EDA_HW_boston_CMPE188

February 4, 2025

[55]:
```
import pandas as pd
import matplotlib.pyplot as plt
from pandas import set_option
from pandas import read_csv
from sklearn.preprocessing import StandardScaler
from sklearn.preprocessing import Normalizer
from numpy import set_printoptions
import seaborn as sns
from pandas.plotting import scatter_matrix
```

1. In this assignment you will perform exploratory data analysis on the Boston dataset.
2. The dataset has been provided on Canvas.
3. Load the dataset into a Pandas dataframe.
4. Clean the data (if needed).

[56]:
```
filename = 'boston.csv'
data = read_csv(filename)
set_printoptions(precision=3)
data = data.drop('index', axis=1)
data.head(5)
```

[56]:

	crim	zn	indus	chas	nox	rm	age	dis	rad	tax	ptratio	black	lstat	medv
0	6.3e-03	18.0	2.3	0	0.5	6.6	65.2	4.1	1	296	15.3	396.9	5.0	24.0
1	2.7e-02	0.0	7.1	0	0.5	6.4	78.9	5.0	2	242	17.8	396.9	9.1	21.6
2	2.7e-02	0.0	7.1	0	0.5	7.2	61.1	5.0	2	242	17.8	392.8	4.0	34.7
3	3.2e-02	0.0	2.2	0	0.5	7.0	45.8	6.1	3	222	18.7	394.6	2.9	33.4
4	6.9e-02	0.0	2.2	0	0.5	7.1	54.2	6.1	3	222	18.7	396.9	5.3	36.2

[57]:
```
# Check for missing values
print(data.isnull().sum())
```

```
crim       0
zn         0
```

```
indus      0
chas       0
nox        0
rm         0
age        0
dis        0
rad        0
tax        0
ptratio    0
black      0
lstat      0
medv       0
dtype: int64
```

Nothing to clean

5. The output in this data set is Medv (median price). The rest of the columns are considered input. Separate the data into an input and output dataframes/Series. You can ignore/eliminate categorical data.

[58]:
```
# Split into input/output datasets (medv is output)
array = data.values
Y1 = data['medv']
X1 = data.drop('medv', axis=1)
X1names = X1.columns
```

6. Perform normalization and standardization on the data. We normally normalize and standardize the input frame and keep the output intact.
7. Put the new normalized input data frame and the output into a new data frame called data_norm. Do the same for standardized data. Call the new data frame for standardized data as data_stand.

[59]:
```
data_norm = X1.copy()
# Normalize
norm_scaler = Normalizer().fit(data_norm)
data_norm = norm_scaler.transform(data_norm)
# add output to normalized data
data_norm = pd.DataFrame(data_norm, columns=X1names)
data_norm['medv'] = Y1

data_stand = X1.copy()
# Standardize
stand_scaler = StandardScaler().fit(data_stand)
data_stand = stand_scaler.transform(data_stand)
# add output to standardized data
data_stand = pd.DataFrame(data_stand, columns=X1names)
data_stand['medv'] = Y1
data_objects = ((data_norm, 'data_norm'), (data_stand, 'data_stand'), (data,␣
 ↪"data_raw"))
```

8. Perform basic EDA, i.e. descriptive stats, plot the histograms and match/verify with descriptive stats.

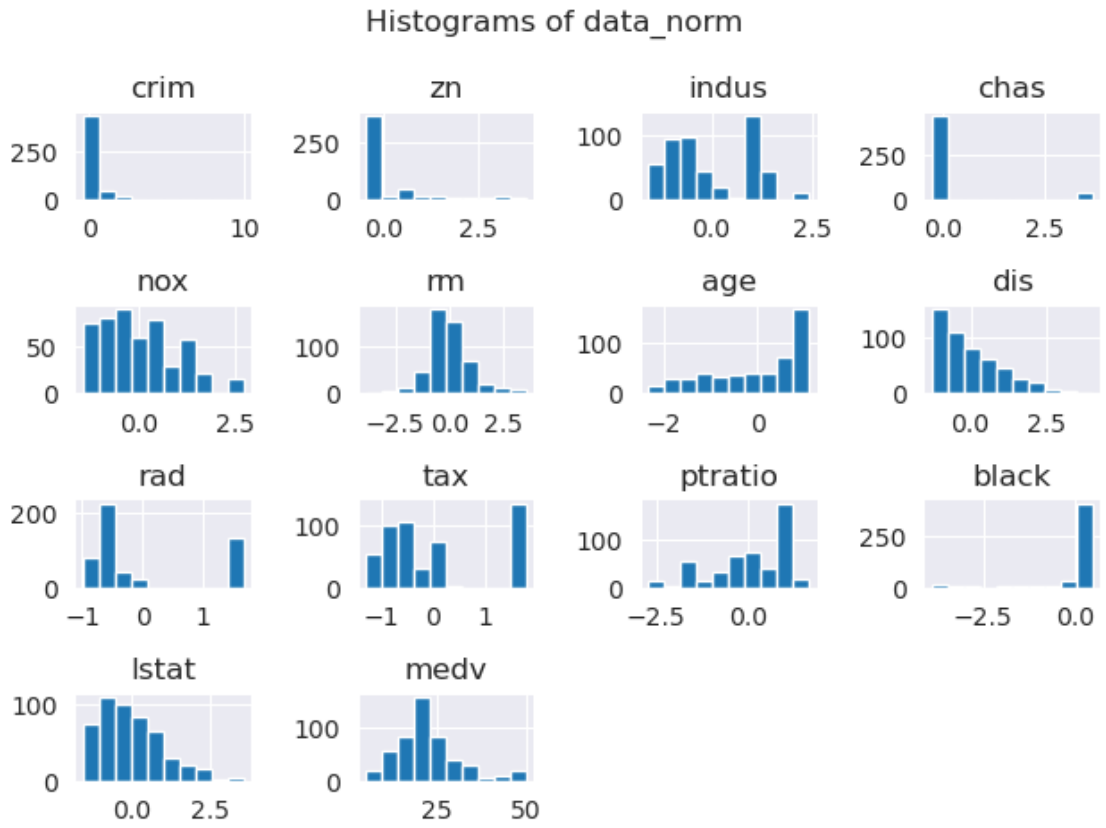
[60]:
```
# Descriptive stats
set_option('display.width', 100)
set_option('display.precision', 1)
for data, name in data_objects:
    print(f"Data: {name}")
    print(data.describe())
```

