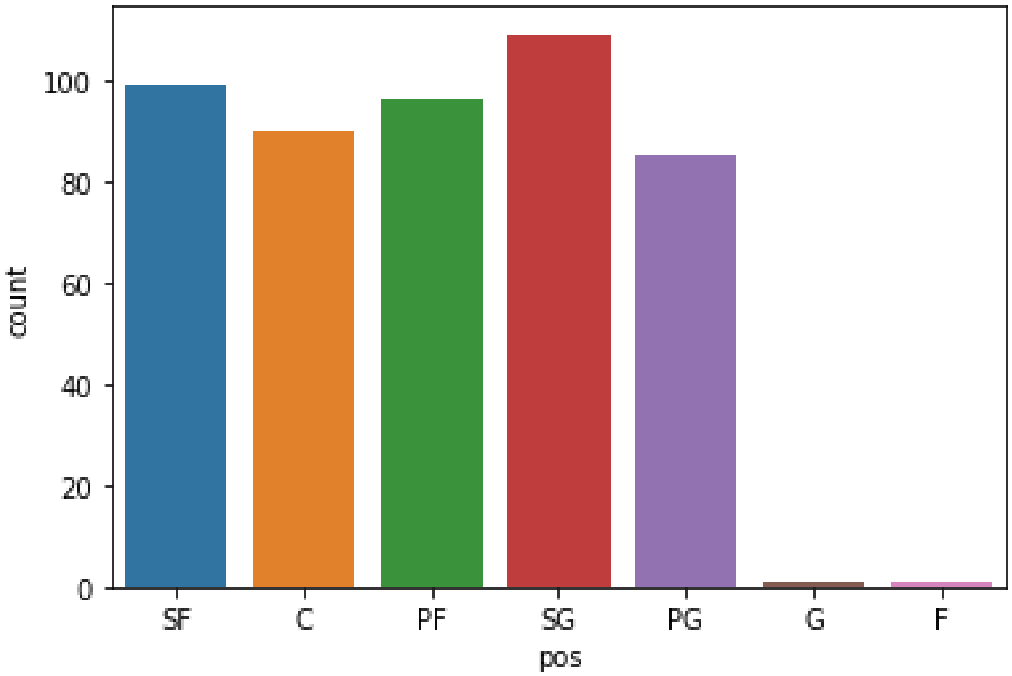
[17]:
```
df_nba['pos'].value_counts()
```

[17]:
```
SG    109
SF     99
PF     96
C      90
PG     85
G       1
F       1
```

```
Name: pos, dtype: int64
```

[21]:
```
sns.countplot(x='pos',data=df_nba)
```

[21]: <AxesSubplot:xlabel='pos', ylabel='count'>



[18]:
```
df_nba['pos'].isna().sum()
```

[18]: 0

No NULL values are present and we cannot rank these values hence using Onehot encoder on top of these data

[23]:
```
df_tmp=pd.get_dummies(df_nba['pos'],drop_first=True)
df_nba=df_nba.drop('pos',axis=1)
df_nba=pd.concat([df_nba,df_tmp],axis=1)
df_nba.head()
```

[23]:

	player	age	bref_team_id	g	gs	mp	fg	fga	fg.	x3p	…	\
0	Quincy Acy	23	TOT	63	0	847	66	141	0.468	4	…	
1	Steven Adams	20	OKC	81	20	1197	93	185	0.503	0	…	
2	Jeff Adrien	27	TOT	53	12	961	143	275	0.520	0	…	
3	Arron Afflalo	28	ORL	73	73	2552	464	1011	0.459	128	…	
4	Alexis Ajinca	25	NOP	56	30	951	136	249	0.546	0	…	

```
    pf   pts     season  season_end  F  G  PF  PG  SF  SG
0  122   171  2013-2014        2013  0  0   0   0   1   0
1  203   265  2013-2014        2013  0  0   0   0   0   0
2  108   362  2013-2014        2013  0  0   1   0   0   0
3  136  1330  2013-2014        2013  0  0   0   0   0   1
4  187   328  2013-2014        2013  0  0   0   0   0   0

[5 rows x 36 columns]
```

[25]:
```python
df_nba.columns
```

[25]:
```
Index(['player', 'age', 'bref_team_id', 'g', 'gs', 'mp', 'fg', 'fga', 'fg.',
       'x3p', 'x3pa', 'x3p.', 'x2p', 'x2pa', 'x2p.', 'efg.', 'ft', 'fta',
       'ft.', 'orb', 'drb', 'trb', 'ast', 'stl', 'blk', 'tov', 'pf', 'pts',
       'season', 'season_end', 'F', 'G', 'PF', 'PG', 'SF', 'SG'],
      dtype='object')
```

[26]:
```python
#Dropping some columns which do not contribute towards deciding the dependent␣
↪variable pts
df_nba=df_nba.drop(columns=['player','season','season_end','bref_team_id'])
```

[28]:
```python
print(df_nba.columns)
len(df_nba.columns)
```

```
Index(['age', 'g', 'gs', 'mp', 'fg', 'fga', 'fg.', 'x3p', 'x3pa', 'x3p.',
       'x2p', 'x2pa', 'x2p.', 'efg.', 'ft', 'fta', 'ft.', 'orb', 'drb', 'trb',
       'ast', 'stl', 'blk', 'tov', 'pf', 'pts', 'F', 'G', 'PF', 'PG', 'SF',
       'SG'],
      dtype='object')
```

[28]: 32

[30]:
```python
df_nba.corr()
```

[30]:
```
           age         g        gs        mp        fg       fga       fg.  \
age   1.000000 -0.012074  0.025163  0.007961 -0.009749 -0.018304  0.025221
g    -0.012074  1.000000  0.610951  0.864487  0.739993  0.746963  0.322201
gs    0.025163  0.610951  1.000000  0.860036  0.821619  0.811531  0.234677
mp    0.007961  0.864487  0.860036  1.000000  0.931120  0.936883  0.273682
fg   -0.009749  0.739993  0.821619  0.931120  1.000000  0.988262  0.278007
fga  -0.018304  0.746963  0.811531  0.936883  0.988262  1.000000  0.211174
fg.   0.025221  0.322201  0.234677  0.273682  0.278007  0.211174  1.000000
x3p   0.050611  0.518074  0.501808  0.645056  0.597239  0.662004 -0.025510
x3pa  0.028850  0.537011  0.515718  0.666126  0.613988  0.685535 -0.041720
x3p.  0.014235  0.103762  0.063468  0.138230  0.110514  0.152111 -0.039424
x2p  -0.028862  0.684729  0.785619  0.863941  0.960853  0.924781  0.333179
x2pa -0.035970  0.694243  0.784812  0.874109  0.962059  0.944490  0.283523
```

