

```
In [1]: import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.linear_model import LogisticRegression
```

```
In [2]: df=pd.read_csv(r"D:\New folder\madrid_2013.csv")
df
```

Out[2]:

	date	BEN	CO	EBE	MXV	NMHC	NO_2	NOx	OXY	O_3	PM10
0	2002-04-01 01:00:00	NaN	1.39	NaN	NaN	NaN	145.100006	352.100006	NaN	6.54	41.990002
1	2002-04-01 01:00:00	1.93	0.71	2.33	6.20	0.15	98.150002	153.399994	2.67	6.85	20.980000
2	2002-04-01 01:00:00	NaN	0.80	NaN	NaN	NaN	103.699997	134.000000	NaN	13.01	28.440001
3	2002-04-01 01:00:00	NaN	1.61	NaN	NaN	NaN	97.599998	268.000000	NaN	5.12	42.180000
4	2002-04-01 01:00:00	NaN	1.90	NaN	NaN	NaN	92.089996	237.199997	NaN	7.28	76.330002
...
217291	2002-11-01 00:00:00	4.16	1.14	NaN	NaN	NaN	81.080002	265.700012	NaN	7.21	36.750000
217292	2002-11-01 00:00:00	3.67	1.73	2.89	NaN	0.38	113.900002	373.100006	NaN	5.66	63.389999
217293	2002-11-01 00:00:00	1.37	0.58	1.17	2.37	0.15	65.389999	107.699997	1.30	9.11	9.640000
217294	2002-11-01 00:00:00	4.51	0.91	4.83	10.99	NaN	149.800003	202.199997	1.00	5.75	NaN
217295	2002-11-01 00:00:00	3.11	1.17	3.00	7.77	0.26	80.110001	180.300003	2.25	7.38	29.240000

217296 rows × 16 columns



```
In [3]: df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 217296 entries, 0 to 217295
Data columns (total 16 columns):
#   Column      Non-Null Count  Dtype
---  -
0   date        217296 non-null  object
1   BEN         66747 non-null   float64
2   CO          216637 non-null  float64
3   EBE         58547 non-null   float64
4   MXY         41255 non-null   float64
5   NMHC        87045 non-null   float64
6   NO_2        216439 non-null  float64
7   NOx         216439 non-null  float64
8   OXY         41314 non-null   float64
9   O_3         216726 non-null  float64
10  PM10        209113 non-null  float64
11  PXY         41256 non-null   float64
12  SO_2        216507 non-null  float64
13  TCH         87115 non-null   float64
14  TOL         66619 non-null   float64
15  station     217296 non-null  int64
dtypes: float64(14), int64(1), object(1)
memory usage: 26.5+ MB
```

```
In [4]: df1=df.fillna(value=0)
df1
```

Out[4]:

	date	BEN	CO	EBE	MXV	NMHC	NO_2	NOx	OXY	O_3	PM10
0	2002-04-01 01:00:00	0.00	1.39	0.00	0.00	0.00	145.100006	352.100006	0.00	6.54	41.990002
1	2002-04-01 01:00:00	1.93	0.71	2.33	6.20	0.15	98.150002	153.399994	2.67	6.85	20.980000
2	2002-04-01 01:00:00	0.00	0.80	0.00	0.00	0.00	103.699997	134.000000	0.00	13.01	28.440001
3	2002-04-01 01:00:00	0.00	1.61	0.00	0.00	0.00	97.599998	268.000000	0.00	5.12	42.180000
4	2002-04-01 01:00:00	0.00	1.90	0.00	0.00	0.00	92.089996	237.199997	0.00	7.28	76.330002
...
217291	2002-11-01 00:00:00	4.16	1.14	0.00	0.00	0.00	81.080002	265.700012	0.00	7.21	36.750000
217292	2002-11-01 00:00:00	3.67	1.73	2.89	0.00	0.38	113.900002	373.100006	0.00	5.66	63.389999
217293	2002-11-01 00:00:00	1.37	0.58	1.17	2.37	0.15	65.389999	107.699997	1.30	9.11	9.640000
217294	2002-11-01 00:00:00	4.51	0.91	4.83	10.99	0.00	149.800003	202.199997	1.00	5.75	0.000000
217295	2002-11-01 00:00:00	3.11	1.17	3.00	7.77	0.26	80.110001	180.300003	2.25	7.38	29.240000

