lab8

September 10, 2020

[67]:
```python
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
from sklearn.metrics import mean_squared_error, r2_score
import seaborn as sns


from sklearn.linear_model import LinearRegression
```

1 data description

[68]:
```python
housing = pd.read_csv(r'D:\msc3\machine learning\lab8\housing.csv')
print(housing.head())
```

```
      CRIM    ZN  INDUS  CHAS    NOX     RM   AGE     DIS  RAD  TAX  PTRATIO  \
0  0.00632  18.0   2.31   0.0  0.538  6.575  65.2  4.0900    1  296     15.3
1  0.02731   0.0   7.07   0.0  0.469  6.421  78.9  4.9671    2  242     17.8
2  0.02729   0.0   7.07   0.0  0.469  7.185  61.1  4.9671    2  242     17.8
3  0.03237   0.0   2.18   0.0  0.458  6.998  45.8  6.0622    3  222     18.7
4  0.06905   0.0   2.18   0.0  0.458  7.147  54.2  6.0622    3  222     18.7

        B  LSTAT  MEDV
0  396.90   4.98  24.0
1  396.90   9.14  21.6
2  392.83   4.03  34.7
3  394.63   2.94  33.4
4  396.90    NaN  36.2
```

[69]:
```python
housing.head()
```

[69]:

```
      CRIM    ZN  INDUS  CHAS    NOX     RM   AGE     DIS  RAD  TAX  PTRATIO  \
0  0.00632  18.0   2.31   0.0  0.538  6.575  65.2  4.0900    1  296     15.3
1  0.02731   0.0   7.07   0.0  0.469  6.421  78.9  4.9671    2  242     17.8
2  0.02729   0.0   7.07   0.0  0.469  7.185  61.1  4.9671    2  242     17.8
3  0.03237   0.0   2.18   0.0  0.458  6.998  45.8  6.0622    3  222     18.7
4  0.06905   0.0   2.18   0.0  0.458  7.147  54.2  6.0622    3  222     18.7
```

```
        B  LSTAT  MEDV
0  396.90   4.98  24.0
1  396.90   9.14  21.6
2  392.83   4.03  34.7
3  394.63   2.94  33.4
4  396.90    NaN  36.2
```

[70]:
```
print("Number of data:"+str(len(housing.index)))
```

```
Number of data:506
```

[71]:
```
housing.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 506 entries, 0 to 505
Data columns (total 14 columns):
 #   Column   Non-Null Count  Dtype
---  ------   --------------  -----
 0   CRIM     486 non-null    float64
 1   ZN       486 non-null    float64
 2   INDUS    486 non-null    float64
 3   CHAS     486 non-null    float64
 4   NOX      506 non-null    float64
 5   RM       506 non-null    float64
 6   AGE      486 non-null    float64
 7   DIS      506 non-null    float64
 8   RAD      506 non-null    int64
 9   TAX      506 non-null    int64
 10  PTRATIO  506 non-null    float64
 11  B        506 non-null    float64
 12  LSTAT    486 non-null    float64
 13  MEDV     506 non-null    float64
dtypes: float64(12), int64(2)
memory usage: 55.5 KB
```

[72]:
```
housing.isnull().any()
```

[72]:
```
CRIM        True
ZN          True
INDUS       True
CHAS        True
NOX        False
RM         False
AGE         True
DIS        False
RAD        False
```

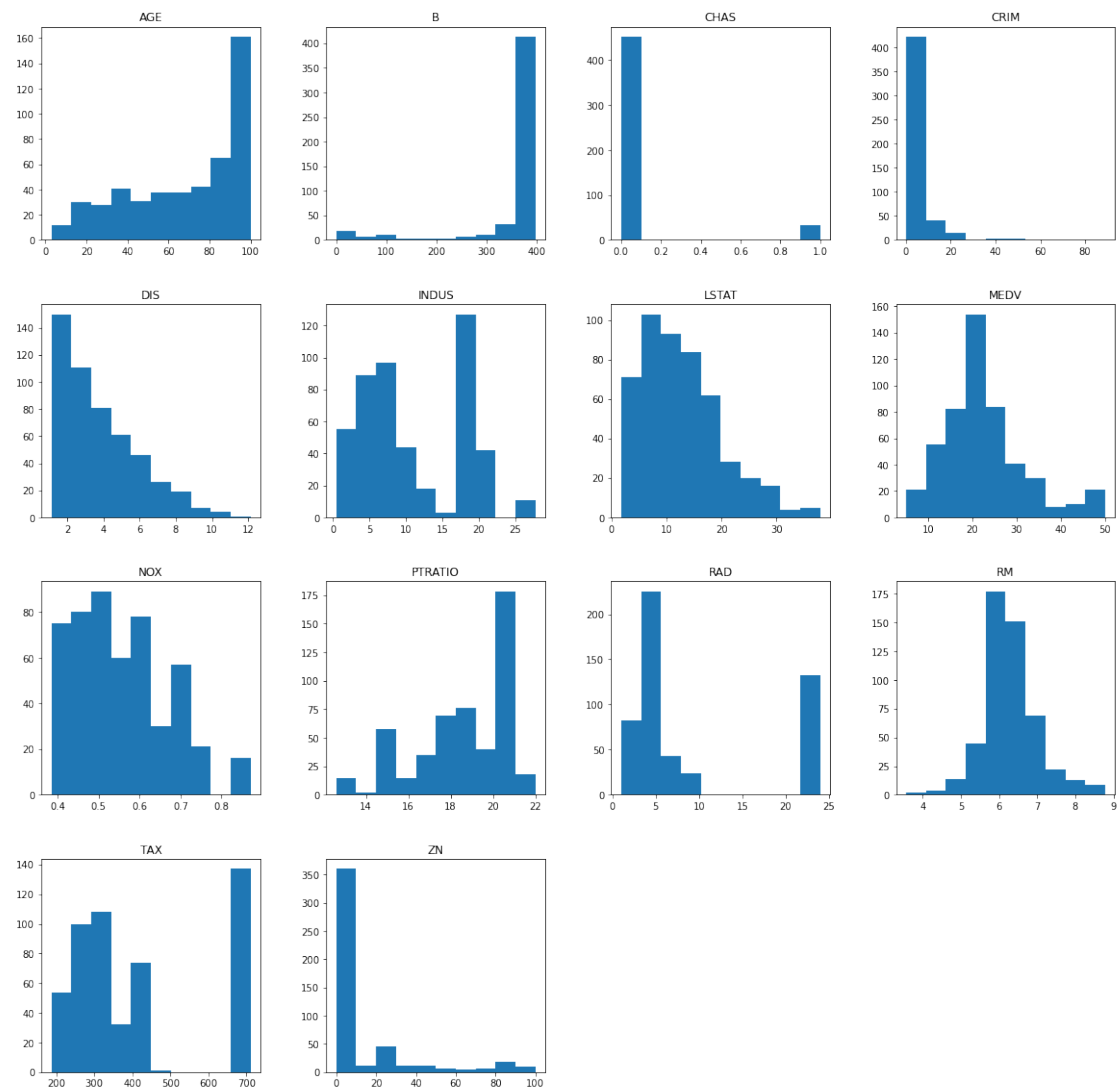
```
TAX        False
PTRATIO    False
B          False
LSTAT       True
MEDV       False
dtype: bool
```