x2p.	0.011306	0.283050	0.205289	0.243727	0.238487	0.185373	0.880201
efg.	0.073002	0.351884	0.231222	0.304770	0.277694	0.236838	0.908930
ft	-0.046554	0.598333	0.707049	0.805468	0.893619	0.887922	0.217450
fta	-0.061751	0.615001	0.720527	0.814450	0.895138	0.877945	0.258550
ft.	0.021481	0.252328	0.178607	0.278872	0.277730	0.312489	-0.008697
orb	-0.068726	0.546902	0.560067	0.576844	0.562293	0.487154	0.423358
drb	0.010822	0.707389	0.774892	0.821145	0.820259	0.771821	0.377067
trb	-0.013451	0.682688	0.735738	0.774492	0.769339	0.710910	0.404832
ast	0.019216	0.551128	0.636059	0.733041	0.708228	0.748141	0.068105
stl	-0.028315	0.709650	0.743178	0.852331	0.786597	0.803290	0.185385
blk	-0.017398	0.475581	0.505589	0.506254	0.484208	0.412738	0.401431
tov	-0.030789	0.713508	0.767107	0.885406	0.903383	0.910689	0.221846
pf	-0.028221	0.865797	0.725573	0.884484	0.798769	0.786560	0.359125
pts	-0.011910	0.728462	0.810294	0.927464	0.992041	0.989211	0.248276
F	0.048873	-0.094284	-0.039395	-0.062044	-0.050756	-0.051837	-0.047997
G	-0.005543	-0.087067	-0.037855	-0.060465	-0.050756	-0.051465	-0.099505
PF	0.069581	0.073336	0.028462	0.036107	0.086495	0.048004	0.149736
PG	0.008714	0.021857	0.063176	0.093028	0.071924	0.117994	-0.163892
SF	-0.021367	0.022745	-0.002361	0.028666	-0.036136	-0.016313	-0.105781
SG	-0.047980	-0.051562	-0.078331	-0.049145	-0.043080	-0.014752	-0.156684

	x3p	x3pa	x3p.	…	blk	tov	pf	\
age	0.050611	0.028850	0.014235	…	-0.017398	-0.030789	-0.028221	
g	0.518074	0.537011	0.103762	…	0.475581	0.713508	0.865797	
gs	0.501808	0.515718	0.063468	…	0.505589	0.767107	0.725573	
mp	0.645056	0.666126	0.138230	…	0.506254	0.885406	0.884484	
fg	0.597239	0.613988	0.110514	…	0.484208	0.903383	0.798769	
fga	0.662004	0.685535	0.152111	…	0.412738	0.910689	0.786560	
fg.	-0.025510	-0.041720	-0.039424	…	0.401431	0.221846	0.359125	
x3p	1.000000	0.991700	0.462709	…	-0.043707	0.560520	0.446711	
x3pa	0.991700	1.000000	0.449886	…	-0.040987	0.589799	0.463455	
x3p.	0.462709	0.449886	1.000000	…	-0.187411	0.097876	-0.019089	
x2p	0.351640	0.374057	-0.032484	…	0.580246	0.860769	0.777982	
x2pa	0.382531	0.408290	-0.013775	…	0.536007	0.875709	0.777085	
x2p.	0.041768	0.042401	-0.118689	…	0.303162	0.188567	0.297251	
efg.	0.219614	0.196420	0.296875	…	0.267443	0.216401	0.329529	
ft	0.503353	0.527835	0.059541	…	0.383611	0.872003	0.663557	
fta	0.441246	0.467615	0.017214	…	0.456063	0.877715	0.698489	
ft.	0.369515	0.370768	0.289435	…	-0.068472	0.248213	0.184079	
orb	-0.065822	-0.058075	-0.314490	…	0.782384	0.468581	0.713271	
drb	0.280171	0.291838	-0.094895	…	0.740026	0.736415	0.821327	
trb	0.182848	0.193712	-0.166848	…	0.779353	0.679468	0.816910	
ast	0.617553	0.643211	0.212819	…	0.104589	0.855144	0.538109	
stl	0.592092	0.622973	0.150476	…	0.317737	0.826865	0.737628	
blk	-0.043707	-0.040987	-0.187411	…	1.000000	0.396247	0.633609	
tov	0.560520	0.589799	0.097876	…	0.396247	1.000000	0.775430	
pf	0.446711	0.463455	-0.019089	…	0.633609	0.775430	1.000000	

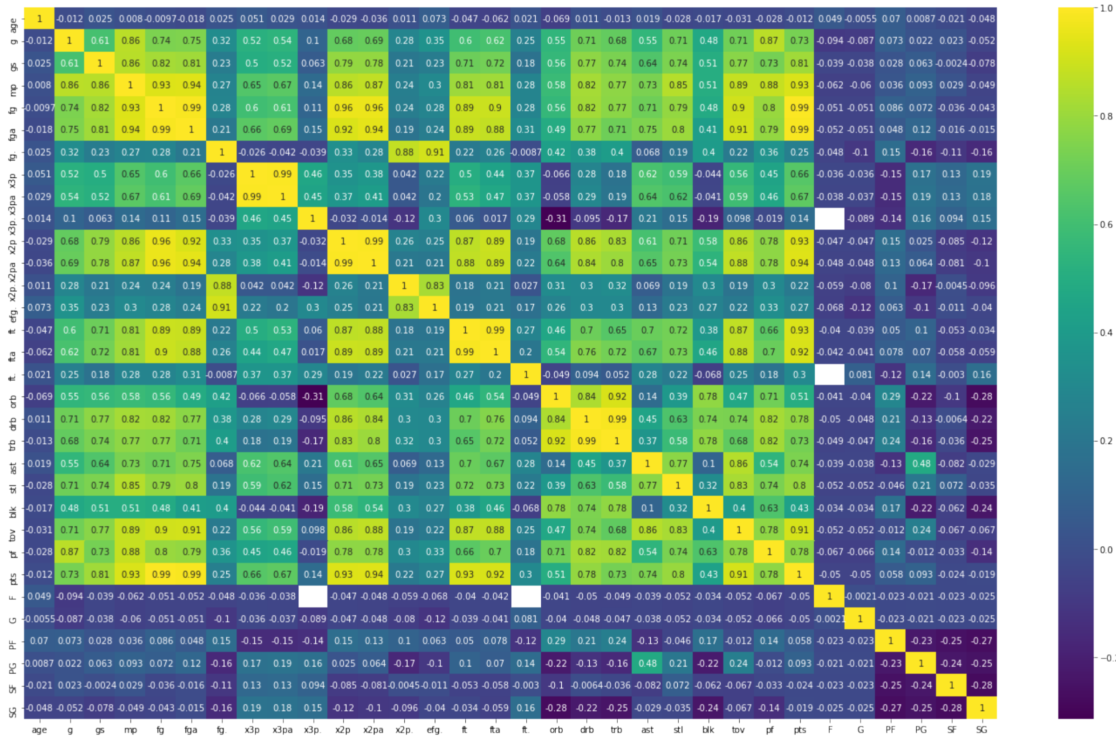
```
pts    0.655342  0.672076  0.144431  …  0.433549  0.912724  0.778060
F     -0.035590 -0.037905       NaN  … -0.034190 -0.051638 -0.067285
G     -0.035590 -0.037217 -0.089108  … -0.034190 -0.051638 -0.066001
PF    -0.151726 -0.153465 -0.135649  …  0.168143 -0.012027  0.139112
PG     0.170361  0.187046  0.163930  … -0.219456  0.243799 -0.011712
SF     0.125237  0.134670  0.094480  … -0.061735 -0.066778 -0.032964
SG     0.188286  0.182473  0.154223  … -0.241891 -0.067078 -0.142179

           pts         F         G        PF        PG        SF        SG
age  -0.011910  0.048873 -0.005543  0.069581  0.008714 -0.021367 -0.047980
g     0.728462 -0.094284 -0.087067  0.073336  0.021857  0.022745 -0.051562
gs    0.810294 -0.039395 -0.037855  0.028462  0.063176 -0.002361 -0.078331
mp    0.927464 -0.062044 -0.060465  0.036107  0.093028  0.028666 -0.049145
fg    0.992041 -0.050756 -0.050756  0.086495  0.071924 -0.036136 -0.043080
fga   0.989211 -0.051837 -0.051465  0.048004  0.117994 -0.016313 -0.014752
fg.   0.248276 -0.047997 -0.099505  0.149736 -0.163892 -0.105781 -0.156684
x3p   0.655342 -0.035590 -0.035590 -0.151726  0.170361  0.125237  0.188286
x3pa  0.672076 -0.037905 -0.037217 -0.153465  0.187046  0.134670  0.182473
x3p.  0.144431       NaN -0.089108 -0.135649  0.163930  0.094480  0.154223
x2p   0.931493 -0.046946 -0.046946  0.153364  0.025098 -0.085437 -0.115322
x2pa  0.937036 -0.047890 -0.047735  0.129444  0.063539 -0.081226 -0.100841
x2p.  0.219348 -0.058634 -0.079531  0.100293 -0.168260 -0.004531 -0.096172
efg.  0.268952 -0.067955 -0.119007  0.062501 -0.102962 -0.010598 -0.040253
ft    0.927618 -0.040199 -0.039317  0.050240  0.101028 -0.052702 -0.034356
fta   0.918979 -0.042001 -0.041305  0.077617  0.069737 -0.057641 -0.059054
ft.   0.303459       NaN  0.080893 -0.119340  0.143504 -0.002971  0.156332
orb   0.505524 -0.041063 -0.040327  0.288111 -0.222632 -0.101065 -0.276687
drb   0.784675 -0.049611 -0.047725  0.208410 -0.129565 -0.006406 -0.222352
trb   0.725930 -0.048718 -0.047121  0.240491 -0.162998 -0.035973 -0.247065
ast   0.738295 -0.039245 -0.038199 -0.129022  0.478513 -0.081803 -0.029044
stl   0.797449 -0.051598 -0.051598 -0.046397  0.208807  0.071806 -0.034528
blk   0.433549 -0.034190 -0.034190  0.168143 -0.219456 -0.061735 -0.241891
tov   0.912724 -0.051638 -0.051638 -0.012027  0.243799 -0.066778 -0.067078
pf    0.778060 -0.067285 -0.066001  0.139112 -0.011712 -0.032964 -0.142179
pts   1.000000 -0.049786 -0.049592  0.057858  0.093224 -0.024474 -0.018688
F    -0.049786  1.000000 -0.002083 -0.022792 -0.021147 -0.023236 -0.024707
G    -0.049592 -0.002083  1.000000 -0.022792 -0.021147 -0.023236 -0.024707
PF    0.057858 -0.022792 -0.022792  1.000000 -0.231349 -0.254209 -0.270301
PG    0.093224 -0.021147 -0.021147 -0.231349  1.000000 -0.235856 -0.250786
SF   -0.024474 -0.023236 -0.023236 -0.254209 -0.235856  1.000000 -0.275567
SG   -0.018688 -0.024707 -0.024707 -0.270301 -0.250786 -0.275567  1.000000

[32 rows x 32 columns]
```

[40]:
```python
plt.figure(figsize=(25,15))
sns.heatmap(df_nba.corr(),annot=True,cmap='viridis')
```

[40]: <AxesSubplot:>



From above correlation heatmap it seems like some of the features are quite correlated with each other. These are basically the ones with almost same feature names.

[51]:
```
x3p=df_nba[['x3p','x3pa','x3p.']]
x3p['tmp']=x3p['x3p']/x3p['x3pa']
x3p.head()
```

[51]:

	x3p	x3pa	x3p.	tmp
0	4	15	0.266667	0.266667
1	0	0	NaN	NaN
2	0	0	NaN	NaN
3	128	300	0.426667	0.426667
4	0	1	0.000000	0.000000

x3p. show the percentage of columns x3p and x3pa. Hence dropping these columns. Also replacing NaN values in x3p. feature with 0 as this seems to be due to divide by zero issue.

[53]:
```
df_nba=df_nba.drop(columns=['x3p','x3pa'])
```

[55]:
```
df_nba['x3p.']=df_nba['x3p.'].fillna(0)
```

[56]:
```
df_nba.columns
```

[56]:
```
Index(['age', 'g', 'gs', 'mp', 'fg', 'fga', 'fg.', 'x3p.', 'x2p', 'x2pa',
       'x2p.', 'efg.', 'ft', 'fta', 'ft.', 'orb', 'drb', 'trb', 'ast', 'stl',
       'blk', 'tov', 'pf', 'pts', 'F', 'G', 'PF', 'PG', 'SF', 'SG'],
      dtype='object')
```

Similar patterns are observed with features 'fg', 'fga', 'fg.','x2p', 'x2pa', 'x2p.','ft', 'fta', 'ft.' hence handling these same way as above displayed.

