Regression model with sklearn

```
# Load all the necessary libraries
import pandas as pd
import numpy as np
from pandas import Series, DataFrame
from sklearn.linear_model import LinearRegression
from sklearn.model_selection import KFold
from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score

# Load the file
airport=pd.read_csv('/content/airport.csv')
```

```
# Check the number of rows and columns
airport.shape
```

```
(19, 13)
```

```
# View the dataset
print(airport)
```

```
    year     dep     arr  dep_dem  ...  caputil  eff_dep  eff_arr   saer
0   2000  172170  158570   215157  ...    46.67    91.93    94.31  93.00
1   2001  147010  133806   176997  ...    42.79    93.41    95.48  94.34
2   2002  142779  129089   169072  ...    41.13    94.81    95.87  95.29
3   2003  140023  126800   168626  ...    41.59    94.26    94.73  94.47
4   2004  161351  160474   203993  ...    50.32    93.22    94.93  94.02
5   2005  176738  176139   249869  ...    54.73    91.55    93.92  92.63
6   2006  191852  191288   326131  ...    57.28    91.98    94.20  92.92
7   2007  222946  222505   407468  ...    62.42    90.42    91.82  91.05
8   2008  221203  221458   352677  ...    60.47    89.35    92.10  90.67
9   2009  209595  209710   312026  ...    57.35    89.91    92.47  91.14
10  2010  200902  200595   277480  ...    58.61    92.05    92.89  92.45
11  2011  205231  204685   266431  ...    56.99    91.84    92.76  92.30
12  2012  202430  202162   254435  ...    54.19    93.28    94.91  94.06
13  2013  203798  203443   264611  ...    54.76    93.27    94.07  93.66
14  2014  213113  212793   269706  ...    56.86    93.58    93.62  93.60
15  2015  220122  220306   285469  ...    59.45    93.68    93.92  93.80
16  2016  225989  226432   296871  ...    58.37    93.35    94.09  93.71
17  2017  223126  223879   317699  ...    59.47    92.18    93.47  92.81
18  2018  227425  227342   312875  ...    59.58    92.29    94.00  93.08

[19 rows x 13 columns]
```

```
# Create a data frame
airport=pd.DataFrame(airport, columns=['caputil', 'dep'])
# Define X and Y
X=pd.DataFrame(airport['caputil'])
Y=pd.DataFrame(airport['dep'])
```

```
# Define the model
reg = LinearRegression()
```

```
# Determine three folds
scores=[]
kfold = KFold(n_splits=3, shuffle=True, random_state=42)
```

```
# Create the iteration for the three folds
for i, (train, test) in enumerate(kfold.split(X, Y)):
    reg.fit(X.iloc[train,:], Y.iloc[train,:])
    score = reg.score(X.iloc[test,:], Y.iloc[test,:])
    scores.append(score)
print(scores)
```

```
[0.9029142706220207, 0.9048352664783202, 0.5119143545760048]
```

```
# Determine the coefficient of determination with sklearn
reg = LinearRegression().fit(X, Y)
print('Coefficient of Determination:', reg.score(X, Y))
```

```
Coefficient of Determination: 0.8897612752328165
```

```
# Determine the coefficient for X
print('Coefficients:', reg.coef_)
print('Coefficients:', reg.coef_)
```

```
Coefficients: [[4202.71508638]]
```

```
# Determine the intercept
print('Intercept:', reg.intercept_)
```

```
Intercept: [-33354.0929305]
```

```
# Predict the Y values
Y_pred=reg.predict(Y)
```

```
# Determine the values
print('Predicted Values: ',Y_pred)
```

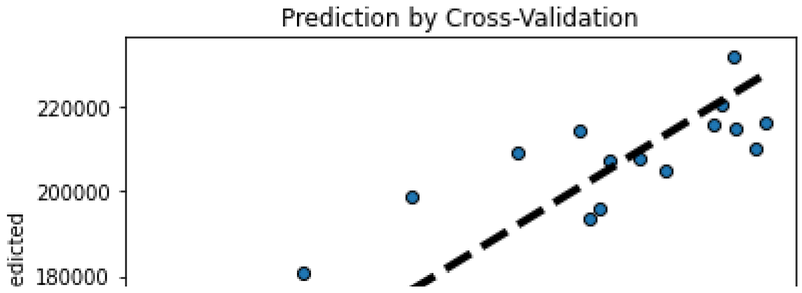
```
Predicted Values:  [[7.23548102e+08]
 [6.17807791e+08]
 [6.00026103e+08]
 [5.88443420e+08]
 [6.78078928e+08]
 [7.42746105e+08]
 [8.06265941e+08]
 [9.36945164e+08]
 [9.29619831e+08]
 [8.80834714e+08]
 [8.44300512e+08]
 [8.62494066e+08]
 [8.50722261e+08]
 [8.56471575e+08]
 [8.95619866e+08]
 [9.25076696e+08]
 [9.49734026e+08]
 [9.37701652e+08]
 [9.55769124e+08]]
```

```
# Visualize predicted errors
from sklearn.model_selection import cross_val_predict
predicted = cross_val_predict(reg, X, Y, cv=10)
```

```
# Determine the predicted errors
print('Predicted Errors: ', predicted)
```

```
Predicted Errors:  [[160835.55508042]
 [143928.21704009]
 [138393.80845549]
 [140358.20860634]
 [180662.82450213]
 [198806.56295092]
 [209181.70395083]
 [231558.86084681]
 [220561.15973044]
 [207488.73277439]
 [214087.71393934]
 [207154.97715331]
 [193506.03241906]
 [195900.52219425]
 [204795.19251424]
 [215536.69965656]
 [210137.99688364]
 [214613.01298902]
 [216056.74708452]]
```

```
# Create a graph of the predicted versus cross-validated errors
import matplotlib.pyplot as plt
%matplotlib inline
fig, ax = plt.subplots()
ax.scatter(Y, predicted, edgecolors=(0, 0, 0))
ax.plot([Y.min(), Y.max()], [Y.min(), Y.max()], 'k--', lw=4)
ax.set_xlabel('Measured')
ax.set_ylabel('Predicted')
plt.title('Prediction by Cross-Validation', fontdict=None, loc='center', pad=None)
plt.show()
```



Regression Model with statsmodels

```
# Method 2 Using Statsmodels
import statsmodels.api as sm
from scipy import stats
```

```
/usr/local/lib/python3.6/dist-packages/statsmodels/tools/_testing.py:19: FutureWarning: pandas.util.testing is deprecated. Use the functions in the public API at
  import pandas.util.testing as tm
```

```
# Add a constant
X2 = sm.add_constant(X)
# Define the model
est = sm.OLS(Y, X2)
# Fit the model
est2 = est.fit()
print("summary()\n",est2.summary())
print("pvalues\n",est2.pvalues)
print("tvalues\n",est2.tvalues)
print("rsquared\n",est2.rsquared)
print("rsquared_adj\n",est2.rsquared_adj)
```

```
summary()
                             OLS Regression Results
==============================================================================
Dep. Variable:                    dep   R-squared:                       0.890
Model:                            OLS   Adj. R-squared:                  0.883
Method:                 Least Squares   F-statistic:                     137.2
Date:                Sun, 14 Feb 2021   Prob (F-statistic):           1.45e-09
Time:                        16:34:20   Log-Likelihood:                -201.11
No. Observations:                  19   AIC:                             406.2
Df Residuals:                      17   BIC:                             408.1
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const      -3.335e+04   1.96e+04     -1.698      0.108   -7.48e+04    8092.445
caputil     4202.7151    358.786     11.714      0.000    3445.742    4959.688
==============================================================================
Omnibus:                        2.344   Durbin-Watson:                   0.634
Prob(Omnibus):                  0.310   Jarque-Bera (JB):                1.898
Skew:                          -0.721   Prob(JB):                        0.387
Kurtosis:                       2.437   Cond. No.                         464.
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
pvalues
 const      1.077598e-01
caputil    1.454602e-09
dtype: float64
tvalues
 const      -1.697874
caputil    11.713701
dtype: float64
rsquared
 0.8897612752328165
rsquared_adj
 0.8832766443641586
/usr/local/lib/python3.6/dist-packages/scipy/stats/stats.py:1535: UserWarning: kurtosistest only valid for n>=20 ... continuing anyway, n=19
  "anyway, n=%i" % int(n))
```

```
# Determine predicted values and R-squared with scikitlearn
from sklearn.metrics import r2_score
predictions = est2.predict(X2)

print(est2.predict(X2))

print("r2_score",r2_score(Y,predictions))
```

```
0     162786.620151
1     146480.085616
2     139503.578572
```

```
3     141436.827512
4     178126.530216
5     196660.503747
6     207377.427217
7     228979.382761
8     220784.088343
9     207671.617273
10    212967.038282
11    206158.639842
12    194391.037600
13    196786.585199
14    205612.286881
15    216497.318955
16    211958.386661
17    216581.373256
18    217043.671916
dtype: float64
r2_score 0.8897612752328165
```

How to create a dummy variable with sklearn

```
import warnings
warnings.filterwarnings('ignore')
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
df=pd.read_table('http://data.princeton.edu/wws509/datasets/salary.dat', delim_whitespace=True)
df.head()
```

	sx	rk	yr	dg	yd	sl
0	male	full	25	doctorate	35	36350
1	male	full	13	doctorate	22	35350
2	male	full	10	doctorate	23	28200
3	female	full	7	doctorate	27	26775
4	male	full	19	masters	30	33696

```
# To create a dummy variable
dummy=pd.get_dummies(df['sx'])
dummy.head()
```

	female	male
0	0	1
1	0	1
2	0	1
3	1	0
4	0	1

```
# To merge the dataframes
df.merge(dummy, left_index=True, right_index=True)
df.head()
```

	sx	rk	yr	dg	yd	sl	female	male
0	male	full	25	doctorate	35	36350	0	1
1	male	full	13	doctorate	22	35350	0	1
2	male	full	10	doctorate	23	28200	0	1
3	female	full	7	doctorate	27	26775	1	0
4	male	full	19	masters	30	33696	0	1

```
# To concatenate on column 1
df=pd.concat([df, dummy], axis=1)
df.head()
```

	sx	rk	yr	dg	yd	sl	female	male
0	male	full	25	doctorate	35	36350	0	1
1	male	full	13	doctorate	22	35350	0	1
2	male	full	10	doctorate	23	28200	0	1

```
import pandas as pd
df = pd.read_csv('http://statweb.stanford.edu/~tibs/ElemStatLearn/datasets/SAheart.data', index_col=0)# copy data and separate predictors and response
X = df.copy()
y = X.pop('chd')
df.head()
```

	sbp	tobacco	ldl	adiposity	famhist	typea	obesity	alcohol	age	chd
row.names										
1	160	12.00	5.73	23.11	Present	49	25.30	97.20	52	1
2	144	0.01	4.41	28.61	Absent	55	28.87	2.06	63	1
3	118	0.08	3.48	32.28	Present	52	29.14	3.81	46	0
4	170	7.50	6.41	38.03	Present	51	31.99	24.26	58	1
5	134	13.60	3.50	27.78	Present	60	25.99	57.34	49	1

```
# compute percentage of chronic heart disease for famhist
y.groupby(X.famhist).mean()
```

```
famhist
Absent     0.237037
Present    0.500000
Name: chd, dtype: float64
```

Creating a dummy variable with statsmodels

```
import statsmodels.formula.api as smf
# encode df.famhist as a numeric via pd.Factor
est = smf.ols(formula="sbp ~ age+ obesity+adiposity+C(famhist)", data=df).fit()
est.summary()
```

```
                              OLS Regression Results
     Dep. Variable:  sbp                     R-squared:  0.174
             Model:  OLS                Adj. R-squared:  0.167
            Method:  Least Squares         F-statistic:  24.04
              Date:  Thu, 25 Feb 2021 Prob (F-statistic): 4.55e-18
              Time:  11:52:36           Log-Likelihood:  -2006.3
 No. Observations:   462                           AIC:  4023.
      Df Residuals:  457                           BIC:  4043.
          Df Model:  4
  Covariance Type:   nonrobust
                              coef     std err   t      P>|t|  [0.025  0.975]
         Intercept           104.7562  6.167   16.985  0.000  92.636  116.876
C(famhist)[T.Present]         -0.6380  1.822   -0.350  0.726  -4.218  2.942
               age             0.4072  0.081    5.028  0.000  0.248   0.566
           obesity             0.2788  0.310    0.900  0.368  -0.330  0.888
         adiposity             0.3596  0.206    1.749  0.081  -0.045  0.764
      Omnibus:      78.787  Durbin-Watson:      1.887
Prob(Omnibus):      0.000   Jarque-Bera (JB):   140.851
         Skew:      0.989        Prob(JB):      2.60e-31
     Kurtosis:      4.846       Cond. No.       412.


Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
```