217296 rows × 16 columns



In [5]: df1.info()

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 217296 entries, 0 to 217295
Data columns (total 16 columns):
#   Column      Non-Null Count  Dtype
---  -
0   date        217296 non-null  object
1   BEN         217296 non-null  float64
2   CO          217296 non-null  float64
3   EBE         217296 non-null  float64
4   MXY         217296 non-null  float64
5   NMHC        217296 non-null  float64
6   NO_2        217296 non-null  float64
7   NOx         217296 non-null  float64
8   OXY         217296 non-null  float64
9   O_3         217296 non-null  float64
10  PM10        217296 non-null  float64
11  PXY         217296 non-null  float64
12  SO_2        217296 non-null  float64
13  TCH         217296 non-null  float64
14  TOL         217296 non-null  float64
15  station     217296 non-null  int64
dtypes: float64(14), int64(1), object(1)
memory usage: 26.5+ MB
```

In [6]: df1.columns

```
Out[6]: Index(['date', 'BEN', 'CO', 'EBE', 'MXY', 'NMHC', 'NO_2', 'NOx', 'OXY', 'O_3',
               'PM10', 'PXY', 'SO_2', 'TCH', 'TOL', 'station'],
              dtype='object')
```

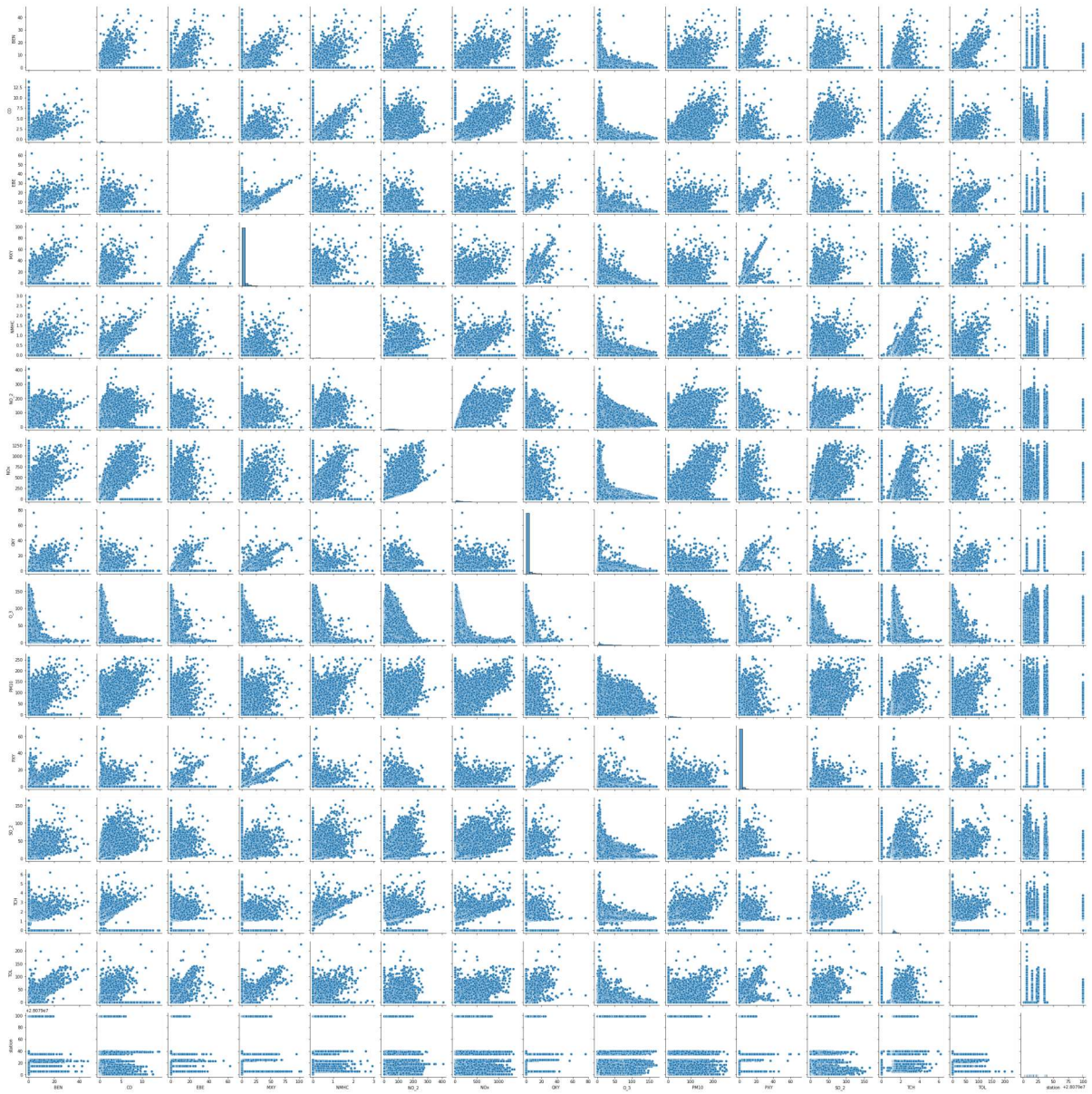
```
In [7]: df2=df1[['BEN', 'CO', 'EBE', 'MXY', 'NMHC', 'NO_2', 'NOx', 'OXY', 'O_3',  
              'PM10', 'PXY', 'SO_2', 'TCH', 'TOL', 'station']]  
df2
```

Out[7]:

	BEN	CO	EBE	MXY	NMHC	NO_2	NOx	OXY	O_3	PM10	PXY
0	0.00	1.39	0.00	0.00	0.00	145.100006	352.100006	0.00	6.54	41.990002	0.00
1	1.93	0.71	2.33	6.20	0.15	98.150002	153.399994	2.67	6.85	20.980000	2.53
2	0.00	0.80	0.00	0.00	0.00	103.699997	134.000000	0.00	13.01	28.440001	0.00
3	0.00	1.61	0.00	0.00	0.00	97.599998	268.000000	0.00	5.12	42.180000	0.00
4	0.00	1.90	0.00	0.00	0.00	92.089996	237.199997	0.00	7.28	76.330002	0.00
...
217291	4.16	1.14	0.00	0.00	0.00	81.080002	265.700012	0.00	7.21	36.750000	0.00
217292	3.67	1.73	2.89	0.00	0.38	113.900002	373.100006	0.00	5.66	63.389999	0.00
217293	1.37	0.58	1.17	2.37	0.15	65.389999	107.699997	1.30	9.11	9.640000	0.94
217294	4.51	0.91	4.83	10.99	0.00	149.800003	202.199997	1.00	5.75	0.000000	5.52
217295	3.11	1.17	3.00	7.77	0.26	80.110001	180.300003	2.25	7.38	29.240000	3.35

```
In [8]: sns.pairplot(df2)
```

```
Out[8]: <seaborn.axisgrid.PairGrid at 0x20a881eaa90>
```

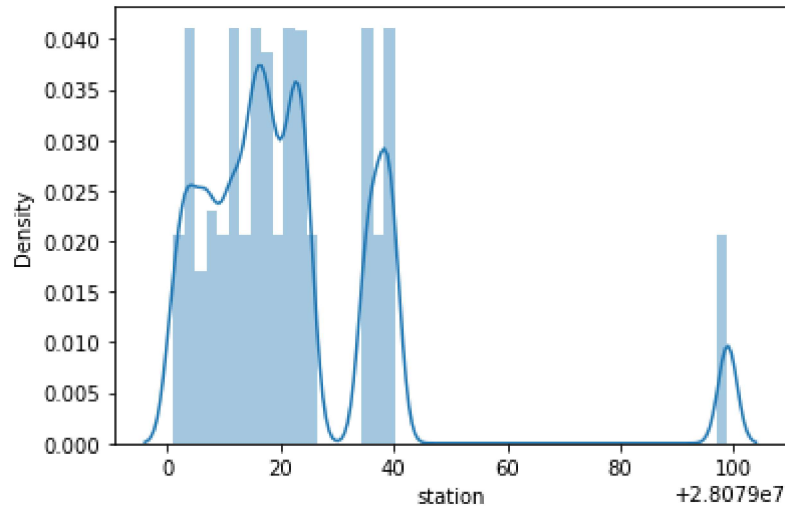


```
In [9]: sns.distplot(df2['station'])
```

```
C:\ProgramData\Anaconda3\lib\site-packages\seaborn\distributions.py:2557: FutureWarning: `distplot` is a deprecated function and will be removed in a future version. Please adapt your code to use either `displot` (a figure-level function with similar flexibility) or `histplot` (an axes-level function for histograms).
```

```
warnings.warn(msg, FutureWarning)
```

```
Out[9]: <AxesSubplot:xlabel='station', ylabel='Density'>
```



```
In [10]: x=df2[['BEN', 'CO', 'EBE', 'MXY', 'NMHC', 'NO_2', 'NOx', 'O_3', 'PM10', 'PXY',
              y=df2['station']]
```

```
In [24]: from sklearn.model_selection import train_test_split
x_train,x_test,y_train,y_test = train_test_split(x,y,test_size=0.3)
```

linear

```
In [12]: from sklearn.linear_model import LinearRegression
```

```
In [13]: lr=LinearRegression()
         lr.fit(x_train,y_train)
```

Out[13]: LinearRegression()

```
In [14]: coeff =pd.DataFrame(lr.coef_,x.columns,columns=["Co-efficient"])
coeff
```

Out[14]:

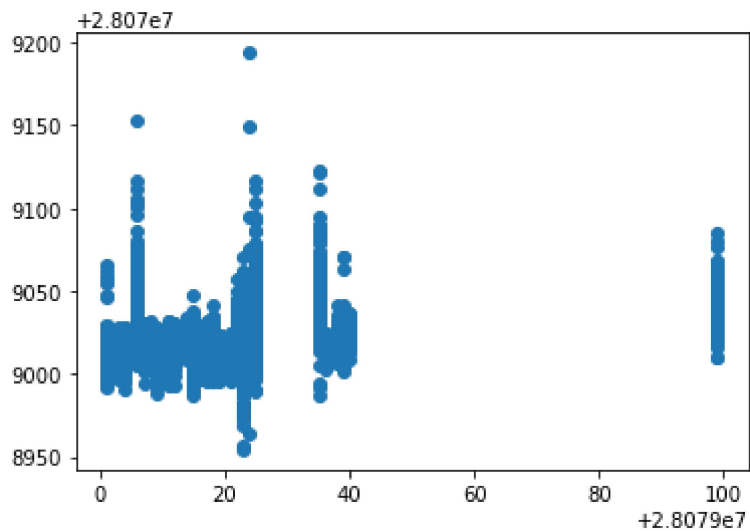
Co-efficient	
BEN	2.833498
CO	4.218625
EBE	-1.896436
MXY	0.996361
NMHC	-11.596930
NO_2	-0.044724
NOx	-0.038944
O_3	-0.014382
PM10	0.032646
PXY	4.152622
SO_2	-0.108335
TCH	6.355155
TOL	-0.418133
OXY	-2.160064

```
In [15]: print(lr.intercept_)

28079023.010687977
```

```
In [16]: prediction =lr.predict(x_test)
py.scatter(y_test,prediction)
```

Out[16]: <matplotlib.collections.PathCollection at 0x20aa0591eb0>




```
In [17]: print(lr.score(x_test,y_test))
```

```
0.13971016103643064
```

```
In [18]: print(lr.score(x_train,y_train))
```

```
0.1377927917601448
```

Ridge

```
In [19]: from sklearn.linear_model import Ridge,Lasso
```

```
In [20]: rr=Ridge(alpha=10)  
rr.fit(x_train,y_train)
```

```
Out[20]: Ridge(alpha=10)
```

```
In [21]: rr.score(x_test,y_test)
```

```
Out[21]: 0.13971942807063387
```

Lasso

```
In [22]: la=Lasso(alpha=10)  
la.fit(x_train,y_train)
```

```
Out[22]: Lasso(alpha=10)
```

```
In [23]: la.score(x_test,y_test)
```

```
Out[23]: 0.05961311096197963
```

elasticnet

```
In [24]: from sklearn.linear_model import ElasticNet  
en=ElasticNet()  
en.fit(x_train,y_train)
```

```
Out[24]: ElasticNet()
```

```
In [25]: print(en.coef_)
```

```
[ 0.52192221  0.06008224 -0.          0.79420303  0.          -0.05650403  
 -0.0175735  -0.01514683  0.04193206  0.86416339 -0.09613152  1.46701895  
 -0.02315909  0.          ]
```

```
In [26]: print(en.intercept_)
```

```
28079025.64837437
```

```
In [27]: print(en.predict(x_test))
```

```
[28079022.98173612 28079021.18830581 28079020.94239793 ...  
28079040.90115401 28079016.84820627 28079026.37385159]
```

```
In [28]: print(en.score(x_test,y_test))
```

```
0.10679846191048736
```

logistic

```
In [8]: feature_matrix=df2.iloc[:,0:14]  
target_vector=df2.iloc[:,-1]
```

```
In [9]: feature_matrix=df2[['BEN', 'CO', 'EBE', 'MXV', 'NMHC', 'NO_2', 'NOx', 'O_3', 'PM  
y=df2['station']
```

```
In [10]: feature_matrix.shape
```

```
Out[10]: (217296, 14)
```

```
In [11]: target_vector.shape
```

```
Out[11]: (217296,)
```

```
In [12]: from sklearn.preprocessing import StandardScaler
```

```
In [13]: fs=StandardScaler().fit_transform(feature_matrix)
```

```
In [14]: logr =LogisticRegression()  
logr.fit(fs,target_vector)
```

```
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\linear_model\_logistic.py:  
763: ConvergenceWarning: lbfgs failed to converge (status=1):  
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.
```

```
Increase the number of iterations (max_iter) or scale the data as shown in:  
https://scikit-learn.org/stable/modules/preprocessing.html (https://scikit-learn.org/stable/modules/preprocessing.html)  
Please also refer to the documentation for alternative solver options:  
https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression (https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression)  
n_iter_i = _check_optimize_result(  

```

```
Out[14]: LogisticRegression()
```

```
In [15]: observation=[[1.4,2.3,5.0,11,12,13,14,15,4,5,7,6,7,13]]
```

```
In [16]: prediction=logr.predict(observation)
print(prediction)

[28079099]
```

```
In [17]: logr.classes_
```

```
Out[17]: array([28079001, 28079003, 28079004, 28079006, 28079007, 28079008,
                28079009, 28079011, 28079012, 28079014, 28079015, 28079016,
                28079017, 28079018, 28079019, 28079021, 28079022, 28079023,
                28079024, 28079025, 28079035, 28079036, 28079038, 28079039,
                28079040, 28079099], dtype=int64)
```

```
In [18]: logr.score(fs,target_vector)
```

```
Out[18]: 0.9224836168176128
```

```
In [19]: logr.predict_proba(observation)[0][0]
```

```
Out[19]: 0.0
```

```
In [20]: logr.predict_proba(observation)[0][1]
```

```
Out[20]: 0.0
```

random forest

```
In [21]: from sklearn.ensemble import RandomForestClassifier
from sklearn.tree import plot_tree
```

```
In [22]: x=df2.drop('station',axis=1)
y=df2['station']
```

```
In [25]: x_train,x_test,y_train,y_test = train_test_split(x,y,test_size=0.70)
```

```
In [26]: rfc=RandomForestClassifier()
rfc.fit(x_train,y_train)
```

```
Out[26]: RandomForestClassifier()
```

```
In [27]: parameters = {'max_depth':[1,2,3,4,5],
                        'min_samples_leaf':[5,10,15,20,25],
                        'n_estimators':[10,20,30,40,50]}
```

```
In [28]: from sklearn.model_selection import GridSearchCV
```

```
In [29]: grid_search = GridSearchCV(estimator=rfc,param_grid=parameters,cv=2,scoring='accuracy')
grid_search.fit(x_train,y_train)
```

```
Out[29]: GridSearchCV(cv=2, estimator=RandomForestClassifier(),
                    param_grid={'max_depth': [1, 2, 3, 4, 5],
                                'min_samples_leaf': [5, 10, 15, 20, 25],
                                'n_estimators': [10, 20, 30, 40, 50]},
                    scoring='accuracy')
```

```
In [30]: grid_search.best_score_
```

```
Out[30]: 0.46224765294225933
```

```
In [31]: rfc_best =grid_search.best_estimator_
```

```
In [32]: py.figure(figsize=(80,50))
plot_tree(rfc_best.estimators_[5],feature_names=x.columns,filled=True)
```

```
Out[32]: [Text(2317.846153846154, 2491.5, 'BEN <= 0.08\ngini = 0.96\nsamples = 41186\nvalue = [2613, 2648, 2619, 2168, 2497, 320, 2540, 2737, 2575\n2576, 2686, 2622, 2476, 2383, 2628, 2641, 2616, 2607\n2667, 2543, 2591, 2678, 2659, 2720, 2751, 2627]'),
Text(1373.5384615384614, 2038.5, 'CO <= 0.685\ngini = 0.943\nsamples = 28522\nvalue = [2613, 2648, 2619, 16, 2497, 320, 2540, 2737, 2575\n2576, 44, 2622, 2476, 2383, 2628, 2641, 155, 10, 179\n41, 72, 2678, 2659, 2720, 2751, 25]'),
Text(686.7692307692307, 1585.5, 'NMHC <= 0.005\ngini = 0.939\nsamples = 17000\nvalue = [778, 1645, 1812, 16, 1245, 83, 935, 2041, 1386, 767\n32, 2008, 1895, 1726, 1675, 1960, 106, 10, 146, 37\n57, 1910, 930, 1801, 1893, 19]'),
Text(343.38461538461536, 1132.5, 'CO <= 0.205\ngini = 0.919\nsamples = 12554\nvalue = [778, 1645, 1812, 16, 70, 2, 935, 10, 1269, 767, 18\n2008, 1895, 56, 1675, 1960, 106, 9, 9, 37, 24\n1910, 930, 1801, 90, 4]'),
Text(171.69230769230768, 679.5, 'TCH <= 1.205\ngini = 0.886\nsamples = 2227\nvalue = [59, 137, 428, 16, 20, 2, 22, 10, 508, 77, 2, 291\n575, 53, 58, 658, 20, 9, 3, 12, 14, 134, 177\n223, 25, 2]'),
Text(85.84615384615384, 226.5, 'gini = 0.884\nsamples = 2169\nvalue = [59, 137, 428, 16, 20, 2, 22, 10, 508, 77, 2, 291\n575, 53, 58, 658, 20, 9, 3, 12, 14, 134, 177\n223, 25, 2]')]
```

conclusion

The bestfit model is Logistic Regression with score of 0.9224836168176128

```
In [ ]:
```