[59]:
```
df_nba=df_nba.drop(columns=['fg','fga','x2p','x2pa','ft','fta'])
```

[64]:
```
df_nba[['fg.','x2p.','ft.','efg.']]=df_nba[['fg.','x2p.','ft.','efg.']].
 ↪fillna(0)
```

[65]:
```
df_nba.isna().sum()
```

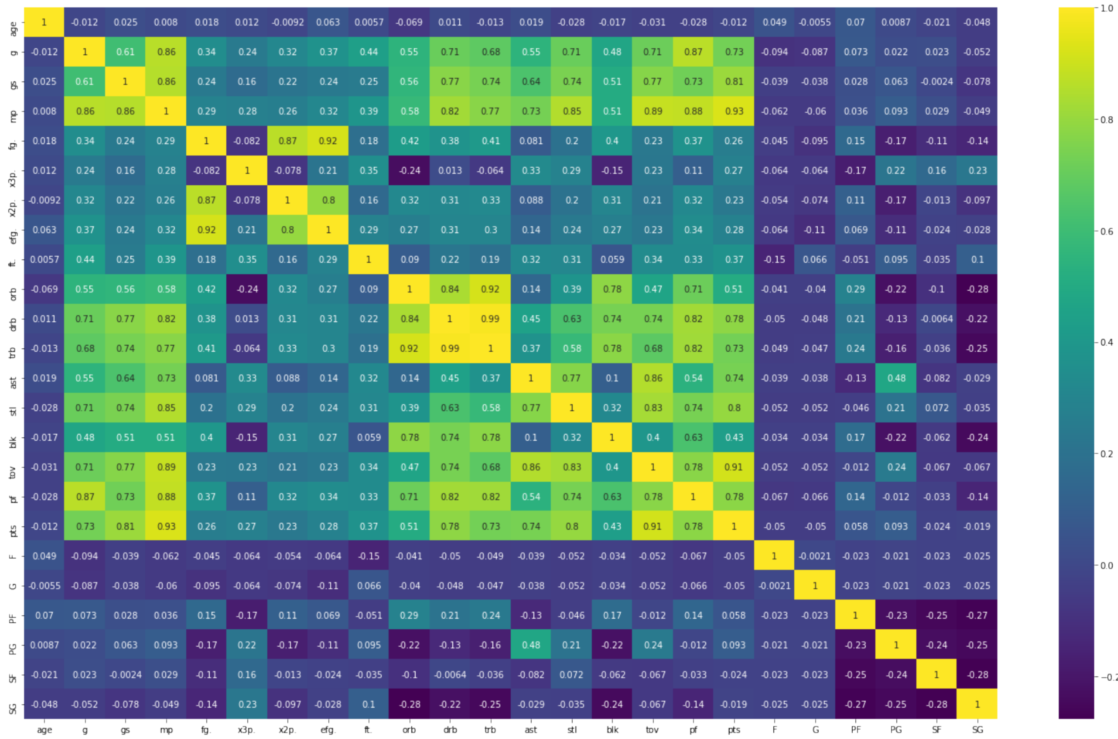
[65]:
```
age     0
g       0
gs      0
mp      0
fg.     0
x3p.    0
x2p.    0
efg.    0
ft.     0
orb     0
drb     0
trb     0
ast     0
stl     0
blk     0
tov     0
pf      0
pts     0
F       0
G       0
PF      0
PG      0
SF      0
SG      0
dtype: int64
```

NULL values are handled now. Few of the correlated columns are dropped. Now checking correlation heatmap.

[66]:
```
plt.figure(figsize=(25,15))
sns.heatmap(df_nba.corr(),annot=True,cmap='viridis')
```

[66]:

```
<AxesSubplot:>
```



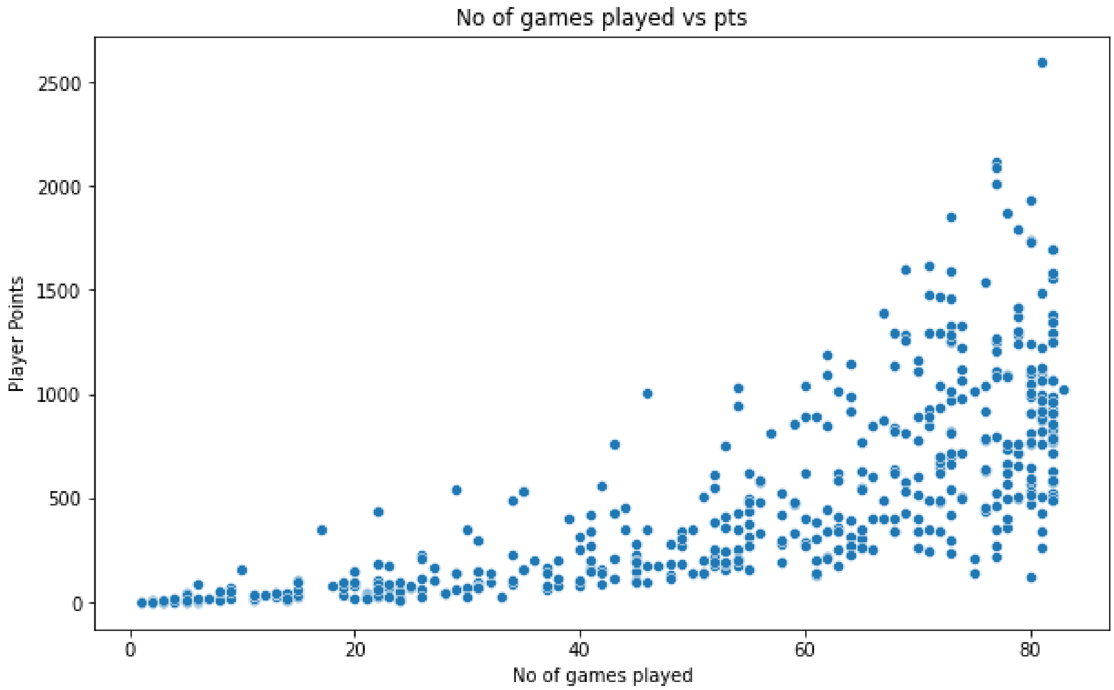
0.0.3 Feature: g & gs

[69]:

```python
plt.figure(figsize=(10,6))
sns.scatterplot('g','pts',data=df_nba)
plt.title('No of games played vs pts')
plt.xlabel('No of games played')
plt.ylabel('Player Points')
```