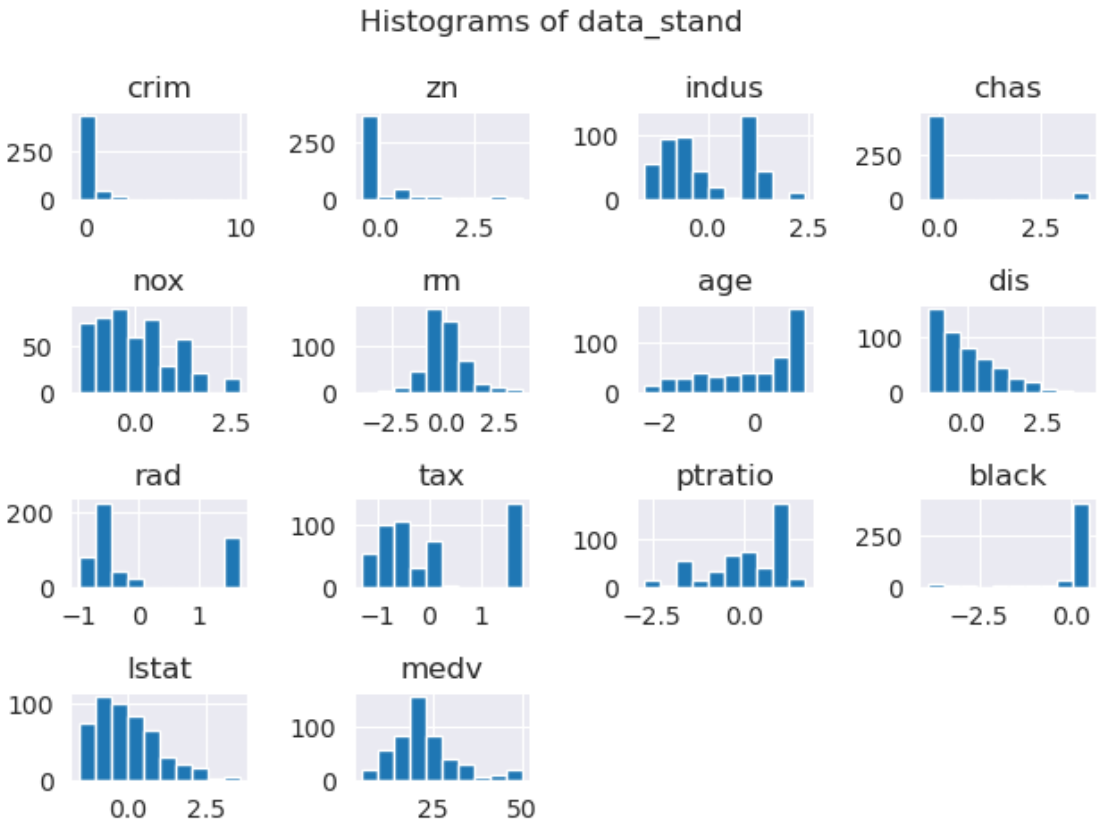
```
Data: data_norm
          crim       zn    indus     chas      nox       rm      age      dis
rad    tax  \
count  5.1e+02  5.1e+02  5.1e+02  5.1e+02  5.1e+02  5.1e+02  5.1e+02  5.1e+02
5.1e+02  506.0
mean   5.1e-03  2.3e-02  1.9e-02  1.3e-04  9.9e-04  1.2e-02  1.2e-01  7.3e-03
1.5e-02    0.7
std    1.2e-02  4.7e-02  1.1e-02  4.8e-04  1.9e-04  2.7e-03  4.8e-02  4.6e-03
1.1e-02    0.2
min    1.3e-05  0.0e+00  9.6e-04  0.0e+00  6.6e-04  4.7e-03  6.4e-03  1.5e-03
1.7e-03    0.4
25%    1.6e-04  0.0e+00  1.1e-02  0.0e+00  8.7e-04  9.4e-03  8.6e-02  3.3e-03
7.9e-03    0.6
50%    5.0e-04  0.0e+00  1.7e-02  0.0e+00  9.7e-04  1.2e-02  1.3e-01  6.4e-03
1.0e-02    0.7
75%    5.2e-03  2.5e-02  2.4e-02  0.0e+00  1.1e-03  1.3e-02  1.6e-01  1.1e-02
3.1e-02    0.9
max    1.1e-01  2.1e-01  6.1e-02  2.4e-03  2.1e-03  1.8e-02  2.4e-01  2.8e-02
3.6e-02    1.0

       ptratio    black    lstat   medv
count  5.1e+02  5.1e+02  5.1e+02  506.0
mean   3.3e-02  6.6e-01  2.2e-02   22.5
std    6.0e-03  2.1e-01  1.1e-02    9.2
min    2.4e-02  4.8e-04  3.1e-03    5.0
25%    2.7e-02  5.1e-01  1.4e-02   17.0
50%    3.3e-02  7.4e-01  2.0e-02   21.2
75%    3.8e-02  8.1e-01  2.8e-02   25.0
max    5.3e-02  8.9e-01  7.0e-02   50.0
Data: data_stand
          crim       zn    indus     chas      nox       rm      age      dis
rad    tax  \
count  5.1e+02  5.1e+02  5.1e+02  5.1e+02  5.1e+02  5.1e+02  5.1e+02  5.1e+02
5.1e+02  506.0
mean  -1.1e-16  7.9e-17  2.1e-16 -3.5e-17 -2.0e-16 -1.1e-16 -1.5e-16 -8.4e-17
-1.1e-16    0.0
std    1.0e+00  1.0e+00  1.0e+00  1.0e+00  1.0e+00  1.0e+00  1.0e+00  1.0e+00
1.0e+00    1.0
```

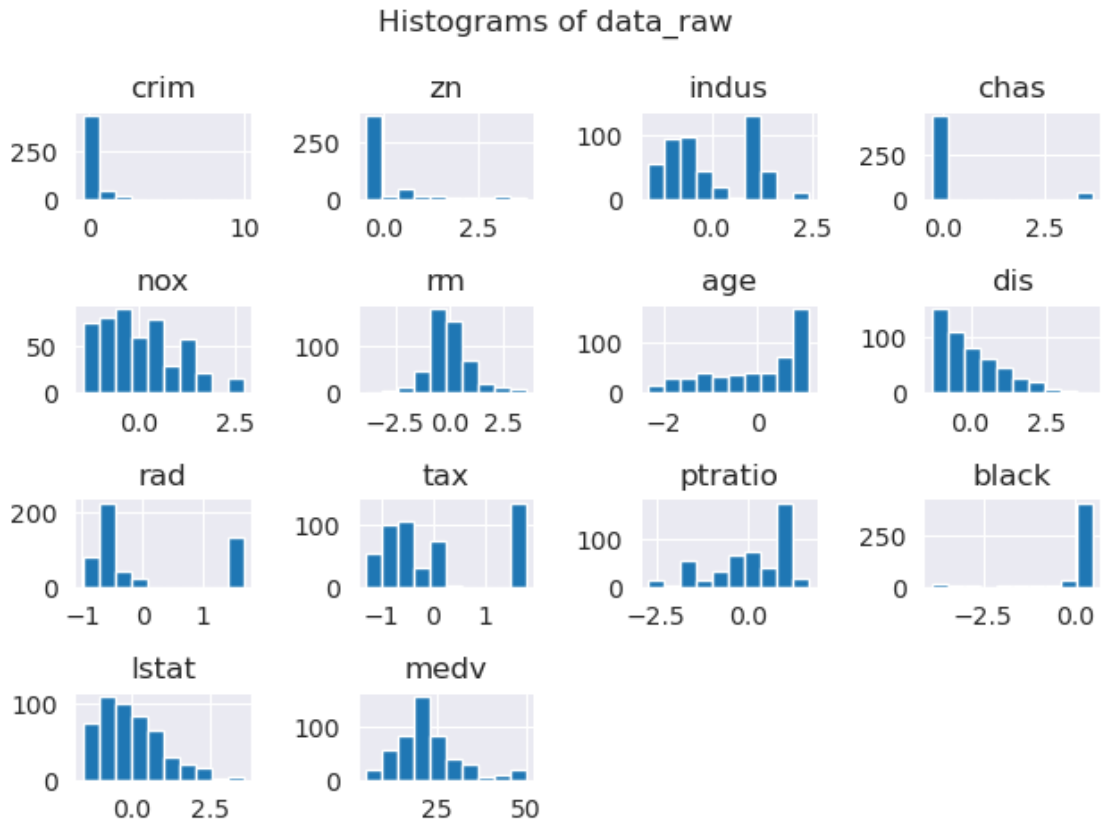
```
min   -4.2e-01 -4.9e-01 -1.6e+00 -2.7e-01 -1.5e+00 -3.9e+00 -2.3e+00 -1.3e+00
-9.8e-01   -1.3
25%   -4.1e-01 -4.9e-01 -8.7e-01 -2.7e-01 -9.1e-01 -5.7e-01 -8.4e-01 -8.1e-01
-6.4e-01   -0.8
50%   -3.9e-01 -4.9e-01 -2.1e-01 -2.7e-01 -1.4e-01 -1.1e-01  3.2e-01 -2.8e-01
-5.2e-01   -0.5
75%    7.4e-03  4.9e-02  1.0e+00 -2.7e-01  6.0e-01  4.8e-01  9.1e-01  6.6e-01
1.7e+00    1.5
max    9.9e+00  3.8e+00  2.4e+00  3.7e+00  2.7e+00  3.6e+00  1.1e+00  4.0e+00
1.7e+00    1.8

       ptratio    black    lstat   medv
count  5.1e+02  5.1e+02  5.1e+02  506.0
mean  -4.2e-16 -7.4e-16 -3.1e-16   22.5
std    1.0e+00  1.0e+00  1.0e+00    9.2
min   -2.7e+00 -3.9e+00 -1.5e+00    5.0
25%   -4.9e-01  2.1e-01 -8.0e-01   17.0
50%    2.7e-01  3.8e-01 -1.8e-01   21.2
75%    8.1e-01  4.3e-01  6.0e-01   25.0
max    1.6e+00  4.4e-01  3.5e+00   50.0
Data: data_raw
          crim     zn  indus     chas    nox     rm    age    dis    rad    tax
ptratio  black  \
count  5.1e+02  506.0  506.0  5.1e+02  506.0  506.0  506.0  506.0  506.0  506.0
506.0  506.0
mean   3.6e+00   11.4   11.1  6.9e-02    0.6    6.3   68.6    3.8    9.5  408.2
18.5  356.7
std    8.6e+00   23.3    6.9  2.5e-01    0.1    0.7   28.1    2.1    8.7  168.5
2.2   91.3
min    6.3e-03    0.0    0.5  0.0e+00    0.4    3.6    2.9    1.1    1.0  187.0
12.6    0.3
25%    8.2e-02    0.0    5.2  0.0e+00    0.4    5.9   45.0    2.1    4.0  279.0
17.4  375.4
50%    2.6e-01    0.0    9.7  0.0e+00    0.5    6.2   77.5    3.2    5.0  330.0
19.1  391.4
75%    3.7e+00   12.5   18.1  0.0e+00    0.6    6.6   94.1    5.2   24.0  666.0
20.2  396.2
max    8.9e+01  100.0   27.7  1.0e+00    0.9    8.8  100.0   12.1   24.0  711.0
22.0  396.9

       lstat   medv
count  506.0  506.0
mean    12.7   22.5
std      7.1    9.2
min      1.7    5.0
25%      6.9   17.0
50%     11.4   21.2
75%     17.0   25.0
```

```
max      38.0    50.0
```

[61]:
```
# Histograms
for data, name in data_objects:
    data_stand.hist()
    plt.suptitle(f"Histograms of {name}")
    plt.tight_layout()
    plt.show()
```




Histograms of data_stand
crim
zn
indus
chas
nox
rm
age
dis
rad
tax
ptratio
black
lstat
medv

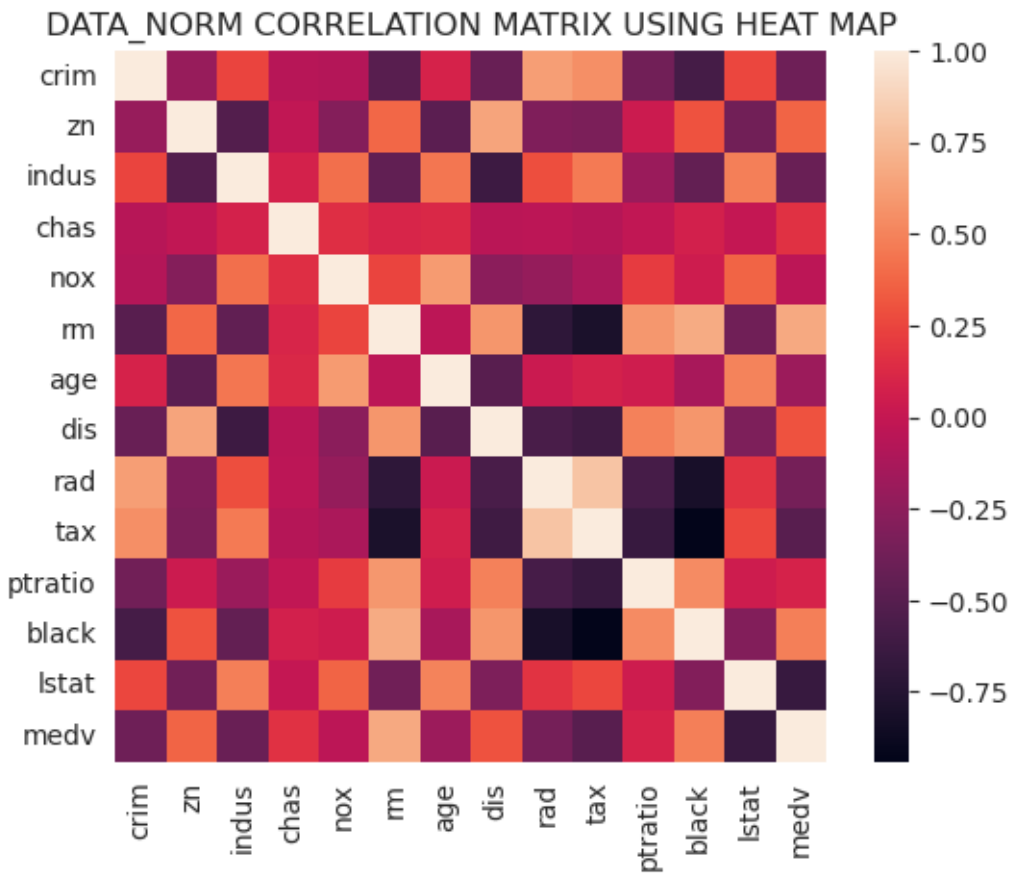


9. Continue with correlation analysis (calculate correlation and plot correlation heatmap) and scatter plots.

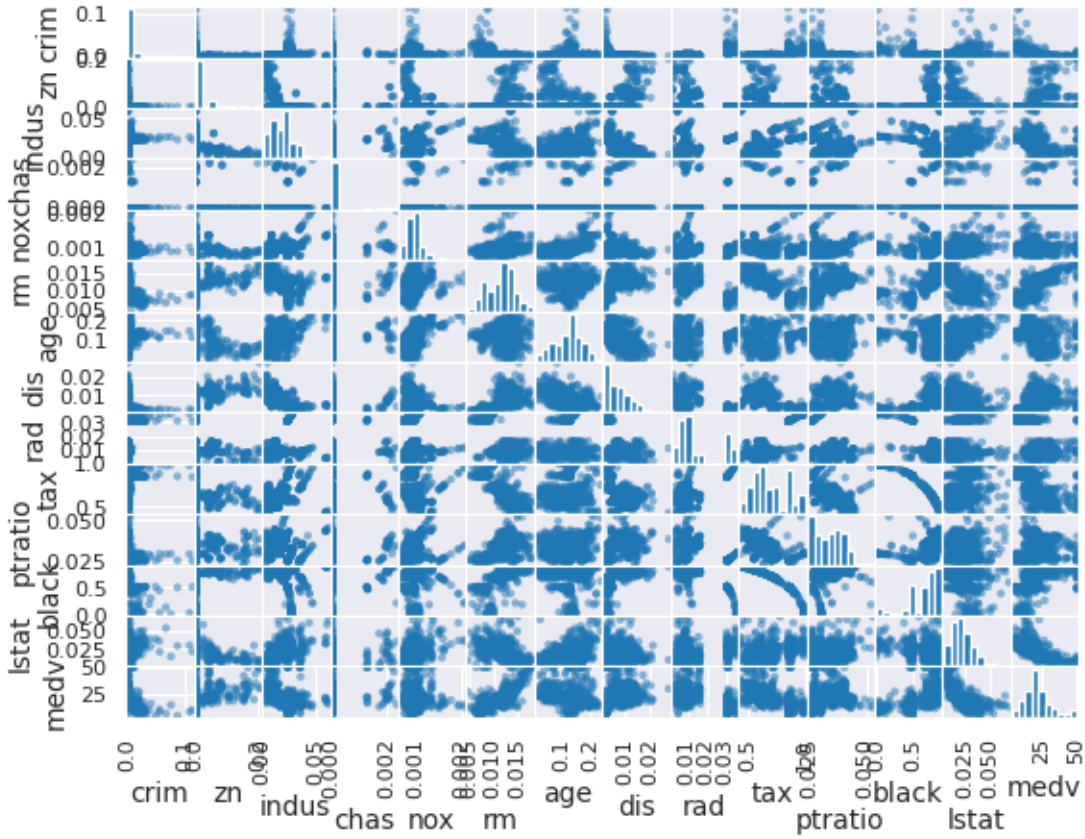
[62]:
```
for data, name in data_objects:
    plt.figure() # new plot
    corMat = data_norm.corr(method='pearson')
    print(corMat)
    ## plot correlation matrix as a heat map
    sns.heatmap(corMat, square=True)
    plt.yticks(rotation=0)
    plt.xticks(rotation=90)
    plt.title(f"{name.upper()} CORRELATION MATRIX USING HEAT MAP")
    plt.show()

    ## scatter plot of all data
    plt.figure()
    scatter_matrix(data_norm)
    plt.show()
```

```
            crim       zn     indus      chas       nox        rm       age       dis
rad       tax  \
```

```
crim     1.0e+00 -2.1e-01  2.5e-01 -6.3e-02 -8.2e-02 -4.9e-01  8.7e-02 -4.2e-01
6.1e-01  5.5e-01
zn      -2.1e-01  1.0e+00 -5.2e-01 -1.9e-02 -3.0e-01  3.9e-01 -4.8e-01  6.4e-01
-3.1e-01 -3.3e-01
indus    2.5e-01 -5.2e-01  1.0e+00  8.2e-02  4.1e-01 -4.5e-01  4.5e-01 -6.3e-01
2.8e-01  4.6e-01
chas    -6.3e-02 -1.9e-02  8.2e-02  1.0e+00  1.5e-01  1.0e-01  1.2e-01 -5.2e-02
-4.0e-02 -7.5e-02
nox     -8.2e-02 -3.0e-01  4.1e-01  1.5e-01  1.0e+00  2.5e-01  6.0e-01 -2.6e-01
-2.1e-01 -1.2e-01
rm      -4.9e-01  3.9e-01 -4.5e-01  1.0e-01  2.5e-01  1.0e+00 -3.9e-02  5.8e-01
-7.0e-01 -8.0e-01
age      8.7e-02 -4.8e-01  4.5e-01  1.2e-01  6.0e-01 -3.9e-02  1.0e+00 -4.9e-01
2.5e-02  7.9e-02
dis     -4.2e-01  6.4e-01 -6.3e-01 -5.2e-02 -2.6e-01  5.8e-01 -4.9e-01  1.0e+00
-5.6e-01 -6.2e-01
rad      6.1e-01 -3.1e-01  2.8e-01 -4.0e-02 -2.1e-01 -7.0e-01  2.5e-02 -5.6e-01
1.0e+00  8.0e-01
tax      5.5e-01 -3.3e-01  4.6e-01 -7.5e-02 -1.2e-01 -8.0e-01  7.9e-02 -6.2e-01
8.0e-01  1.0e+00
ptratio -3.8e-01  3.3e-02 -2.0e-01 -1.6e-02  2.1e-01  5.9e-01  4.8e-02  4.9e-01
-5.8e-01 -6.5e-01
black   -5.9e-01  3.0e-01 -4.5e-01  7.0e-02  4.2e-02  6.8e-01 -1.3e-01  5.8e-01
-8.1e-01 -9.4e-01
lstat    2.5e-01 -3.7e-01  4.8e-01 -2.4e-03  3.7e-01 -3.8e-01  5.0e-01 -3.3e-01
1.7e-01  2.6e-01
medv    -3.9e-01  3.7e-01 -4.1e-01  1.7e-01 -4.5e-02  6.7e-01 -1.9e-01  3.0e-01
-3.6e-01 -5.0e-01

         ptratio    black    lstat     medv
crim    -3.8e-01 -5.9e-01  2.5e-01 -3.9e-01
zn       3.3e-02  3.0e-01 -3.7e-01  3.7e-01
indus   -2.0e-01 -4.5e-01  4.8e-01 -4.1e-01
chas    -1.6e-02  7.0e-02 -2.4e-03  1.7e-01
nox      2.1e-01  4.2e-02  3.7e-01 -4.5e-02
rm       5.9e-01  6.8e-01 -3.8e-01  6.7e-01
age      4.8e-02 -1.3e-01  5.0e-01 -1.9e-01
dis      4.9e-01  5.8e-01 -3.3e-01  3.0e-01
rad     -5.8e-01 -8.1e-01  1.7e-01 -3.6e-01
tax     -6.5e-01 -9.4e-01  2.6e-01 -5.0e-01
ptratio  1.0e+00  5.4e-01  4.3e-02  8.6e-02
black    5.4e-01  1.0e+00 -3.0e-01  4.8e-01
lstat    4.3e-02 -3.0e-01  1.0e+00 -6.5e-01
medv     8.6e-02  4.8e-01 -6.5e-01  1.0e+00
```

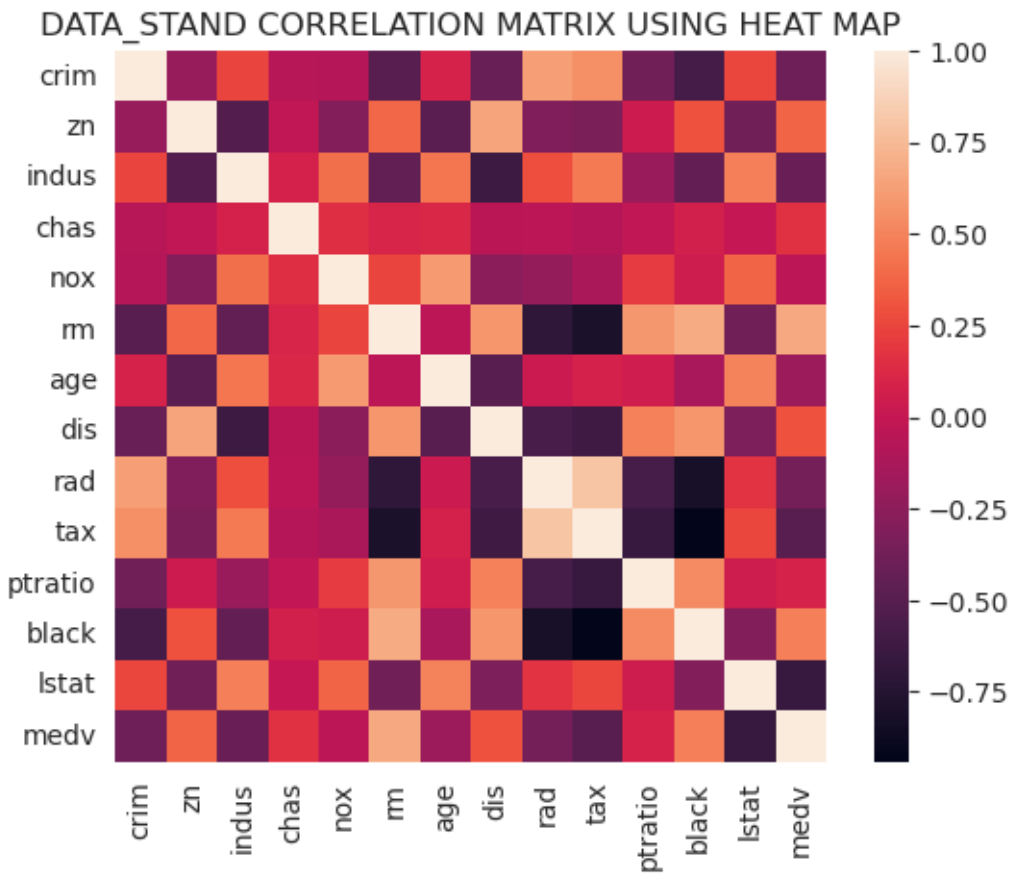


<Figure size 640x480 with 0 Axes>

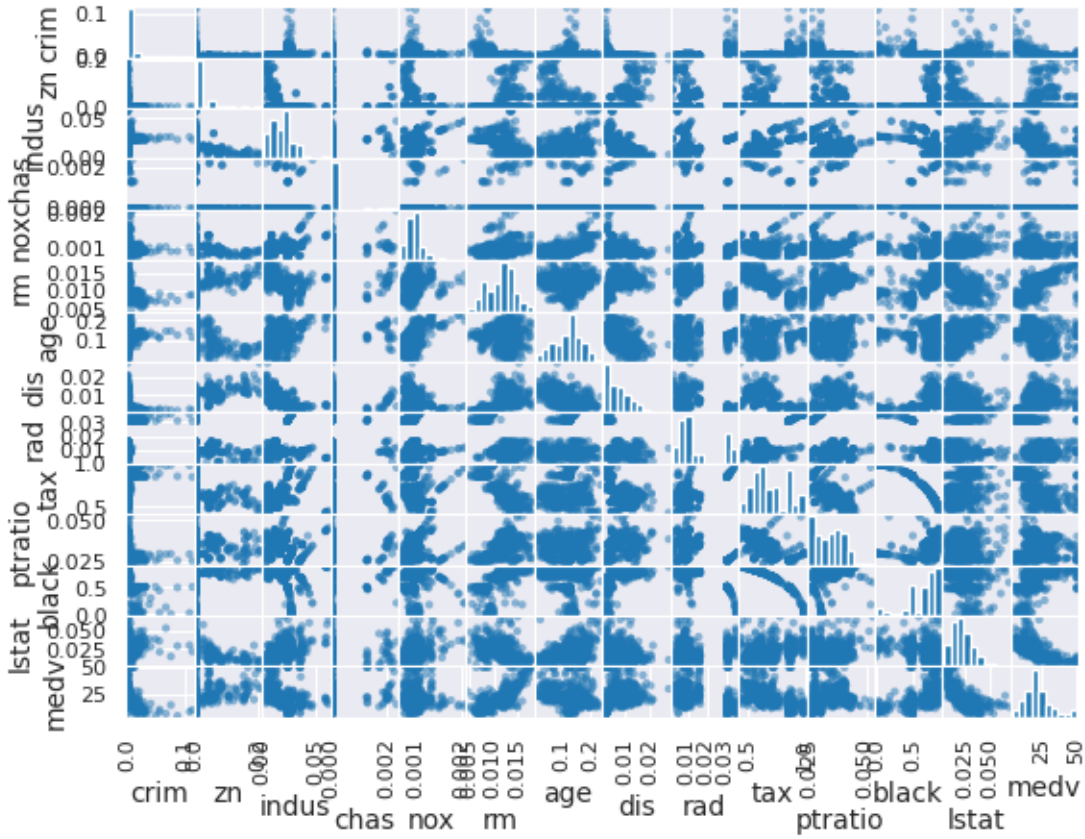


	crim	zn	indus	chas	nox	rm	age	dis	rad	tax
crim	1.0e+00	-2.1e-01	2.5e-01	-6.3e-02	-8.2e-02	-4.9e-01	8.7e-02	-4.2e-01	6.1e-01	5.5e-01
zn	-2.1e-01	1.0e+00	-5.2e-01	-1.9e-02	-3.0e-01	3.9e-01	-4.8e-01	6.4e-01	-3.1e-01	-3.3e-01
indus	2.5e-01	-5.2e-01	1.0e+00	8.2e-02	4.1e-01	-4.5e-01	4.5e-01	-6.3e-01	2.8e-01	4.6e-01
chas	-6.3e-02	-1.9e-02	8.2e-02	1.0e+00	1.5e-01	1.0e-01	1.2e-01	-5.2e-02	-4.0e-02	-7.5e-02
nox	-8.2e-02	-3.0e-01	4.1e-01	1.5e-01	1.0e+00	2.5e-01	6.0e-01	-2.6e-01	-2.1e-01	-1.2e-01
rm	-4.9e-01	3.9e-01	-4.5e-01	1.0e-01	2.5e-01	1.0e+00	-3.9e-02	5.8e-01	-7.0e-01	-8.0e-01
age	8.7e-02	-4.8e-01	4.5e-01	1.2e-01	6.0e-01	-3.9e-02	1.0e+00	-4.9e-01	2.5e-02	7.9e-02
dis	-4.2e-01	6.4e-01	-6.3e-01	-5.2e-02	-2.6e-01	5.8e-01	-4.9e-01	1.0e+00	-5.6e-01	-6.2e-01
rad	6.1e-01	-3.1e-01	2.8e-01	-4.0e-02	-2.1e-01	-7.0e-01	2.5e-02	-5.6e-01	1.0e+00	8.0e-01

```
tax      5.5e-01 -3.3e-01  4.6e-01 -7.5e-02 -1.2e-01 -8.0e-01  7.9e-02 -6.2e-01
8.0e-01  1.0e+00
ptratio -3.8e-01  3.3e-02 -2.0e-01 -1.6e-02  2.1e-01  5.9e-01  4.8e-02  4.9e-01
-5.8e-01 -6.5e-01
black   -5.9e-01  3.0e-01 -4.5e-01  7.0e-02  4.2e-02  6.8e-01 -1.3e-01  5.8e-01
-8.1e-01 -9.4e-01
lstat    2.5e-01 -3.7e-01  4.8e-01 -2.4e-03  3.7e-01 -3.8e-01  5.0e-01 -3.3e-01
1.7e-01  2.6e-01
medv    -3.9e-01  3.7e-01 -4.1e-01  1.7e-01 -4.5e-02  6.7e-01 -1.9e-01  3.0e-01
-3.6e-01 -5.0e-01

         ptratio    black    lstat     medv
crim    -3.8e-01 -5.9e-01  2.5e-01 -3.9e-01
zn       3.3e-02  3.0e-01 -3.7e-01  3.7e-01
indus   -2.0e-01 -4.5e-01  4.8e-01 -4.1e-01
chas    -1.6e-02  7.0e-02 -2.4e-03  1.7e-01
nox      2.1e-01  4.2e-02  3.7e-01 -4.5e-02
rm       5.9e-01  6.8e-01 -3.8e-01  6.7e-01
age      4.8e-02 -1.3e-01  5.0e-01 -1.9e-01
dis      4.9e-01  5.8e-01 -3.3e-01  3.0e-01
rad     -5.8e-01 -8.1e-01  1.7e-01 -3.6e-01
tax     -6.5e-01 -9.4e-01  2.6e-01 -5.0e-01
ptratio  1.0e+00  5.4e-01  4.3e-02  8.6e-02
black    5.4e-01  1.0e+00 -3.0e-01  4.8e-01
lstat    4.3e-02 -3.0e-01  1.0e+00 -6.5e-01
medv     8.6e-02  4.8e-01 -6.5e-01  1.0e+00
```

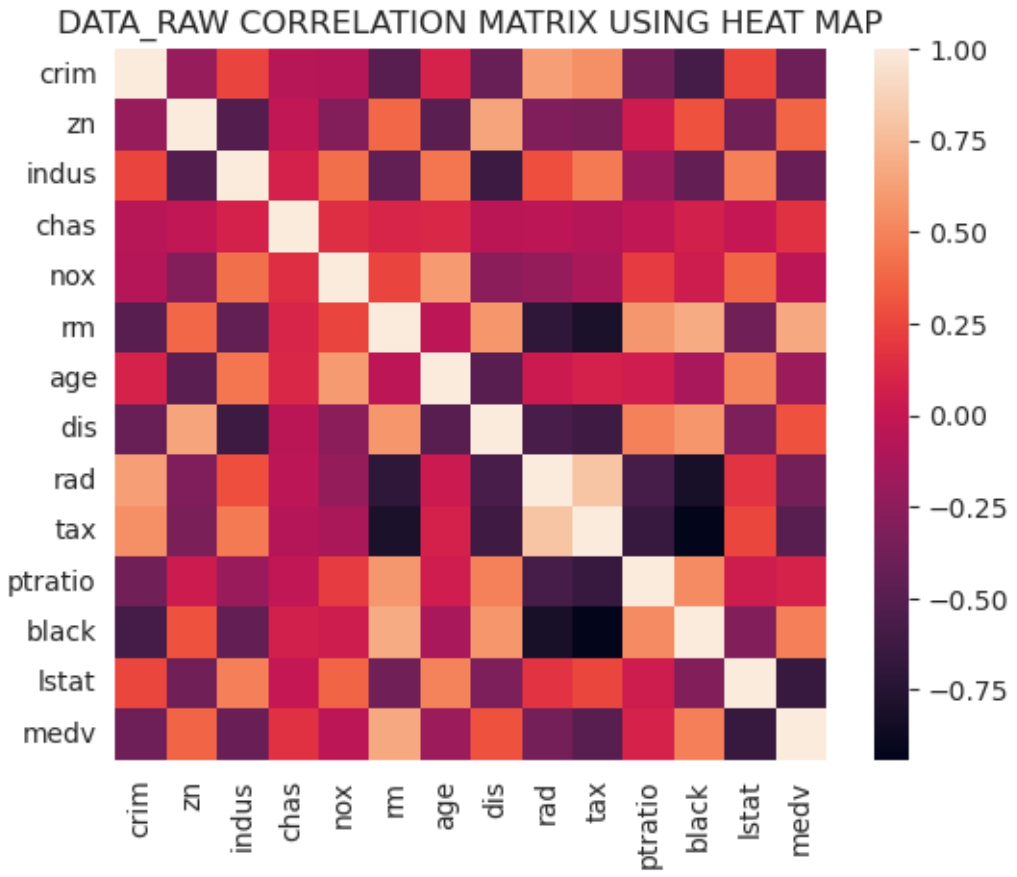



```
<Figure size 640x480 with 0 Axes>
```

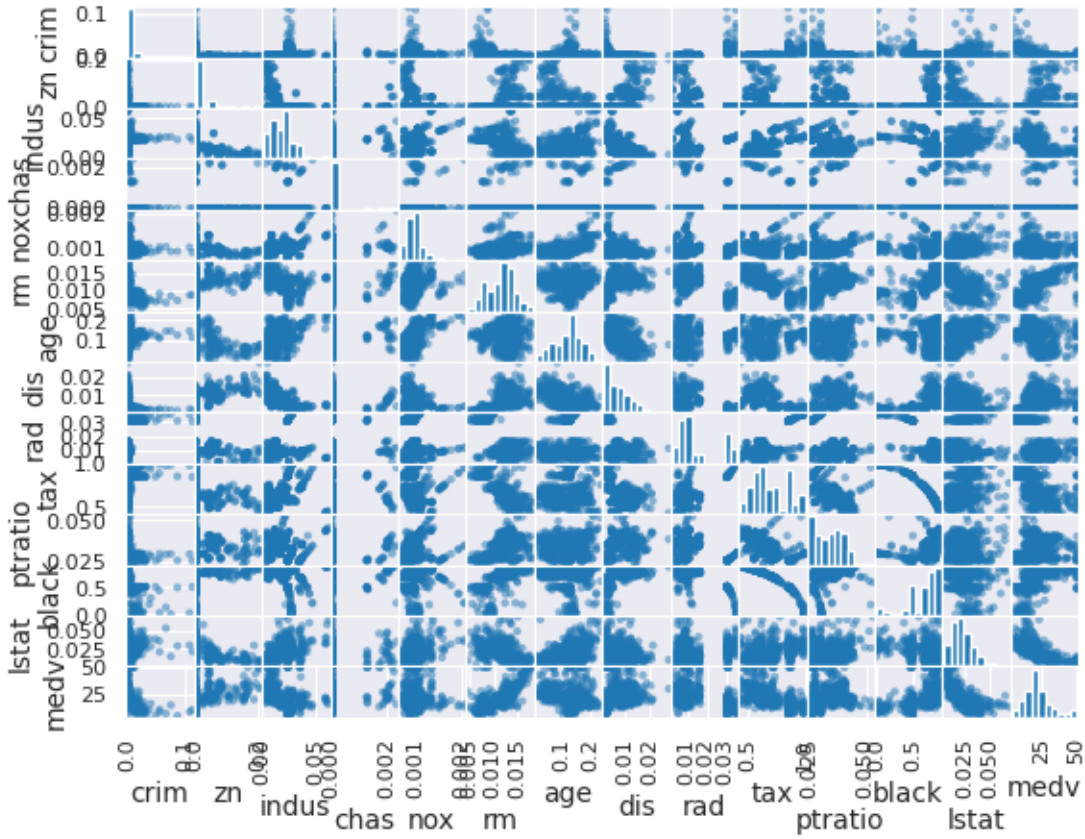


	crim	zn	indus	chas	nox	rm	age	dis	rad	tax
crim	1.0e+00	-2.1e-01	2.5e-01	-6.3e-02	-8.2e-02	-4.9e-01	8.7e-02	-4.2e-01	6.1e-01	5.5e-01
zn	-2.1e-01	1.0e+00	-5.2e-01	-1.9e-02	-3.0e-01	3.9e-01	-4.8e-01	6.4e-01	-3.1e-01	-3.3e-01
indus	2.5e-01	-5.2e-01	1.0e+00	8.2e-02	4.1e-01	-4.5e-01	4.5e-01	-6.3e-01	2.8e-01	4.6e-01
chas	-6.3e-02	-1.9e-02	8.2e-02	1.0e+00	1.5e-01	1.0e-01	1.2e-01	-5.2e-02	-4.0e-02	-7.5e-02
nox	-8.2e-02	-3.0e-01	4.1e-01	1.5e-01	1.0e+00	2.5e-01	6.0e-01	-2.6e-01	-2.1e-01	-1.2e-01
rm	-4.9e-01	3.9e-01	-4.5e-01	1.0e-01	2.5e-01	1.0e+00	-3.9e-02	5.8e-01	-7.0e-01	-8.0e-01
age	8.7e-02	-4.8e-01	4.5e-01	1.2e-01	6.0e-01	-3.9e-02	1.0e+00	-4.9e-01	2.5e-02	7.9e-02
dis	-4.2e-01	6.4e-01	-6.3e-01	-5.2e-02	-2.6e-01	5.8e-01	-4.9e-01	1.0e+00	-5.6e-01	-6.2e-01
rad	6.1e-01	-3.1e-01	2.8e-01	-4.0e-02	-2.1e-01	-7.0e-01	2.5e-02	-5.6e-01	1.0e+00	8.0e-01

```
tax      5.5e-01 -3.3e-01  4.6e-01 -7.5e-02 -1.2e-01 -8.0e-01  7.9e-02 -6.2e-01
8.0e-01  1.0e+00
ptratio -3.8e-01  3.3e-02 -2.0e-01 -1.6e-02  2.1e-01  5.9e-01  4.8e-02  4.9e-01
-5.8e-01 -6.5e-01
black   -5.9e-01  3.0e-01 -4.5e-01  7.0e-02  4.2e-02  6.8e-01 -1.3e-01  5.8e-01
-8.1e-01 -9.4e-01
lstat    2.5e-01 -3.7e-01  4.8e-01 -2.4e-03  3.7e-01 -3.8e-01  5.0e-01 -3.3e-01
1.7e-01  2.6e-01
medv    -3.9e-01  3.7e-01 -4.1e-01  1.7e-01 -4.5e-02  6.7e-01 -1.9e-01  3.0e-01
-3.6e-01 -5.0e-01

         ptratio    black    lstat     medv
crim    -3.8e-01 -5.9e-01  2.5e-01 -3.9e-01
zn       3.3e-02  3.0e-01 -3.7e-01  3.7e-01
indus   -2.0e-01 -4.5e-01  4.8e-01 -4.1e-01
chas    -1.6e-02  7.0e-02 -2.4e-03  1.7e-01
nox      2.1e-01  4.2e-02  3.7e-01 -4.5e-02
rm       5.9e-01  6.8e-01 -3.8e-01  6.7e-01
age      4.8e-02 -1.3e-01  5.0e-01 -1.9e-01
dis      4.9e-01  5.8e-01 -3.3e-01  3.0e-01
rad     -5.8e-01 -8.1e-01  1.7e-01 -3.6e-01
tax     -6.5e-01 -9.4e-01  2.6e-01 -5.0e-01
ptratio  1.0e+00  5.4e-01  4.3e-02  8.6e-02
black    5.4e-01  1.0e+00 -3.0e-01  4.8e-01
lstat    4.3e-02 -3.0e-01  1.0e+00 -6.5e-01
medv     8.6e-02  4.8e-01 -6.5e-01  1.0e+00
```




```
<Figure size 640x480 with 0 Axes>
```



11. Identify the high correlation columns from the headmap and compare the results from those of the scatter plots. Do the results match? Explain.

[ ]: