Lab 6: Ridge/LASSO Regression

Problem statement:

- Develop Ridge Regression model and try to tune it with varying alpha values. Plot SSE against each value of alpha. [Download suitable dataset with enough features, refer to access R-preloaded dataset]
- Develop LASSO Regression model and try to tune it with varying alpha values. Plot SSE against each value of alpha.
- Demonstrate the program SPARSITY property of LASSO Regression.

Source Code and Output:

```
"""
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Subject: Machine Learning Lab 7
Task: Ridge/LASSO Regression Implementation
"""

#Importing libraries.
import numpy as np
import pandas as pd
import random
import matplotlib.pyplot as plt
%matplotlib inline
from matplotlib.pylab import rcParams
rcParams['figure.figsize'] = 12, 10

#Define input array with angles from 60deg to 300deg converted to radians
x = np.array([i*np.pi/180 for i in range(60,300,4)])
np.random.seed(10)  #Setting seed for reproducability
y = np.sin(x) + np.random.normal(0,0.15,len(x))
data = pd.DataFrame(np.column_stack([x,y]),columns=['x','y'])
plt.plot(data['x'],data['y'],'.')
```
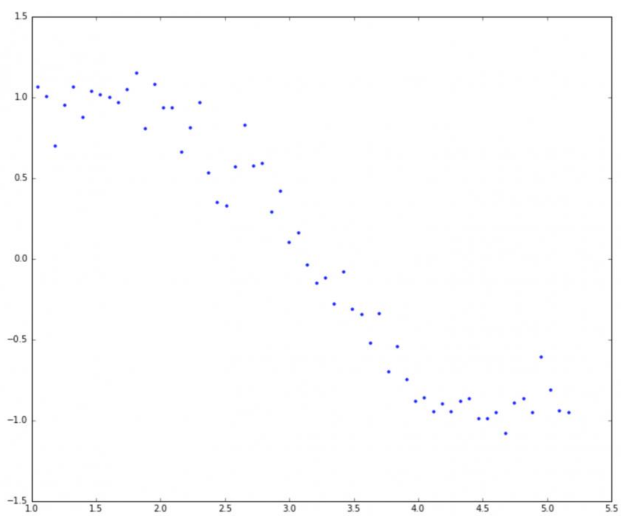
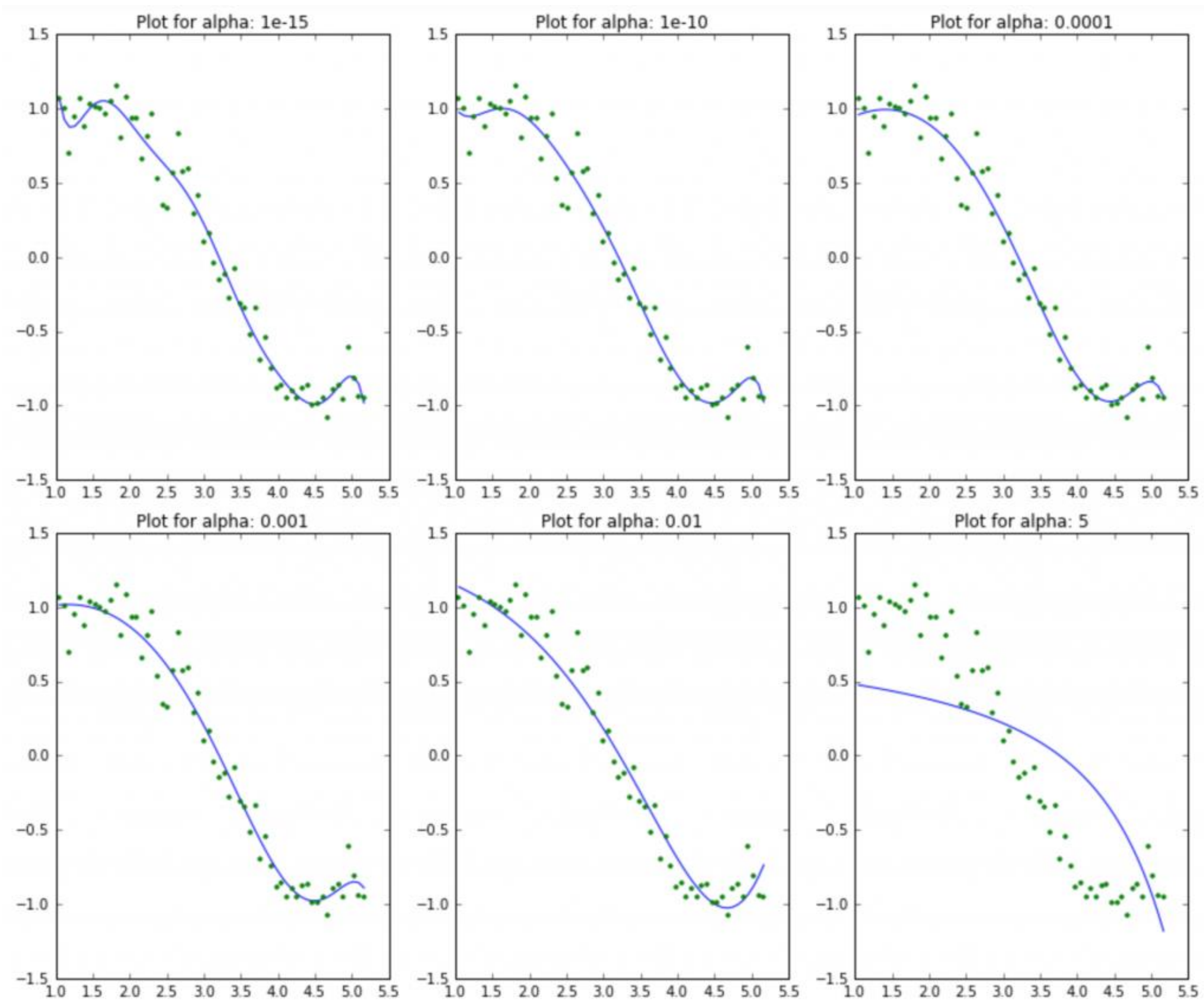



```
for i in range(2,16):  #power of 1 is already there
    colname = 'x_%d'%i      #new var will be x_power
    data[colname] = data['x']**i
print data.head()
```

	x	y	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_10	x_11	x_12	x_13	x_14	x_15
0	1.047198	1.065763	1.096623	1.148381	1.202581	1.259340	1.318778	1.381021	1.446202	1.514459	1.585938	1.660790	1.739176	1.821260	1.907219	1.997235
1	1.117011	1.006086	1.247713	1.393709	1.556788	1.738948	1.942424	2.169709	2.423588	2.707173	3.023942	3.377775	3.773011	4.214494	4.707635	5.258479
2	1.186824	0.695374	1.408551	1.671702	1.984016	2.354677	2.794587	3.316683	3.936319	4.671717	5.544505	6.580351	7.809718	9.268760	11.000386	13.055521
3	1.256637	0.949799	1.579137	1.984402	2.493673	3.133642	3.937850	4.948448	6.218404	7.814277	9.819710	12.339811	15.506664	19.486248	24.487142	30.771450
4	1.326450	1.063496	1.759470	2.333850	3.095735	4.106339	5.446854	7.224981	9.583578	12.712139	16.862020	22.366630	29.668222	39.353420	52.200353	69.241170

```
#Ridge Regression
from sklearn.linear_model import Ridge
def ridge_regression(data, predictors, alpha, models_to_plot={}):
    #Fit the model
    ridgereg = Ridge(alpha=alpha,normalize=True)
    ridgereg.fit(data[predictors],data['y'])
    y_pred = ridgereg.predict(data[predictors])

    #Check if a plot is to be made for the entered alpha
    if alpha in models_to_plot:
        plt.subplot(models_to_plot[alpha])
        plt.tight_layout()
        plt.plot(data['x'],y_pred)
        plt.plot(data['x'],data['y'],'.')
        plt.title('Plot for alpha: %.3g'%alpha)

    #Return the result in pre-defined format
    rss = sum((y_pred-data['y'])**2)
    ret = [rss]
    ret.extend([ridgereg.intercept_])
    ret.extend(ridgereg.coef_)
    return ret
```

```
#Initialize predictors to be set of 15 powers of x
predictors=['x']
predictors.extend(['x_%d'%i for i in range(2,16)])

#Set the different values of alpha to be tested
alpha_ridge = [1e-15, 1e-10, 1e-8, 1e-4, 1e-3,1e-2, 1, 5, 10, 20]

#Initialize the dataframe for storing coefficients.
col = ['rss','intercept'] + ['coef_x_%d'%i for i in range(1,16)]
ind = ['alpha_%.2g'%alpha_ridge[i] for i in range(0,10)]
coef_matrix_ridge = pd.DataFrame(index=ind, columns=col)

models_to_plot = {1e-15:231, 1e-10:232, 1e-4:233, 1e-3:234, 1e-2:235, 5:236}
for i in range(10):
   coef_matrix_ridge.iloc[i,] = ridge_regression(data, predictors, alpha_ridge[i], models_to_plot)
```



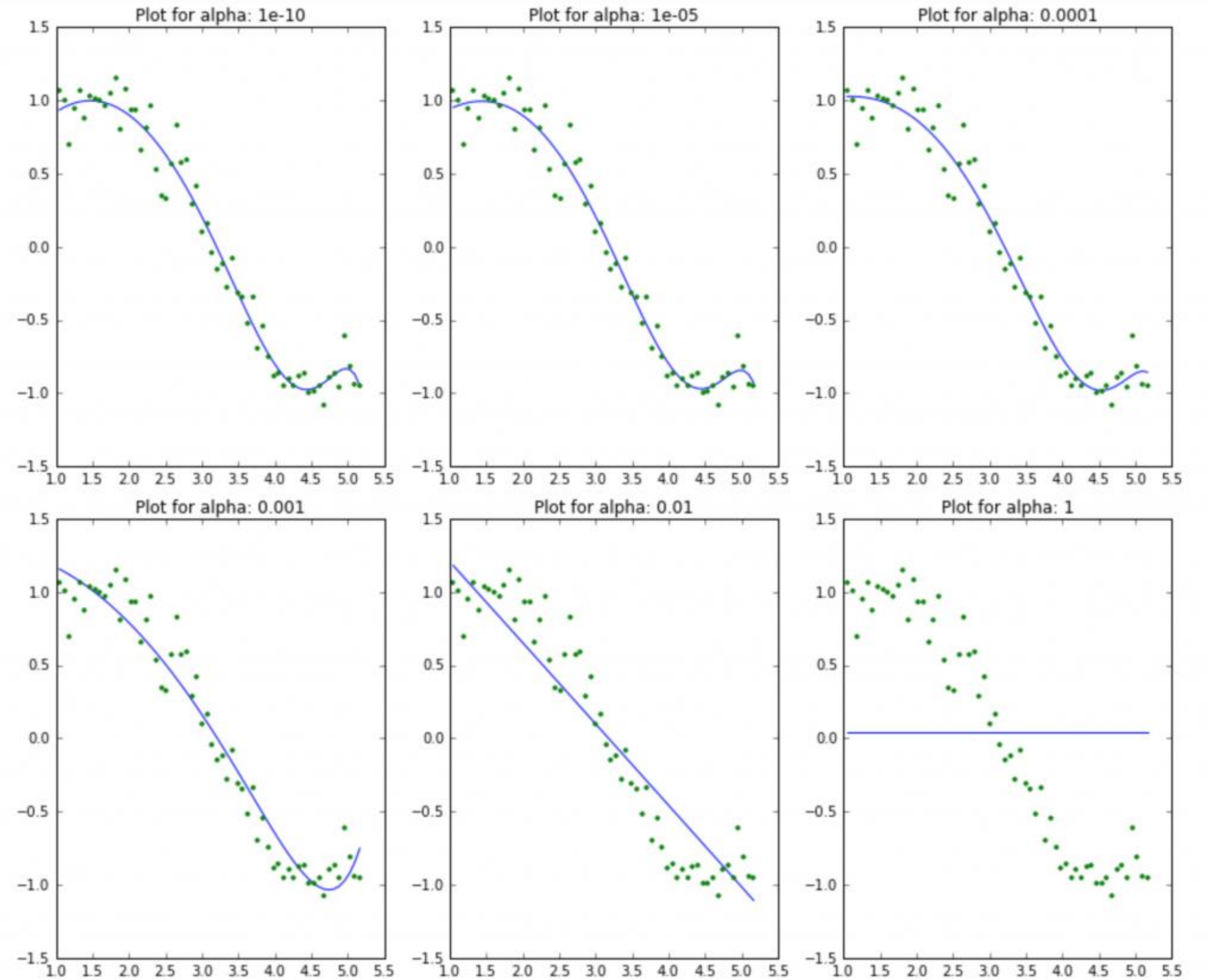
```
#Set the display format to be scientific for ease of analysis
pd.options.display.float_format = '{:,.2g}'.format
coef_matrix_ridge
```

	rss	intercept	coef_x_1	coef_x_2	coef_x_3	coef_x_4	coef_x_5	coef_x_6	coef_x_7	coef_x_8	coef_x_9	coef_x_10	coef_x_11	coe
alpha_1e-15	0.87	95	-3e+02	3.8e+02	-2.4e+02	66	0.96	-4.8	0.64	0.15	-0.026	-0.0054	0.00086	0.0
alpha_1e-10	0.92	11	-29	31	-15	2.9	0.17	-0.091	-0.011	0.002	0.00064	2.4e-05	-2e-05	-4.2
alpha_1e-08	0.95	1.3	-1.5	1.7	-0.68	0.039	0.016	0.00016	-0.00036	-5.4e-05	-2.9e-07	1.1e-06	1.9e-07	2e-
alpha_0.0001	0.96	0.56	0.55	-0.13	-0.026	-0.0028	-0.00011	4.1e-05	1.5e-05	3.7e-06	7.4e-07	1.3e-07	1.9e-08	1.9
alpha_0.001	1	0.82	0.31	-0.087	-0.02	-0.0028	-0.00022	1.8e-05	1.2e-05	3.4e-06	7.3e-07	1.3e-07	1.9e-08	1.7
alpha_0.01	1.4	1.3	-0.088	-0.052	-0.01	-0.0014	-0.00013	7.2e-07	4.1e-06	1.3e-06	3e-07	5.6e-08	9e-09	1.1
alpha_1	5.6	0.97	-0.14	-0.019	-0.003	-0.00047	-7e-05	-9.9e-06	-1.3e-06	-1.4e-07	-9.3e-09	1.3e-09	7.8e-10	2.4
alpha_5	14	0.55	-0.059	-0.0085	-0.0014	-0.00024	-4.1e-05	-6.9e-06	-1.1e-06	-1.9e-07	-3.1e-08	-5.1e-09	-8.2e-10	-1.3
alpha_10	18	0.4	-0.037	-0.0055	-0.00095	-0.00017	-3e-05	-5.2e-06	-9.2e-07	-1.6e-07	-2.9e-08	-5.1e-09	-9.1e-10	-1.6
alpha_20	23	0.28	-0.022	-0.0034	-0.0006	-0.00011	-2e-05	-3.6e-06	-6.6e-07	-1.2e-07	-2.2e-08	-4e-09	-7.5e-10	-1.4

```
coef_matrix_ridge.apply(lambda x: sum(x.values==0),axis=1)
```

```
alpha_1e-15      0
alpha_1e-10      0
alpha_1e-08      0
alpha_0.0001     0
alpha_0.001      0
alpha_0.01       0
alpha_1          0
alpha_5          0
alpha_10         0
alpha_20         0
dtype: int64
```

```
#LASSO Rigression

from sklearn.linear_model import Lasso
def lasso_regression(data, predictors, alpha, models_to_plot={}):
    #Fit the model
    lassoreg = Lasso(alpha=alpha,normalize=True, max_iter=1e5)
    lassoreg.fit(data[predictors],data['y'])
    y_pred = lassoreg.predict(data[predictors])

    #Check if a plot is to be made for the entered alpha
    if alpha in models_to_plot:
        plt.subplot(models_to_plot[alpha])
        plt.tight_layout()
        plt.plot(data['x'],y_pred)
        plt.plot(data['x'],data['y'],'.')
        plt.title('Plot for alpha: %.3g'%alpha)

    #Return the result in pre-defined format
    rss = sum((y_pred-data['y'])**2)
    ret = [rss]
    ret.extend([lassoreg.intercept_])
    ret.extend(lassoreg.coef_)
    return ret

#Initialize predictors to all 15 powers of x
predictors=['x']
predictors.extend(['x_%d'%i for i in range(2,16)])

#Define the alpha values to test
alpha_lasso = [1e-15, 1e-10, 1e-8, 1e-5,1e-4, 1e-3,1e-2, 1, 5, 10]

#Initialize the dataframe to store coefficients
col = ['rss','intercept'] + ['coef_x_%d'%i for i in range(1,16)]
ind = ['alpha_%.2g'%alpha_lasso[i] for i in range(0,10)]
coef_matrix_lasso = pd.DataFrame(index=ind, columns=col)

#Define the models to plot
models_to_plot = {1e-10:231, 1e-5:232,1e-4:233, 1e-3:234, 1e-2:235, 1:236}

#Iterate over the 10 alpha values:
for i in range(10):
    coef_matrix_lasso.iloc[i,] = lasso_regression(data, predictors, alpha_lasso[i], models_to_plot)
```



	rss	intercept	coef_x_1	coef_x_2	coef_x_3	coef_x_4	coef_x_5	coef_x_6	coef_x_7	coef_x_8	coef_x_9	coef_x_10	coef_x_11	coe
alpha_1e-15	0.96	0.22	1.1	-0.37	0.00089	0.0016	-0.00012	-6.4e-05	-6.3e-06	1.4e-06	7.8e-07	2.1e-07	4e-08	5.4
alpha_1e-10	0.96	0.22	1.1	-0.37	0.00088	0.0016	-0.00012	-6.4e-05	-6.3e-06	1.4e-06	7.8e-07	2.1e-07	4e-08	5.4
alpha_1e-08	0.96	0.22	1.1	-0.37	0.00077	0.0016	-0.00011	-6.4e-05	-6.3e-06	1.4e-06	7.8e-07	2.1e-07	4e-08	5.3
alpha_1e-05	0.96	0.5	0.6	-0.13	-0.038	-0	0	0	0	7.7e-06	1e-06	7.7e-08	0	0
alpha_0.0001	1	0.9	0.17	-0	-0.048	-0	-0	0	0	9.5e-06	5.1e-07	0	0	0
alpha_0.001	1.7	1.3	-0	-0.13	-0	-0	-0	0	0	0	0	0	1.5e-08	7.5
alpha_0.01	3.6	1.8	-0.55	-0.00056	-0	-0	-0	-0	-0	-0	-0	0	0	0
alpha_1	37	0.038	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0
alpha_5	37	0.038	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0
alpha_10	37	0.038	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0

HIGH SPARSITY

coef_matrix_lasso.apply(lambda x: sum(x.values==0),axis=1)

```
alpha_1e-15        0
alpha_1e-10        0
alpha_1e-08        0
alpha_1e-05        8
alpha_0.0001      10
alpha_0.001       12
alpha_0.01        13
alpha_1           15
alpha_5           15
alpha_10          15
dtype: int64
```