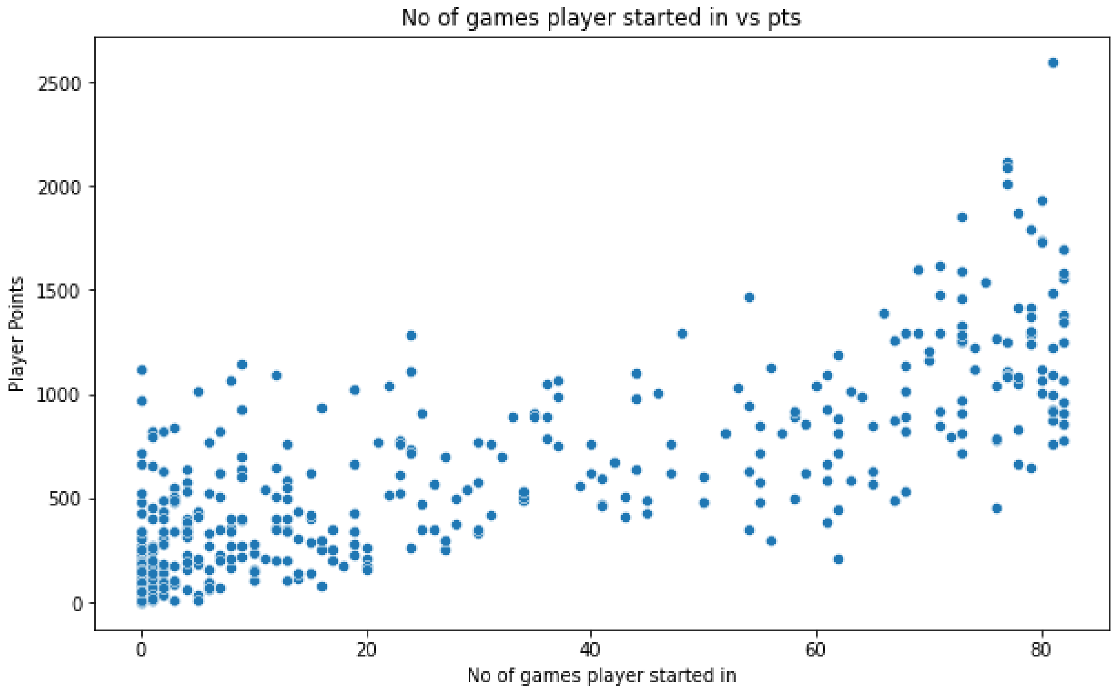
[69]:

```
Text(0, 0.5, 'Player Points')
```



[70]:
```
plt.figure(figsize=(10,6))
sns.scatterplot('gs','pts',data=df_nba)
plt.title('No of games player started in vs pts')
plt.xlabel('No of games player started in')
plt.ylabel('Player Points')
```

[70]: Text(0, 0.5, 'Player Points')



[71]:
```
X=df_nba.drop('pts',axis=1)
y=df_nba['pts']
```

[72]:
```
from sklearn.preprocessing import StandardScaler
```

[73]:
```
sc=StandardScaler()
X_scaled=sc.fit_transform(X)
```

[127]:
```
X_train, X_test, y_train, y_test = train_test_split(X_scaled, y, test_size=0.
↪25, random_state=365)
```

[128]:
```
model=KNeighborsRegressor()
```

[129]:
```
model.fit(X_train,y_train)
```

[129]: KNeighborsRegressor()

[130]:
```
y_pred = model.predict(X_test)
```

[131]:
```
#Prediction score on train dataset
model.score(X_train,y_train)
```

[131]: 0.9178269704362931

[132]:
```
#Prediction score on test dataset
model.score(X_test,y_test)
```

[132]: 0.8308027213906196

[135]:
```
#leaf_s=[i in range(2,40)]
param_grid = { 'algorithm' : ['ball_tree', 'kd_tree', 'brute'],
               'leaf_size' : [i for i in range(5,41,2)],
               'n_neighbors' : [3,5,7,9,10,11,12,13]
             }
```