[73]:

```
housing.hist(bins=10,figsize=(20,20),grid=False)
```

[73]:

```
array([[<matplotlib.axes._subplots.AxesSubplot object at 0x0000019A71DC6C08>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x0000019A6FE23608>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x0000019A6FE39408>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x0000019A704FC548>],
       [<matplotlib.axes._subplots.AxesSubplot object at 0x0000019A7052E4C8>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x0000019A6FD09E48>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x0000019A6FFEECC8>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x0000019A6FE64788>],
       [<matplotlib.axes._subplots.AxesSubplot object at 0x0000019A6FE64D88>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x0000019A6D543808>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x0000019A6D550588>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x0000019A7177AE08>],
       [<matplotlib.axes._subplots.AxesSubplot object at 0x0000019A72324C88>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x0000019A71A83B48>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x0000019A6FCA0B48>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x0000019A6FE54948>]],
      dtype=object)
```



2 data preprocessing

[74]:
```
housing.isnull().sum()
```

[74]:
```
CRIM       20
ZN         20
INDUS      20
CHAS       20
NOX         0
RM          0
AGE        20
DIS         0
```

```
RAD          0
TAX          0
PTRATIO      0
B            0
LSTAT       20
MEDV         0
dtype: int64
```

[75]:
```python
housing.fillna(housing.mean(), inplace=True)
```

[76]:
```python
housing.head()
```

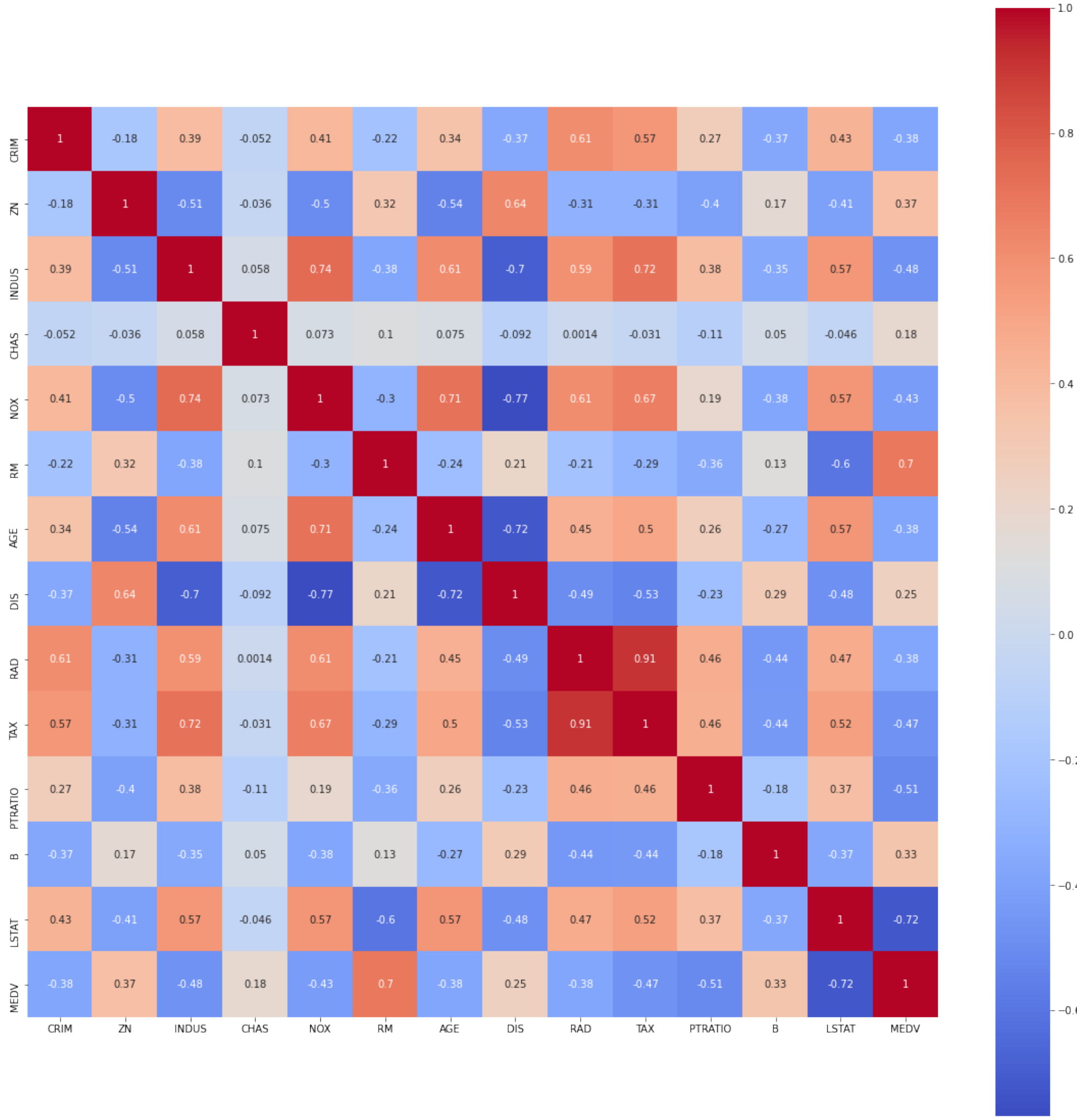
[76]:
```
      CRIM    ZN  INDUS  CHAS    NOX     RM   AGE     DIS  RAD  TAX  PTRATIO  \
0  0.00632  18.0   2.31   0.0  0.538  6.575  65.2  4.0900    1  296     15.3
1  0.02731   0.0   7.07   0.0  0.469  6.421  78.9  4.9671    2  242     17.8
2  0.02729   0.0   7.07   0.0  0.469  7.185  61.1  4.9671    2  242     17.8
3  0.03237   0.0   2.18   0.0  0.458  6.998  45.8  6.0622    3  222     18.7
4  0.06905   0.0   2.18   0.0  0.458  7.147  54.2  6.0622    3  222     18.7

        B      LSTAT  MEDV
0  396.90   4.980000  24.0
1  396.90   9.140000  21.6
2  392.83   4.030000  34.7
3  394.63   2.940000  33.4
4  396.90  12.715432  36.2
```