[136]:
```
gridsearch = GridSearchCV(model, param_grid,verbose=5)
```

[137]:
```
gridsearch.fit(X_train,y_train)
```

```
Fitting 5 folds for each of 432 candidates, totalling 2160 fits
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=3 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=3, score=0.892, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=3 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=3, score=0.892, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=3 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=3, score=0.794, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=3 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=3, score=0.824, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=3 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=3, score=0.886, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=5 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=5, score=0.890, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=5 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=5, score=0.881, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=5 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=5, score=0.798, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=5 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=5, score=0.840, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=5 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=5, score=0.883, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=7 …
```

```
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=7, score=0.870, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=7 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=7, score=0.888, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=7 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=7, score=0.766, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=7 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=7, score=0.826, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=7 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=7, score=0.864, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=9 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=9, score=0.863, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=9 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=9, score=0.888, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=9 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=9, score=0.749, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=9 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=9, score=0.834, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=9 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=9, score=0.858, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=10 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=10, score=0.864, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=10 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=10, score=0.883, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=10 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=10, score=0.753, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=10 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=10, score=0.837, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=10 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=10, score=0.861, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=11 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=11, score=0.870, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=11 …
```

```
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=11, score=0.883, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=11 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=11, score=0.751, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=11 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=11, score=0.830, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=11 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=11, score=0.856, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=12 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=12, score=0.867, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=12 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=12, score=0.878, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=12 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=12, score=0.766, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=12 …
```

```
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.0s remaining:    0.0s
[Parallel(n_jobs=1)]: Done   2 out of   2 | elapsed:    0.0s remaining:    0.0s
[Parallel(n_jobs=1)]: Done   3 out of   3 | elapsed:    0.0s remaining:    0.0s
[Parallel(n_jobs=1)]: Done   4 out of   4 | elapsed:    0.0s remaining:    0.0s
```

```
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=12, score=0.823, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=12 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=12, score=0.850, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=13 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=13, score=0.864, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=13 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=13, score=0.879, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=13 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=13, score=0.766, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=13 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=13, score=0.836, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=5, n_neighbors=13 …
[CV]  algorithm=ball_tree, leaf_size=5, n_neighbors=13, score=0.841, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=3 …
```

```
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=3, score=0.892, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=3 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=3, score=0.892, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=3 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=3, score=0.794, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=3 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=3, score=0.824, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=3 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=3, score=0.886, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=5 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=5, score=0.890, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=5 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=5, score=0.881, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=5 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=5, score=0.798, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=5 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=5, score=0.840, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=5 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=5, score=0.883, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=7 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=7, score=0.870, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=7 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=7, score=0.888, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=7 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=7, score=0.766, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=7 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=7, score=0.826, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=7 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=7, score=0.864, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=9 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=9, score=0.863, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=9 …
```

```
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=9, score=0.888, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=9 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=9, score=0.749, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=9 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=9, score=0.834, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=9 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=9, score=0.858, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=10 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=10, score=0.864, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=10 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=10, score=0.883, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=10 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=10, score=0.753, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=10 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=10, score=0.837, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=10 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=10, score=0.861, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=11 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=11, score=0.870, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=11 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=11, score=0.883, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=11 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=11, score=0.751, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=11 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=11, score=0.830, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=11 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=11, score=0.856, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=12 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=12, score=0.867, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=12 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=12, score=0.878, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=12 …
```

```
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=12, score=0.766, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=12 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=12, score=0.823, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=12 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=12, score=0.850, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=13 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=13, score=0.864, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=13 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=13, score=0.879, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=13 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=13, score=0.766, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=13 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=13, score=0.836, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=7, n_neighbors=13 …
[CV]  algorithm=ball_tree, leaf_size=7, n_neighbors=13, score=0.841, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=9, n_neighbors=3 …
[CV]  algorithm=ball_tree, leaf_size=9, n_neighbors=3, score=0.892, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=9, n_neighbors=3 …
[CV]  algorithm=ball_tree, leaf_size=9, n_neighbors=3, score=0.892, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=9, n_neighbors=3 …
[CV]  algorithm=ball_tree, leaf_size=9, n_neighbors=3, score=0.794, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=9, n_neighbors=3 …
[CV]  algorithm=ball_tree, leaf_size=9, n_neighbors=3, score=0.824, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=9, n_neighbors=3 …
[CV]  algorithm=ball_tree, leaf_size=9, n_neighbors=3, score=0.886, total=
0.0s
[CV] algorithm=ball_tree, leaf_size=9, n_neighbors=5 …
[CV]  algorithm=ball_tree, leaf_size=9, n_neighbors=5, score=0.890, total=
0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
[CV] algorithm=ball_tree, leaf_size=9, n_neighbors=10 …
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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```

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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
[CV] algorithm=ball_tree, leaf_size=33, n_neighbors=10 …
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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[CV]  algorithm=ball_tree, leaf_size=39, n_neighbors=3, score=0.892, total=
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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[CV]  algorithm=ball_tree, leaf_size=39, n_neighbors=12, score=0.878, total=
0.0s
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[CV] algorithm=kd_tree, leaf_size=9, n_neighbors=11 …
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[CV] algorithm=kd_tree, leaf_size=9, n_neighbors=12 …
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[CV] algorithm=kd_tree, leaf_size=9, n_neighbors=13 …
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[CV] algorithm=kd_tree, leaf_size=9, n_neighbors=13 …
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[CV] algorithm=kd_tree, leaf_size=11, n_neighbors=3 …
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[CV] algorithm=kd_tree, leaf_size=11, n_neighbors=7 …
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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[CV] algorithm=kd_tree, leaf_size=15, n_neighbors=5 …
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
[CV] algorithm=kd_tree, leaf_size=29, n_neighbors=3 …
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[CV] algorithm=kd_tree, leaf_size=29, n_neighbors=9 …
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
[CV] algorithm=kd_tree, leaf_size=29, n_neighbors=11 …
[CV]  algorithm=kd_tree, leaf_size=29, n_neighbors=11, score=0.870, total=
0.0s
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[CV]  algorithm=kd_tree, leaf_size=29, n_neighbors=11, score=0.883, total=
0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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[CV]  algorithm=kd_tree, leaf_size=37, n_neighbors=5, score=0.798, total=   0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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[CV]  algorithm=brute, leaf_size=37, n_neighbors=3, score=0.892, total=   0.0s
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[CV]  algorithm=brute, leaf_size=37, n_neighbors=3, score=0.794, total=   0.0s
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[CV]  algorithm=brute, leaf_size=37, n_neighbors=3, score=0.824, total=   0.0s
[CV] algorithm=brute, leaf_size=37, n_neighbors=3 …
[CV]  algorithm=brute, leaf_size=37, n_neighbors=3, score=0.886, total=   0.0s
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[CV]  algorithm=brute, leaf_size=37, n_neighbors=5, score=0.890, total=   0.0s
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[CV]  algorithm=brute, leaf_size=37, n_neighbors=5, score=0.881, total=   0.0s
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[CV]  algorithm=brute, leaf_size=37, n_neighbors=5, score=0.798, total=   0.0s
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[CV]  algorithm=brute, leaf_size=37, n_neighbors=5, score=0.840, total=   0.0s
[CV] algorithm=brute, leaf_size=37, n_neighbors=5 …
[CV]  algorithm=brute, leaf_size=37, n_neighbors=5, score=0.883, total=   0.0s
[CV] algorithm=brute, leaf_size=37, n_neighbors=7 …
[CV]  algorithm=brute, leaf_size=37, n_neighbors=7, score=0.870, total=   0.0s
[CV] algorithm=brute, leaf_size=37, n_neighbors=7 …
[CV]  algorithm=brute, leaf_size=37, n_neighbors=7, score=0.888, total=   0.0s
[CV] algorithm=brute, leaf_size=37, n_neighbors=7 …
[CV]  algorithm=brute, leaf_size=37, n_neighbors=7, score=0.766, total=   0.0s
[CV] algorithm=brute, leaf_size=37, n_neighbors=7 …
[CV]  algorithm=brute, leaf_size=37, n_neighbors=7, score=0.826, total=   0.0s
[CV] algorithm=brute, leaf_size=37, n_neighbors=7 …
```

```
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[CV]  algorithm=brute, leaf_size=37, n_neighbors=9, score=0.863, total=   0.0s
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[CV]  algorithm=brute, leaf_size=37, n_neighbors=9, score=0.749, total=   0.0s
[CV] algorithm=brute, leaf_size=37, n_neighbors=9 …
[CV]  algorithm=brute, leaf_size=37, n_neighbors=9, score=0.834, total=   0.0s
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[CV]  algorithm=brute, leaf_size=37, n_neighbors=9, score=0.858, total=   0.0s
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[CV]  algorithm=brute, leaf_size=37, n_neighbors=10, score=0.861, total=   0.0s
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[CV]  algorithm=brute, leaf_size=37, n_neighbors=11, score=0.870, total=   0.0s
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[CV]  algorithm=brute, leaf_size=37, n_neighbors=11, score=0.883, total=   0.0s
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[CV] algorithm=brute, leaf_size=37, n_neighbors=12 …
[CV]  algorithm=brute, leaf_size=37, n_neighbors=12, score=0.878, total=   0.0s
[CV] algorithm=brute, leaf_size=37, n_neighbors=12 …
[CV]  algorithm=brute, leaf_size=37, n_neighbors=12, score=0.766, total=   0.0s
[CV] algorithm=brute, leaf_size=37, n_neighbors=12 …
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[CV] algorithm=brute, leaf_size=37, n_neighbors=13 …
[CV]  algorithm=brute, leaf_size=37, n_neighbors=13, score=0.879, total=   0.0s
[CV] algorithm=brute, leaf_size=37, n_neighbors=13 …
[CV]  algorithm=brute, leaf_size=37, n_neighbors=13, score=0.766, total=   0.0s
[CV] algorithm=brute, leaf_size=37, n_neighbors=13 …
```

```
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[CV]  algorithm=brute, leaf_size=37, n_neighbors=13, score=0.841, total=   0.0s
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[CV] algorithm=brute, leaf_size=39, n_neighbors=3 …
[CV]  algorithm=brute, leaf_size=39, n_neighbors=3, score=0.892, total=   0.0s
[CV] algorithm=brute, leaf_size=39, n_neighbors=3 …
[CV]  algorithm=brute, leaf_size=39, n_neighbors=3, score=0.794, total=   0.0s
[CV] algorithm=brute, leaf_size=39, n_neighbors=3 …
[CV]  algorithm=brute, leaf_size=39, n_neighbors=3, score=0.824, total=   0.0s
[CV] algorithm=brute, leaf_size=39, n_neighbors=3 …
[CV]  algorithm=brute, leaf_size=39, n_neighbors=3, score=0.886, total=   0.0s
[CV] algorithm=brute, leaf_size=39, n_neighbors=5 …
[CV]  algorithm=brute, leaf_size=39, n_neighbors=5, score=0.890, total=   0.0s
[CV] algorithm=brute, leaf_size=39, n_neighbors=5 …
[CV]  algorithm=brute, leaf_size=39, n_neighbors=5, score=0.881, total=   0.0s
[CV] algorithm=brute, leaf_size=39, n_neighbors=5 …
[CV]  algorithm=brute, leaf_size=39, n_neighbors=5, score=0.798, total=   0.0s
[CV] algorithm=brute, leaf_size=39, n_neighbors=5 …
[CV]  algorithm=brute, leaf_size=39, n_neighbors=5, score=0.840, total=   0.0s
[CV] algorithm=brute, leaf_size=39, n_neighbors=5 …
[CV]  algorithm=brute, leaf_size=39, n_neighbors=5, score=0.883, total=   0.0s
[CV] algorithm=brute, leaf_size=39, n_neighbors=7 …
[CV]  algorithm=brute, leaf_size=39, n_neighbors=7, score=0.870, total=   0.0s
[CV] algorithm=brute, leaf_size=39, n_neighbors=7 …
[CV]  algorithm=brute, leaf_size=39, n_neighbors=7, score=0.888, total=   0.0s
[CV] algorithm=brute, leaf_size=39, n_neighbors=7 …
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[CV] algorithm=brute, leaf_size=39, n_neighbors=7 …
[CV]  algorithm=brute, leaf_size=39, n_neighbors=7, score=0.826, total=   0.0s
[CV] algorithm=brute, leaf_size=39, n_neighbors=7 …
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[CV]  algorithm=brute, leaf_size=39, n_neighbors=9, score=0.834, total=   0.0s
[CV] algorithm=brute, leaf_size=39, n_neighbors=9 …
[CV]  algorithm=brute, leaf_size=39, n_neighbors=9, score=0.858, total=   0.0s
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[CV] algorithm=brute, leaf_size=39, n_neighbors=10 …
[CV]  algorithm=brute, leaf_size=39, n_neighbors=10, score=0.883, total=   0.0s
[CV] algorithm=brute, leaf_size=39, n_neighbors=10 …
```

```
[CV]  algorithm=brute, leaf_size=39, n_neighbors=10, score=0.753, total=   0.0s
[CV] algorithm=brute, leaf_size=39, n_neighbors=10 …
[CV]  algorithm=brute, leaf_size=39, n_neighbors=10, score=0.837, total=   0.0s
[CV] algorithm=brute, leaf_size=39, n_neighbors=10 …
[CV]  algorithm=brute, leaf_size=39, n_neighbors=10, score=0.861, total=   0.0s
[CV] algorithm=brute, leaf_size=39, n_neighbors=11 …
[CV]  algorithm=brute, leaf_size=39, n_neighbors=11, score=0.870, total=   0.0s
[CV] algorithm=brute, leaf_size=39, n_neighbors=11 …
[CV]  algorithm=brute, leaf_size=39, n_neighbors=11, score=0.883, total=   0.0s
[CV] algorithm=brute, leaf_size=39, n_neighbors=11 …
[CV]  algorithm=brute, leaf_size=39, n_neighbors=11, score=0.751, total=   0.0s
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[CV] algorithm=brute, leaf_size=39, n_neighbors=12 …
[CV]  algorithm=brute, leaf_size=39, n_neighbors=12, score=0.867, total=   0.0s
[CV] algorithm=brute, leaf_size=39, n_neighbors=12 …
[CV]  algorithm=brute, leaf_size=39, n_neighbors=12, score=0.878, total=   0.0s
[CV] algorithm=brute, leaf_size=39, n_neighbors=12 …
[CV]  algorithm=brute, leaf_size=39, n_neighbors=12, score=0.766, total=   0.0s
[CV] algorithm=brute, leaf_size=39, n_neighbors=12 …
[CV]  algorithm=brute, leaf_size=39, n_neighbors=12, score=0.823, total=   0.0s
[CV] algorithm=brute, leaf_size=39, n_neighbors=12 …
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[CV]  algorithm=brute, leaf_size=39, n_neighbors=13, score=0.864, total=   0.0s
[CV] algorithm=brute, leaf_size=39, n_neighbors=13 …
[CV]  algorithm=brute, leaf_size=39, n_neighbors=13, score=0.879, total=   0.0s
[CV] algorithm=brute, leaf_size=39, n_neighbors=13 …
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[Parallel(n_jobs=1)]: Done 2160 out of 2160 | elapsed:   10.5s finished
```

[137]:
```
GridSearchCV(estimator=KNeighborsRegressor(),
             param_grid={'algorithm': ['ball_tree', 'kd_tree', 'brute'],
                         'leaf_size': [5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25,
                                       27, 29, 31, 33, 35, 37, 39],
                         'n_neighbors': [3, 5, 7, 9, 10, 11, 12, 13]},
             verbose=5)
```

[138]:
```
# let's see the  best parameters according to gridsearch
best_param=gridsearch.best_params_
```

[139]:
```python
best_param
```

[139]:
```
{'algorithm': 'ball_tree', 'leaf_size': 5, 'n_neighbors': 5}
```

[140]:
```python
# we will use the best parameters in our k-NN algorithm and check if accuracy␣
↪is increasing.
knn = KNeighborsRegressor(algorithm = best_param['algorithm'],␣
↪leaf_size=best_param['leaf_size'], n_neighbors =best_param['n_neighbors'])
```

[141]:
```python
knn.fit(X_train,y_train)
```

[141]:
```
KNeighborsRegressor(algorithm='ball_tree', leaf_size=5)
```

[142]:
```python
#Prediction score on train dataset
knn.score(X_train,y_train)
```

[142]:
```
0.9178269704362931
```

[143]:
```python
knn.score(X_test,y_test)
```

[143]:
```
0.8308027213906196
```

[144]:
```python
from sklearn.model_selection import KFold
#k-fold cross validation
kfold = KFold(n_splits=12,random_state= 365)
kfold.get_n_splits(X_scaled)
```

[144]:
```
12
```

[145]:
```python
from statistics import mean
cnt =0
count=[]
train_score =[]
test_score = []

for train_index,test_index in kfold.split(X_scaled):
    X_train, X_test = X_scaled[train_index], X_scaled[test_index] # our scaled␣
↪data is an array so it can work on x[value]
    y_train, y_test = y.iloc[train_index], y.iloc[test_index] # y is a␣
↪dataframe so we have to use "iloc" to retreive data
    knn.fit(X_train,y_train)
    train_score_ = knn.score(X_train,y_train)
    test_score_ =  knn.score(X_test,y_test)
    cnt+=1
    count.append(cnt)
    train_score.append(train_score_)
    test_score.append(test_score_)
```

```
    print("for k = ", cnt)
    print("train_score is :  ", train_score_, "and test score is :  ",␣
 ↪test_score_)
print("**********************************************")
print("**********************************************")
print("Average train score is :  ", mean(train_score))
print("Average test score is :  ", mean(test_score))
```

```
for k =  1
train_score is :   0.9173650980311231 and test score is :   0.8099265044680258
for k =  2
train_score is :   0.9183800447466562 and test score is :   0.8300722980135616
for k =  3
train_score is :   0.913397057798017 and test score is :   0.883533318037717
for k =  4
train_score is :   0.91883039445607 and test score is :   0.8151802337881243
for k =  5
train_score is :   0.9119163084354981 and test score is :   0.9166172769767958
for k =  6
train_score is :   0.9102260373366035 and test score is :   0.9227306146924167
for k =  7
train_score is :   0.9156444048670855 and test score is :   0.9126264966254687
for k =  8
train_score is :   0.9158586819600634 and test score is :   0.8604182986114282
for k =  9
train_score is :   0.9219999707653729 and test score is :   0.8372308765912193
for k =  10
train_score is :   0.9215595688186271 and test score is :   0.7231324343355142
for k =  11
train_score is :   0.9148488032398331 and test score is :   0.8808744971325257
for k =  12
train_score is :   0.9165574820416257 and test score is :   0.9051565908009657
**********************************************
**********************************************
Average train score is :   0.9163819877080479
Average test score is :   0.8581249533394802
```

[146]:

```
# let's plot the test_accuracy with the value of k in k-fold

plt.plot(count,test_score)
plt.xlabel('Value of K for k-fold')
plt.ylabel('test accuracy')
plt.xticks(np.arange(0, 12, 1))
plt.yticks(np.arange(0.65, 1, 0.05))
```

```
[146]: ([<matplotlib.axis.YTick at 0x24efd7f0>,
  <matplotlib.axis.YTick at 0x24efd928>,
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  Text(0, 0, ''),
  Text(0, 0, ''),
  Text(0, 0, '')])
```

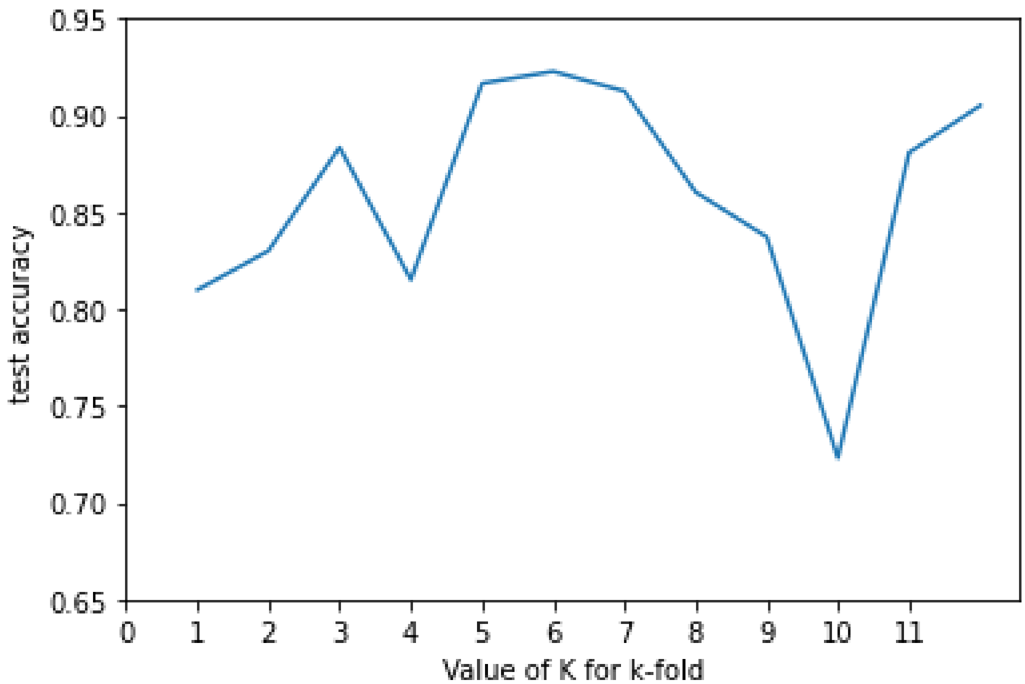


```
[148]: # let's save the model
import pickle

with open('modelForPrediction.sav', 'wb') as f:
    pickle.dump(knn,f)

with open('standardScalar.sav', 'wb') as f:
    pickle.dump(sc,f)
```

```
[ ]:
```