[77]:
```python
housing.isnull().sum()
```

[77]:
```
CRIM       0
ZN         0
INDUS      0
CHAS       0
NOX        0
RM         0
AGE        0
DIS        0
RAD        0
TAX        0
PTRATIO    0
B          0
LSTAT      0
MEDV       0
dtype: int64
```

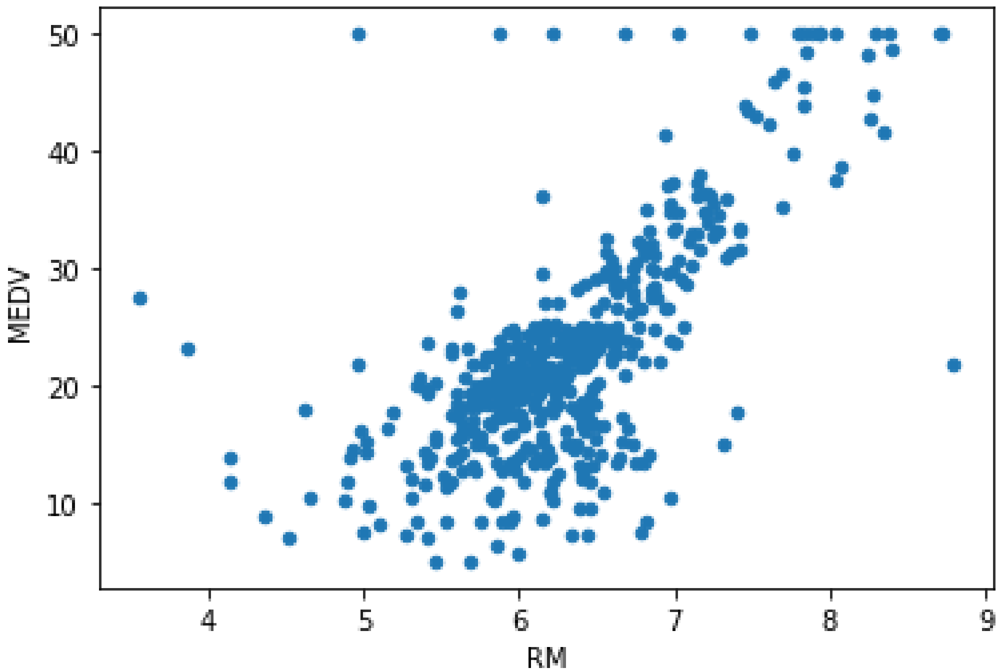
[78]:
```python
plt.figure(figsize=(20,20))
sns.heatmap(housing[housing.columns].corr(), annot=True, square=True,␣
 ↪cmap='coolwarm')
```

```
plt.show()
```



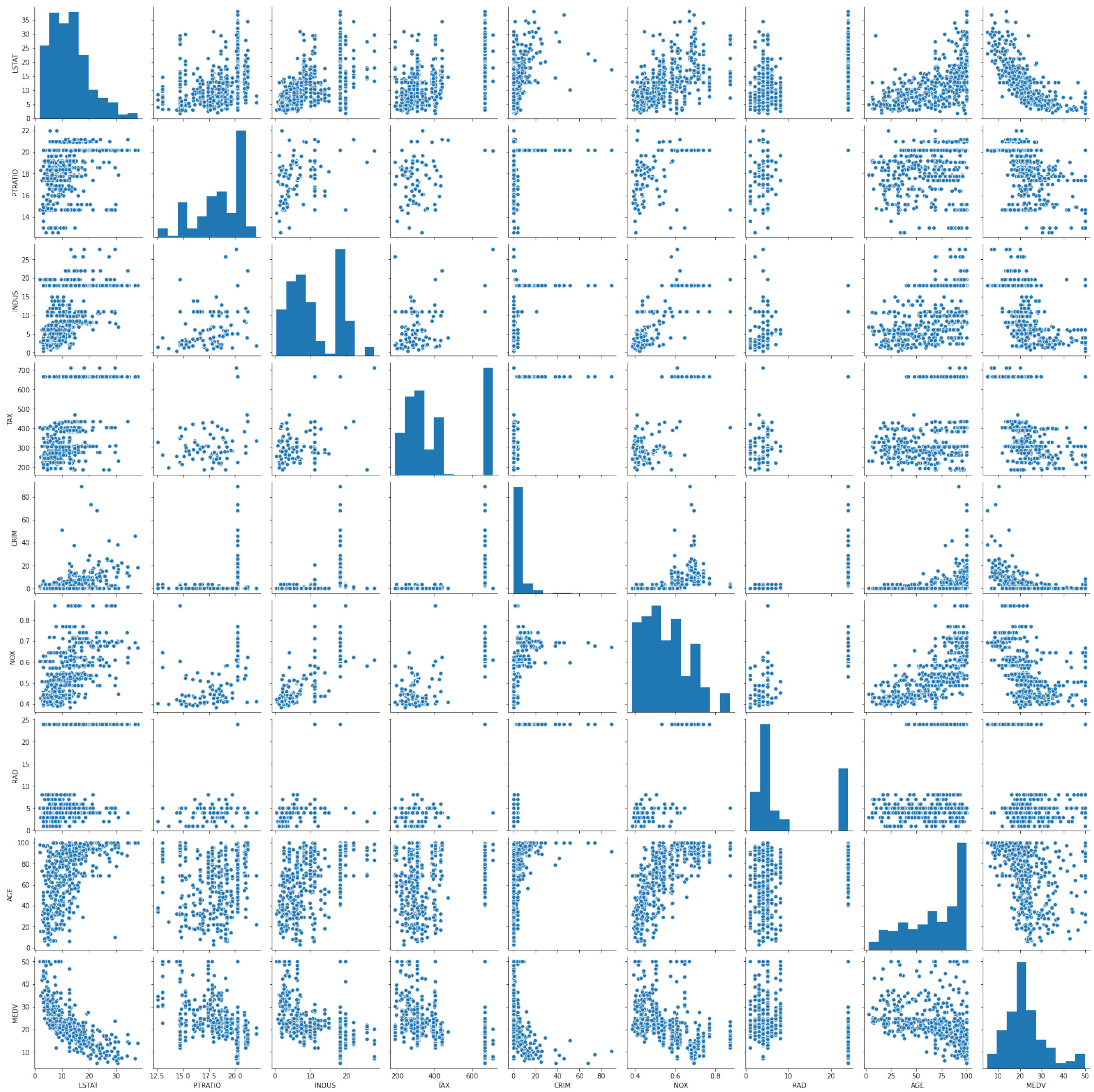
[79]:
```
housing.plot.scatter('RM', 'MEDV')
```

[79]: <matplotlib.axes._subplots.AxesSubplot at 0x19a6fb285c8>



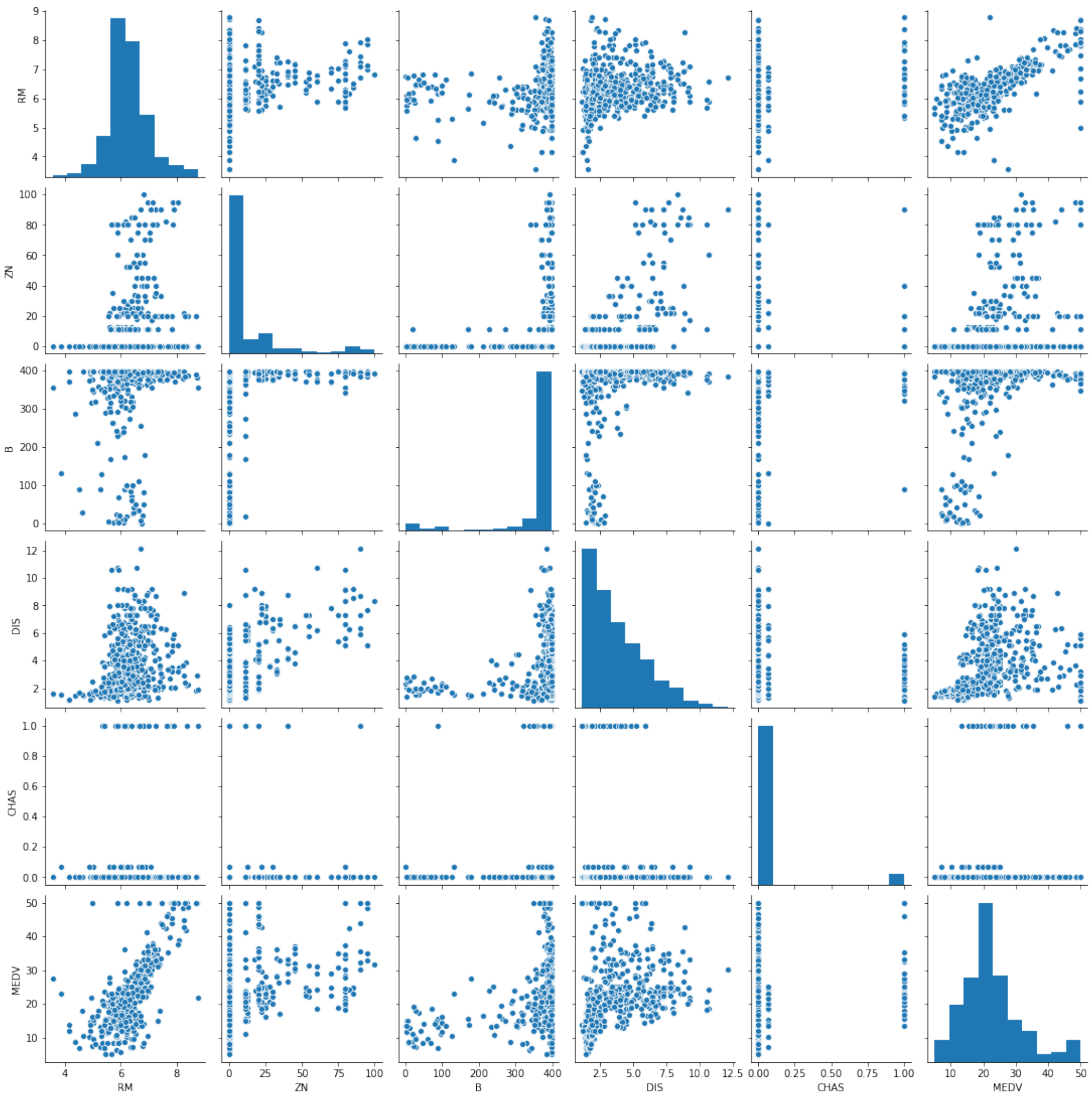
[80]:
```
sns.pairplot(housing, vars = ['LSTAT', 'PTRATIO', 'INDUS', 'TAX', 'CRIM',␣
↪'NOX', 'RAD', 'AGE', 'MEDV'])
```

[80]: <seaborn.axisgrid.PairGrid at 0x19a701f22c8>



[81]:
```
sns.pairplot(housing, vars = ['RM', 'ZN', 'B', 'DIS', 'CHAS','MEDV'])
```

[81]:
```
<seaborn.axisgrid.PairGrid at 0x19a754fd108>
```



[82]:
```
X=housing.drop("MEDV",axis=1)
y=housing["MEDV"]
```

[83]:
```
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,␣
↪random_state=2)
```

[84]:
```
from sklearn.linear_model import LinearRegression
```

3 linear regression

[85]:
```
lm = LinearRegression()
lm.fit(X_train,y_train)
```

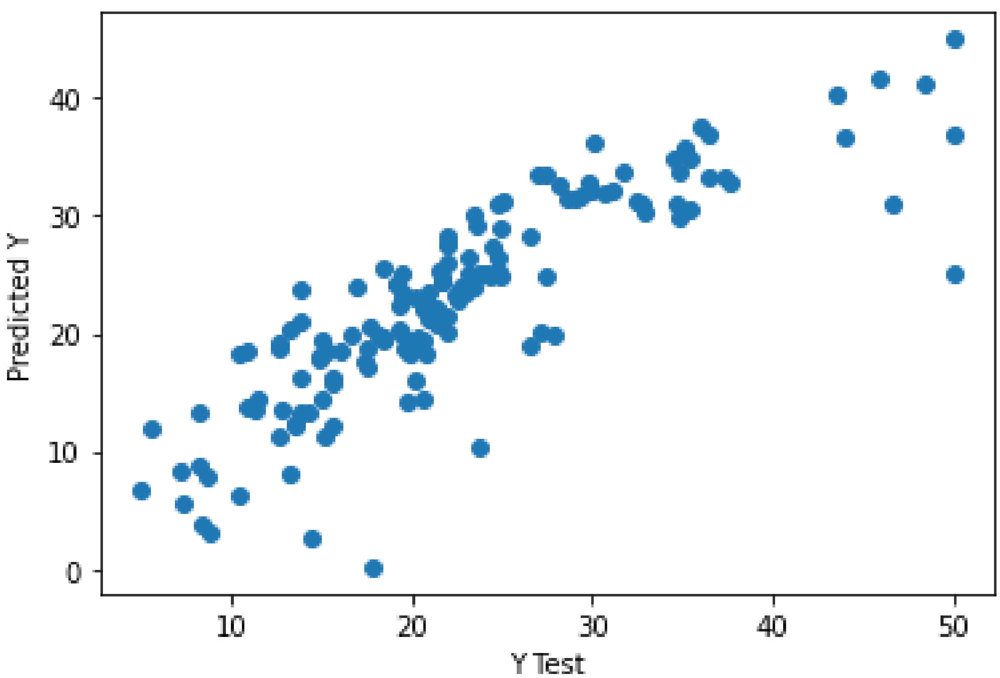
[85]:
```
LinearRegression()
```

[86]:
```
predictions = lm.predict(X_test)
```

4 linear regression results

[87]:
```
plt.scatter(y_test,predictions)
plt.xlabel('Y Test')
plt.ylabel('Predicted Y')
```

[87]:
```
Text(0, 0.5, 'Predicted Y')
```



[88]:
```
from sklearn import metrics

print('MAE:', metrics.mean_absolute_error(y_test, predictions))
print('MSE:', metrics.mean_squared_error(y_test, predictions))
print('RMSE:', np.sqrt(metrics.mean_squared_error(y_test, predictions)))
```

```
MAE: 3.519967422579463
```

```
MSE: 24.648522189830697
RMSE: 4.964727806217648
```

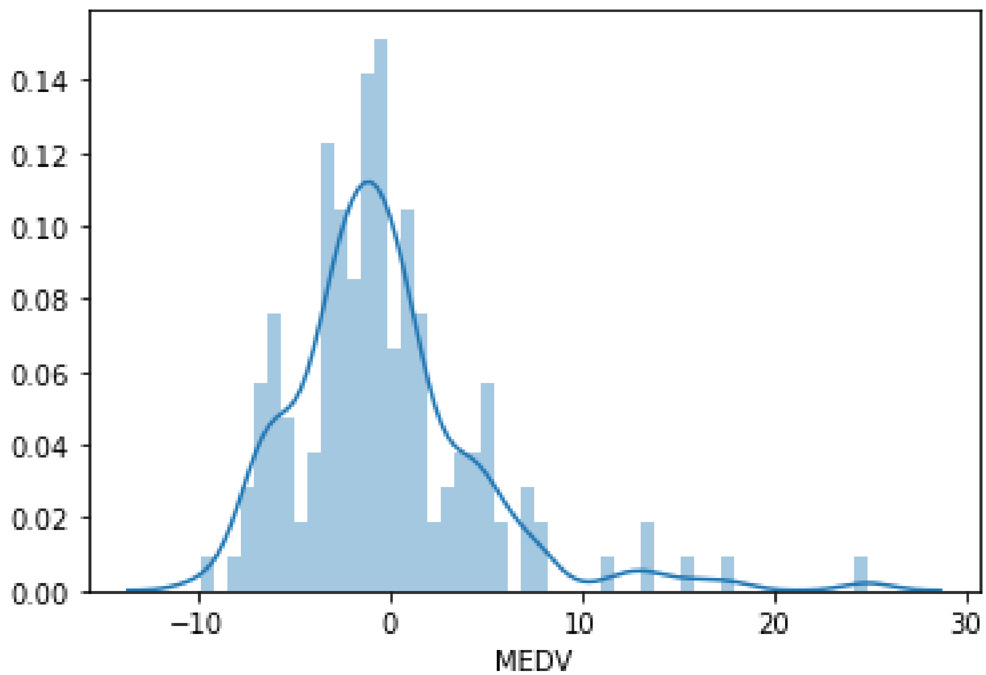
[89]:
```
print('\nIntercept : ',lm.intercept_)
```

```
Intercept :  35.66136284369268
```

[90]:
```
print('Variance score: ',lm.score(X_test, y_test))
```

```
Variance score:  0.7143713037591916
```

[91]:
```
sns.distplot((y_test-predictions),bins=50);
```



[92]:
```
accuracy = lm.score(X_train, y_train)
print("accuracy = ", accuracy * 100, "%")
accuracy = lm.score(X_test, y_test)
print("accuracy = ", accuracy * 100, "%")
```

```
accuracy =  73.16334858739746 %
accuracy =  71.43713037591915 %
```

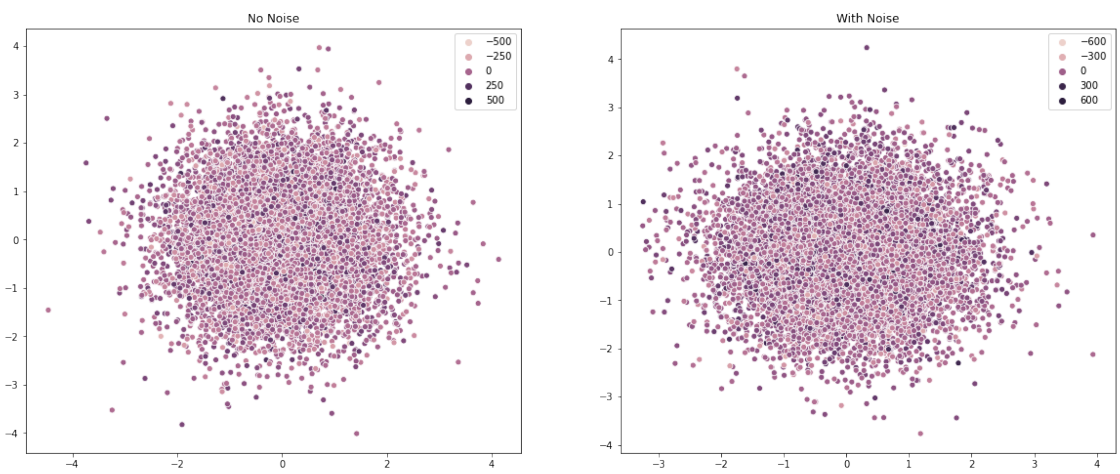
[93]:
```
coefficients = pd.DataFrame(lm.coef_,X.columns)
coefficients.columns = ['coefficients']
coefficients
```

[93]:

	coefficients
CRIM	-0.098965
ZN	0.028741
INDUS	-0.077475
CHAS	3.580316
NOX	-13.928879
RM	3.709667
AGE	0.001627
DIS	-1.362978
RAD	0.291508
TAX	-0.009511
PTRATIO	-1.041404
B	0.012463
LSTAT	-0.555141

5 Synthetic dataset

[94]:
```
from sklearn.datasets import make_regression as mr
# Generate Clean data
X,y = mr(n_samples=10000, n_features=10, n_informative=2, random_state=17)
f, (ax1,ax2) = plt.subplots(nrows=1, ncols=2,figsize=(20,8))
sns.scatterplot(X[:,0],X[:,1],hue=y,ax=ax1);
ax1.set_title("No Noise");
# Generate noisy Data
X,y = mr(n_samples=10000, n_features=10, n_informative=2, noise=20,␣
↪random_state=17)
sns.scatterplot(X[:,0],X[:,1],hue=y,ax=ax2);
ax2.set_title("With Noise");
plt.show();
```



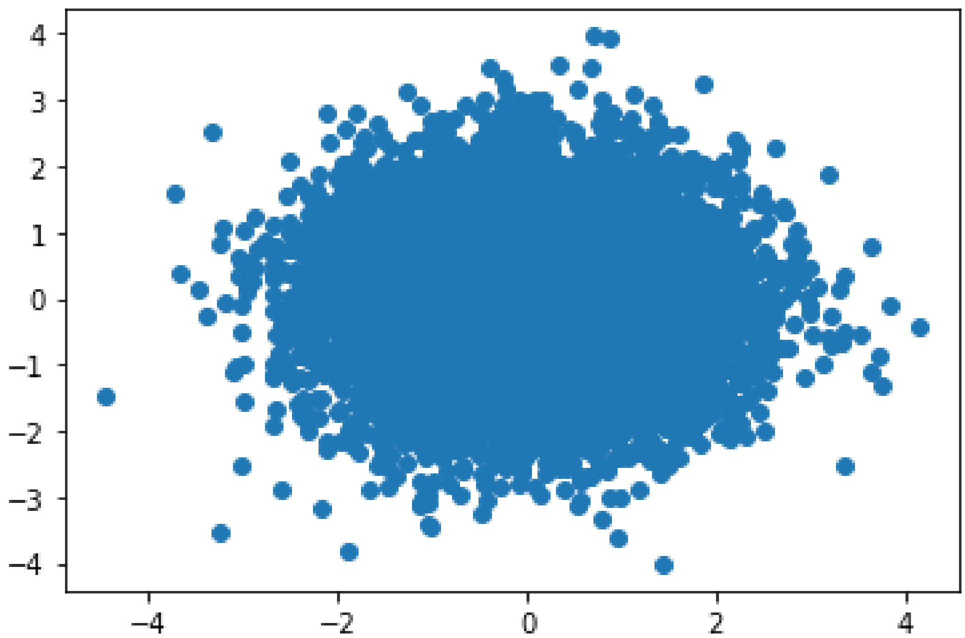
6 Noiseless data

[148]:
```
A,Z = mr(n_samples=10000, n_features=10, n_informative=2, random_state=17)
```

[96]:
```
df=pd.DataFrame(A)
df
```

[96]:
```
             0         1         2         3         4         5         6  \
0    -0.528957 -0.214593  0.074201  0.317663 -0.177406  0.683807 -1.067066
1    -0.268805  0.583482 -0.456163  0.570108 -0.179749 -2.145147  0.206286
2    -0.569527  0.409039 -1.164657  0.138132 -0.526564 -1.460420  0.275581
3    -0.248366 -1.762342 -0.140821 -1.734415  1.964524 -0.080384 -0.112557
4     0.200572 -1.053115  0.591931  0.708054 -0.765569  0.424510  0.689100
…          …        …        …        …        …        …        …
9995  0.550839  0.574948 -1.091812 -0.966188  1.443319  1.543396  1.030029
9996 -0.258148 -0.288071  0.973084 -0.015755 -0.534004 -0.239317  1.546321
9997 -0.204986  0.307516  1.395662  0.993531 -1.477036 -0.041557  1.177534
9998 -0.559787  0.182400 -0.019461  0.392112  0.111563 -0.185284 -0.944699
9999 -0.243293  0.386050  0.079252  0.963318 -0.096055  1.870573  0.215779

             7         8         9
0     0.293464 -0.615365 -0.436058
1     0.196781  1.988881 -2.212377
2    -2.278527  1.429828 -0.177089
3     2.368334 -1.733349  0.354090
4    -0.436887  0.289387  0.225677
…          …        …        …
9995  0.899440 -1.500649  0.572351
9996 -1.411464 -0.898505 -3.129165
9997  0.152798  0.871737 -0.311219
9998 -0.867091 -0.697704  0.214617
9999  0.017291  0.347659 -0.732740

[10000 rows x 10 columns]
```

[97]:
```
df=pd.DataFrame(A)
plt.scatter(df[0],df[1])
plt.show()
```



[98]:
```
from sklearn.model_selection import train_test_split
A_train, A_test, z_train, z_test = train_test_split(A,Z,test_size=0.3,␣
 ↪random_state=2)
```

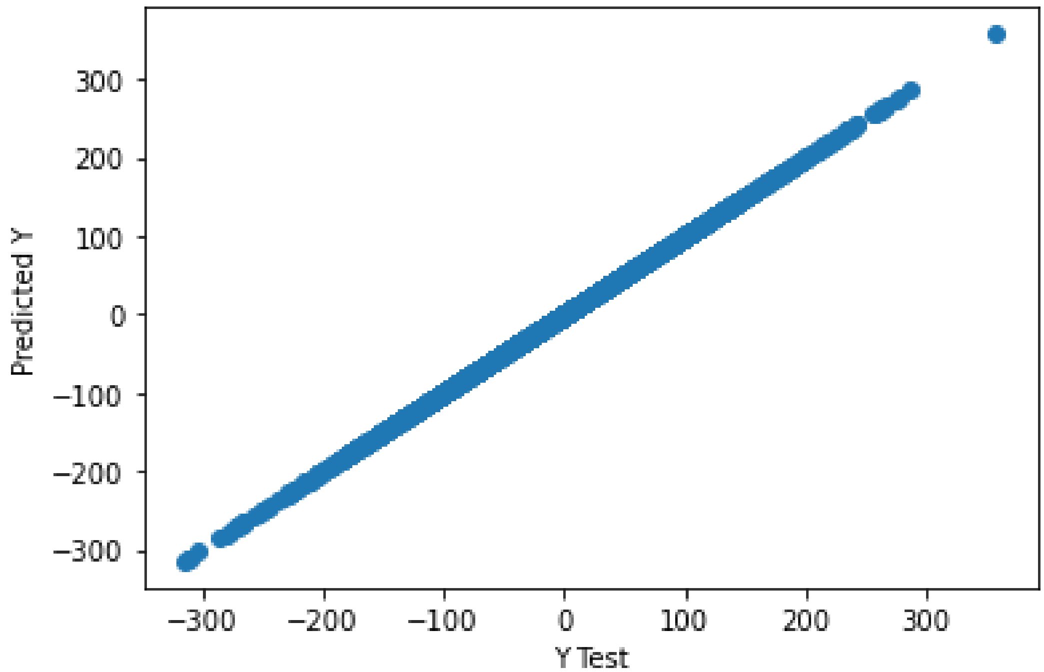
[99]:
```
lm = LinearRegression()
lm.fit(A_train,z_train)
```

[99]: LinearRegression()

[103]:
```
prediction = lm.predict(A_test)
```

[104]:
```
plt.scatter(z_test,prediction)
plt.xlabel('Y Test')
plt.ylabel('Predicted Y')
```

[104]: Text(0, 0.5, 'Predicted Y')



[105]:
```
from sklearn import metrics

print('MAE:', metrics.mean_absolute_error(z_test, prediction))
print('MSE:', metrics.mean_squared_error(z_test, prediction))
print('RMSE:', np.sqrt(metrics.mean_squared_error(z_test, prediction)))
```

```
MAE: 3.466236325744276e-14
MSE: 1.9194207552613397e-27
RMSE: 4.381119440578332e-14
```

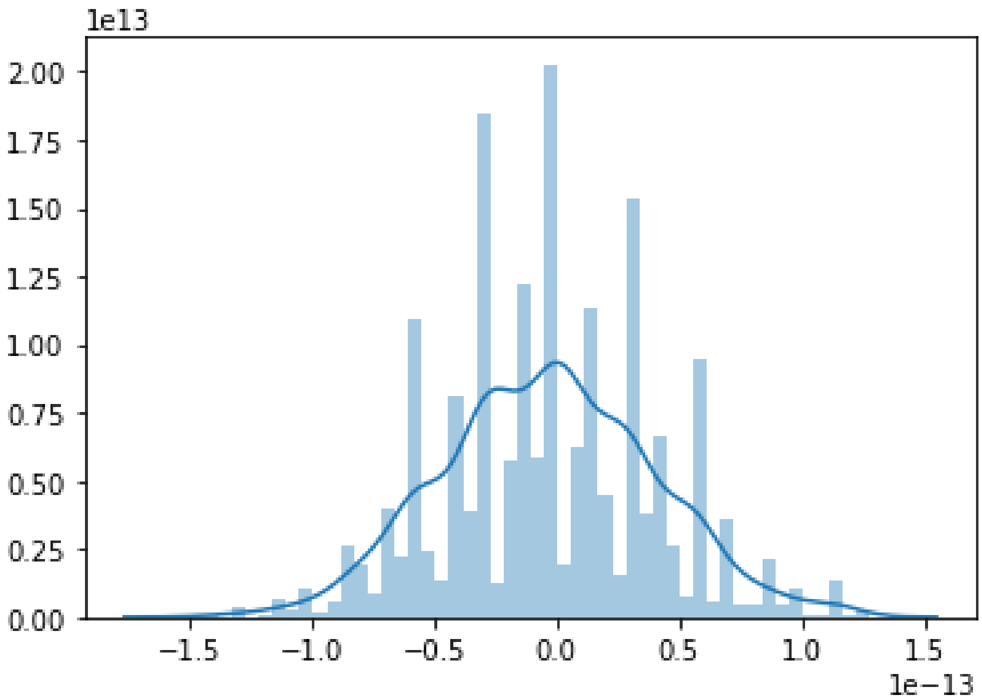
[106]:
```
print('\nIntercept : ',lm.intercept_)
```

```

Intercept :  4.218847493575595e-15
```

[107]:
```
print('Variance score: ',lm.score(A_test, z_test))
```

```
Variance score:  1.0
```

[108]:
```
sns.distplot((z_test-prediction),bins=50);
```



[109]:
```
accuracy = lm.score(A_train, z_train)
print("accuracy = ", accuracy * 100, "%")
accuracy = lm.score(A_test, z_test)
print("accuracy = ", accuracy * 100, "%")
```

```
accuracy =  100.0 %
accuracy =  100.0 %
```

7 Noisy data

[136]:
```
B,w = mr(n_samples=10000, n_features=10, n_informative=2, noise=20,␣
 ↪random_state=17)
```

[137]:
```
df=pd.DataFrame(B)
df
```

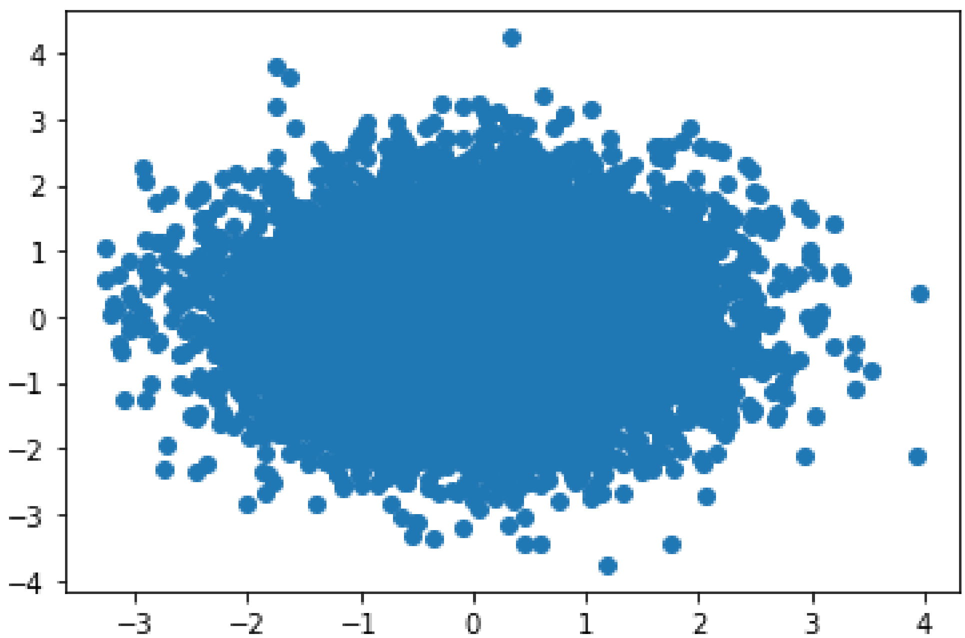
[137]:

	0	1	2	3	4	5	6	\
0	-1.027619	-1.286558	-1.101747	-0.262808	0.304828	0.149726	-1.739105	
1	1.090157	1.386052	1.475800	0.214197	-0.625391	2.218678	0.641034	
2	-0.501386	-1.071103	0.710173	-1.273405	1.375302	-0.177287	1.094835	
3	-0.903947	0.877845	-0.319021	-0.823712	-0.517133	-0.814930	-0.025050	
4	-1.693394	-1.037866	0.622906	2.972829	0.395215	0.367769	-0.488113	
…	…	…	…	…	…	…	…	

```
9995 -0.787534 -1.125008 -0.153964 -0.236301 -0.384459 -0.375466 -0.323895
9996  1.430434  1.231598  0.878692 -0.228201  0.337200  0.864389 -0.722447
9997 -1.002945 -0.645842 -0.966706 -0.944122  0.531353  1.759356 -1.944453
9998 -1.315852 -0.013712 -1.973863 -0.265874 -0.873708 -0.330170 -0.329684
9999  0.643972  0.848857 -1.105132 -0.155327  0.305212  1.017475 -0.658836

             7         8         9
0     0.835792 -0.638274  2.068825
1    -0.339901  0.718192 -0.762642
2     0.150014  0.005352  0.320013
3    -3.061606  0.465944 -0.741907
4     1.632435 -0.903692 -0.289823
…          …         …         …
9995 -0.399361 -1.571562  0.783742
9996  0.583020 -0.336605 -1.204862
9997  1.770926  0.048891 -0.836193
9998  0.334905 -0.454224  0.809742
9999  0.337280  2.766441  0.613684

[10000 rows x 10 columns]
```

[138]:

```
df=pd.DataFrame(B)
plt.scatter(df[0],df[1])
plt.show()
```



[139]:
```
from sklearn.model_selection import train_test_split
B_train, B_test, w_train, w_test = train_test_split(B,w,test_size=0.3,␣
↪random_state=2)
```

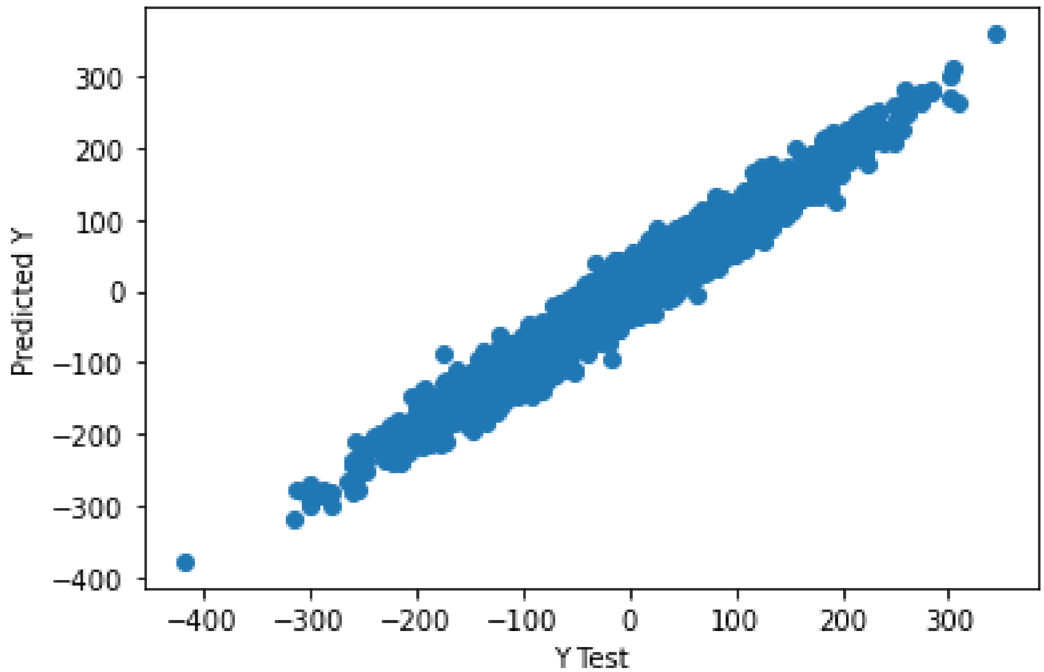
[140]:
```
lm = LinearRegression()
lm.fit(B_train,w_train)
```

[140]:
```
LinearRegression()
```

[141]:
```
pred = lm.predict(B_test)
```

[142]:
```
plt.scatter(w_test,pred)
plt.xlabel('Y Test')
plt.ylabel('Predicted Y')
```

[142]:
```
Text(0, 0.5, 'Predicted Y')
```



[143]:
```
from sklearn import metrics

print('MAE:', metrics.mean_absolute_error(w_test, pred))
print('MSE:', metrics.mean_squared_error(w_test, pred))
print('RMSE:', np.sqrt(metrics.mean_squared_error(w_test, pred)))
```

```
MAE: 16.232067668336278
MSE: 410.0234403997351
```

RMSE: 20.24903554245819

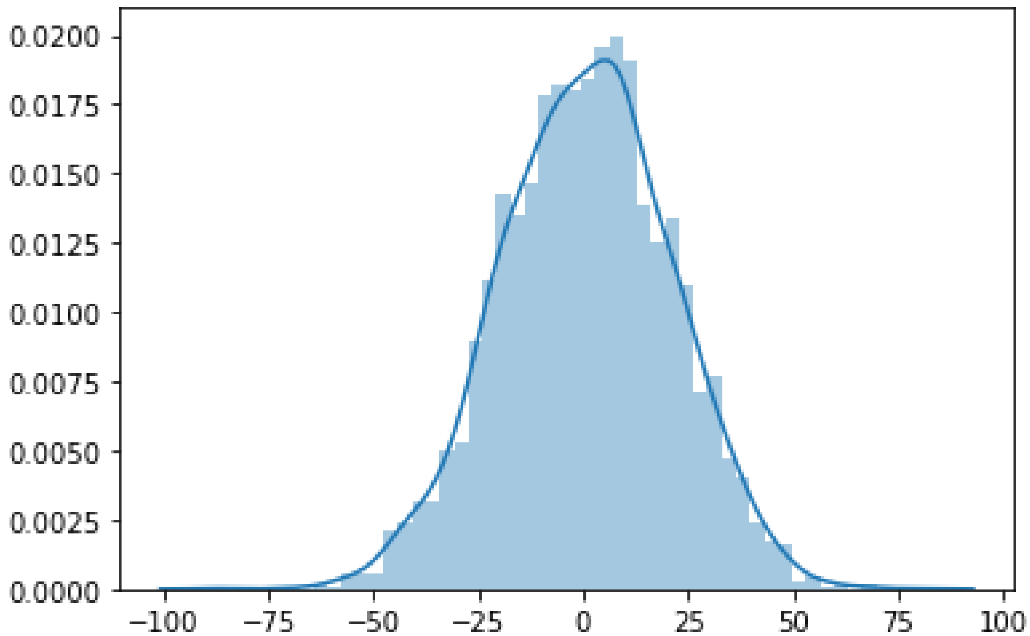
[144]:
```
print('\nIntercept : ',lm.intercept_)
```

Intercept : -0.2811263071730249

[145]:
```
print('Variance score: ',lm.score(B_test, w_test))
```

Variance score: 0.9583422182425166

[146]:
```
sns.distplot((w_test-pred),bins=50);
```



[147]:
```
accuracy = lm.score(B_train, w_train)
print("accuracy = ", accuracy * 100, "%")
accuracy = lm.score(B_test, w_test)
print("accuracy = ", accuracy * 100, "%")
```

accuracy = 95.91527548194786 %
accuracy = 95.83422182425167 %

[ ]: