HOMEWORK 1_801333188

hw1-1a

February 20, 2023

```
[17]: import numpy as np # import numpy library
      import pandas as pd # import pandas library
      import matplotlib.pyplot as plt # import matplotlib library
      from sklearn import preprocessing # import scikit-learn library (source: https:
       →//scikit-learn.org/stable/index.html)
[18]: df = pd.read_csv("/content/sample_data/Housing.csv")
      # display DataFrame
      df
[18]:
                                       bathrooms
                                                   stories mainroad guestroom basement
              price
                      area
                            bedrooms
           13300000
                      7420
                                                          3
                                                                 yes
                                                                             no
           12250000
                                                4
      1
                      8960
                                    4
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                                                                 yes
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           12250000
                     9960
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      3
           12215000
                      7500
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      4
           11410000
                     7420
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      540
            1820000
                      3000
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                                                                                     yes
                                                                 yes
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      541
            1767150
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            1750000
                      3620
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      543
            1750000
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            1750000
                      3850
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                                                                 yes
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          hotwaterheating airconditioning parking prefarea furnishingstatus
      0
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                                        yes
                                                            yes
                                                                        furnished
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      1
                        no
                                        yes
                                                            no
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      2
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                                                                  semi-furnished
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```

[545 rows x 13 columns]

```
[19]: df = df.replace(to_replace=['yes', 'no'], value=[1, 0])
[19]:
                              bedrooms
                                         bathrooms
                                                      stories
                                                                mainroad
                                                                            guestroom
               price area
            13300000
      0
                       7420
                                                             3
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      1
            12250000
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            basement
                       hotwaterheating
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           furnishingstatus
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             semi-furnished
      3
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      4
                   furnished
      540
                 unfurnished
      541
             semi-furnished
      542
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      543
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      544
                 unfurnished
```

[545 rows x 13 columns]

[20]: # create a training set by randomly selecting 80% of the rows from the DataFrame
train = df.sample(frac=0.8, random_state=1)

create a test set by dropping the rows in the training set from the DataFrame
test = df.drop(train.index)

[21]: test

[21]:		price	area	bedrooms	bathrooms	stories	mainroad	guestroom	\
	2	12250000		3	2	2	1	0	•
	3	12215000		4	2	2	1	0	
	7	10150000	16200	5	3	2	1	0	
	15	9100000	6000	4	1	2	1	0	
	22	8645000	8050	3	1	1	1	1	
		•••	•••	•••		•••	•••		
	508	2590000	4400	2	1	1	1	0	
	513	2485000	4400	3	1	2	1	0	
	520	2450000	7700	2	1	1	1	0	
	537	1890000	1700	3	1	2	1	0	
	539	1855000	2990	2	1	1	0	0	
			_						
		basement	hotwat	erheating	airconditi	oning pa		farea \	
	2	1		0		0	2	1	
	3	1		0		1	3	1	
	7	0		0		0	0	0	
	15	1		0		0	2	0	
	22	1		0		1	1	0	
	• •	•••		•••	•••	•••	•••	_	
	508	0		0		0	0	0	
	513	0		0		0	0	0	
	520	0		0		0	0	0	
	537	0		0		0	0	0	

furnishingstatus

2	semi-furnished
3	furnished
7	unfurnished
15	semi-furnished
22	furnished
	•••
508	unfurnished
513	unfurnished
520	unfurnished
537	unfurnished
539	unfurnished

[109 rows x 13 columns]

```
[22]: # select specific columns for the training set
     train = train[['price', 'area', 'bedrooms', 'bathrooms', 'stories', 'parking']]
      # select specific columns for the test set
     test = test[['price', 'area', 'bedrooms', 'bathrooms', 'stories', 'parking']]
[23]: import sklearn.preprocessing # import scikit-learn library for data,
       →preprocessing
      # create an instance of the MinMaxScaler class for scaling features to a range_
     scaler = sklearn.preprocessing.MinMaxScaler()
[24]: train
[24]:
                    area bedrooms bathrooms stories parking
            price
     62
          7070000
                    6240
     247 4550000
                                                     4
                                                              3
                    8400
                                 4
                                            1
                                            2
                                                     2
     142 5600000
                   10500
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     107 6125000
                    6420
                                 3
                                            1
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                                            1
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     483 2940000
                    6615
                                                              0
     359 3710000
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                    3600
                                            2
     36
          8043000
                    7482
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     30
          8400000
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          8750000
                    4320
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                                 2
     527 2275000
                    1836
                                            1
                                                     1
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     [436 rows x 6 columns]
[25]: # create a NumPy array of the 'area' column from the training set
     X1 t = np.array(train['area'])
      # display the NumPy array
     X1_t
                    8400, 10500,
                                                                     2700,
[25]: array([ 6240,
                                  6420,
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                                        1836])
               7482,
                        7475,
                               4320,
[26]: X1_t = np.array(train['area']) # 'area' column
      X2 t = np.array(train['bedrooms']) # 'bedrooms' column
      X3_t = np.array(train['bathrooms']) # 'bathrooms' column
      X4_t = np.array(train['stories']) # 'stories' column
      X5_t = np.array(train['parking']) # 'parking' column
```

3510,

6420,

6450,

6210,

4500,

3000,

3180,

5700,

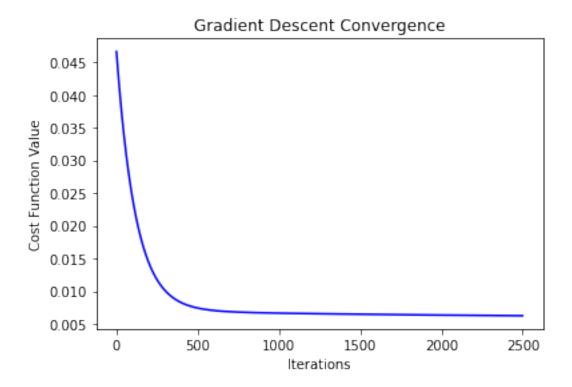
3520,

```
# create a NumPy array of ones to represent the bias term
      X0_t = np.ones(len(train))
[27]: # stack the selected feature arrays vertically using np.vstack
      X = np.vstack([X0_t, X1_t, X2_t, X3_t, X4_t, X5_t])
      # transpose the stacked array to make it a 6 x 436 matrix
      X = X.T
      # convert the stacked array to a NumPy array
      X = np.array(X)
      # display the NumPy array
      Х
[27]: array([[1.000e+00, 6.240e+03, 4.000e+00, 2.000e+00, 2.000e+00, 1.000e+00],
             [1.000e+00, 8.400e+03, 4.000e+00, 1.000e+00, 4.000e+00, 3.000e+00],
             [1.000e+00, 1.050e+04, 4.000e+00, 2.000e+00, 2.000e+00, 1.000e+00],
             [1.000e+00, 7.475e+03, 3.000e+00, 2.000e+00, 4.000e+00, 2.000e+00],
             [1.000e+00, 4.320e+03, 3.000e+00, 1.000e+00, 2.000e+00, 2.000e+00],
             [1.000e+00, 1.836e+03, 2.000e+00, 1.000e+00, 1.000e+00, 0.000e+00]])
[28]: # scale the feature matrix using the fit_transform() method of the scaler object
      X_scaled = scaler.fit_transform(X)
      # assign the scaled feature matrix to the original variable name 'X'
      X = X \text{ scaled}
[29]: # create a 1D NumPy array of zeros with length 6
      theta = np.zeros(6)
      # reshape the 1D array to a column vector using np.reshape
      theta = np.reshape(theta, (6,1))
      # display the column vector
      theta
[29]: array([[0.],
             [0.],
             [0.],
             [0.],
             [0.],
             [0.11)
[30]: | # create a 1D NumPy array 'Y_t' from the 'price' column of the training setu
       →'train'
```

```
# create a copy of 'Y_t' to prevent changing the original data
      Y = Y_t.copy()
      # reshape 'Y' to a column vector using np.reshape
      Y = np.reshape(Y, (436,1))
      # create an instance of the MinMaxScaler class for scaling the target variable_
       \rightarrowto a range of [0, 1]
      scaler = sklearn.preprocessing.MinMaxScaler()
      # scale the target variable using the fit_transform() method of the scaler
       ⇔object
      Y_scaled = scaler.fit_transform(Y)
      # assign the scaled target variable to the original variable name 'Y'
      Y = Y_scaled
[31]: # create a NumPy array 'X T' containing the transpose of the feature matrix 'X'
      X_T = np.array(X.T)
      \# retrieve the number of rows 'm' and the number of columns 'n' from the
       \hookrightarrow feature matrix 'X'
      m, n = X.shape
      # display the values of 'm' and 'n'
      print("Number of training examples (m): ", m)
      print("Number of features (n): ", n)
      # set the number of iterations for gradient descent
      iterations = 2500
      # create a counter variable 'count' and a NumPy array 'j' to store the cost_{\sqcup}
      →function values for each iteration
      count = 0
      j = np.zeros(shape=(iterations, 1), dtype=float)
      # display the shape of the 'j' array
      print("Shape of 'j' array: ", j.shape)
     Number of training examples (m): 436
     Number of features (n): 6
     Shape of 'j' array: (2500, 1)
[32]: # set the initial iteration count to zero
      count = 0
```

Y_t = np.array(train.price)

```
# create a NumPy array 'j' to store the cost function values for each iteration
j = np.zeros(shape=(iterations, 1), dtype=float)
# perform gradient descent for the specified number of iterations
while count < iterations:</pre>
    # calculate the predicted values 'h' using the current parameters 'theta'
    h = X.dot(theta)
    # calculate the cost function value 'j' using the current parameters 'theta'
    j[count] = (1/(2*m)) * np.sum((h-Y)**2)
    # calculate the gradient of the cost function with respect to 'theta'
    grad = (1/m) * X_T.dot(h-Y)
    # update the parameters 'theta' using the learning rate 'alpha' and the \Box
 ⇔gradient 'grad'
    alpha = 0.01
    theta = theta - alpha * grad
    # increment the iteration count
    count += 1
# plot the cost function values over the iterations
plt.plot(j,'b-')
plt.xlabel('Iterations')
plt.ylabel('Cost Function Value')
plt.title('Gradient Descent Convergence')
plt.show()
```

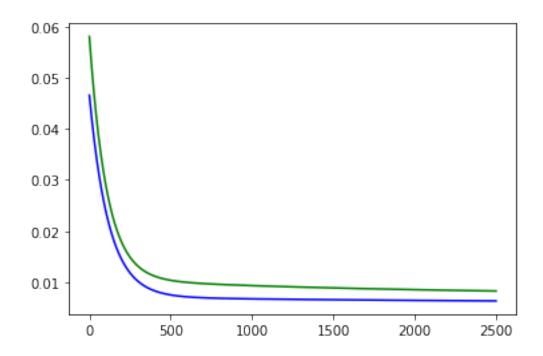


```
N_X1_t = np.array(test.area)
      N_X2_t = np.array(test.bedrooms)
      N_X3_t = np.array(test.bathrooms)
      N_X4_t = np.array(test.stories)
      N_X5_t = np.array(test.parking)
      N_X0_t = np.ones(109)
[34]: # stack the test set features into a design matrix
      N_X = np.vstack([N_X0_t,N_X1_t,N_X2_t,N_X3_t,N_X4_t,N_X5_t])
      N_X_T = N_X.T
      N_X = np.array(N_X_T)
      N_x = scaler.fit_transform(N_X)
      N_X = N_x
      N_X.shape
[34]: (109, 6)
[35]: N_theta = np.array([0.,0.,0.,0.,0.,0.])
      N_theta = N_theta.reshape(6,1)
      N_theta
```

[33]: # extract the test set features into NumPy arrays

```
[35]: array([[0.],
              [0.],
              [0.],
              [0.],
              [0.],
              [0.]])
[36]: N_Y_t = np.array(test.price)
      N_Y = N_Y_t
      N_Y = N_Y_t.reshape(109,1)
      N_y = scaler.fit_transform(N_Y)
      N_Y=N_y
      N_Y.shape
[36]: (109, 1)
[37]: N_X_T = np.array(N_X.T)
      m,n = N_X.shape
      m,n
[37]: (109, 6)
[38]: iterations = 2500
      count=0
      N_j = np.zeros(shape=(iterations, 1), dtype=float)
      while(count < iterations):</pre>
          N_h_t = N_X.dot(N_theta)
          N_h = np.array(N_h_t)
          N_j[count] = (1/(2*m))*np.sum((N_h - N_Y)**2)
          grad_t = N_X_T.dot(N_h-N_Y)
          grad = grad_t*(1/m)
          N_{\text{theta}} = N_{\text{theta}} - 0.01*(grad)
          count += 1
[39]: plt.plot(N_j,'g-')
      plt.plot(j,'b-')
```

[39]: [<matplotlib.lines.Line2D at 0x7f84302065e0>]



hw1-1b

February 20, 2023

```
[1]: import numpy as np # import numpy library
     import pandas as pd # import pandas library
     import matplotlib.pyplot as plt # import matplotlib library
     from sklearn import preprocessing # import scikit-learn library (source: https:
      →//scikit-learn.org/stable/index.html)
[2]: df = pd.read_csv("/content/sample_data/Housing.csv")
     # display DataFrame
     df
[2]:
                                                   stories mainroad guestroom basement
              price
                     area
                            bedrooms
                                       bathrooms
          13300000
                     7420
                                                          3
                                                                 yes
                                                                             no
                                                                                       no
     1
          12250000
                     8960
                                    4
                                                4
                                                          4
                                                                 yes
                                                                             no
                                                                                       no
     2
          12250000
                     9960
                                                2
                                                          2
                                    3
                                                                 yes
                                                                             no
                                                                                      yes
     3
          12215000
                     7500
                                    4
                                                2
                                                          2
                                                                 yes
                                                                             no
                                                                                      yes
     4
          11410000
                     7420
                                                1
                                                          2
                                                                 yes
                                                                            yes
                                                                                      yes
     540
           1820000
                                    2
                                                1
                                                          1
                     3000
                                                                                      yes
                                                                 yes
                                                                             no
     541
                                    3
           1767150
                     2400
                                                1
                                                          1
                                                                  no
                                                                             no
                                                                                       no
                                    2
     542
            1750000
                     3620
                                                1
                                                          1
                                                                 yes
                                                                             no
                                                                                       no
     543
            1750000
                     2910
                                    3
                                                1
                                                          1
                                                                  no
                                                                             no
                                                                                       no
     544
            1750000
                     3850
                                    3
                                                1
                                                          2
                                                                 yes
                                                                             no
                                                                                       no
         hotwaterheating airconditioning parking prefarea furnishingstatus
     0
                                                    2
                                        yes
                                                            yes
                                                                        furnished
                                                    3
     1
                       no
                                                             no
                                                                        furnished
                                        yes
     2
                       no
                                         no
                                                    2
                                                            yes
                                                                  semi-furnished
     3
                                                    3
                                                                        furnished
                                        yes
                       nο
                                                            yes
                                                                        furnished
     4
                       nο
                                        yes
                                                    2
                                                             no
                                                                      unfurnished
     540
                                                    2
                       no
                                         no
                                                             no
     541
                                                    0
                                                                  semi-furnished
                       no
                                         no
                                                             no
     542
                                                    0
                                                                     unfurnished
                       no
                                         no
                                                             no
     543
                                                    0
                                                                        furnished
                       no
                                         no
                                                             no
     544
                                                                     unfurnished
                       no
                                         no
                                                             no
```

[545 rows x 13 columns]

```
[3]: df = df.replace(to_replace=['yes', 'no'], value=[1, 0])
[3]:
                             bedrooms
                                        bathrooms
                                                                mainroad
                                                                           guestroom
              price area
                                                     stories
           13300000
     0
                      7420
                                                             3
                                                                        1
     1
           12250000
                      8960
                                     4
                                                  4
                                                            4
                                                                        1
                                                                                    0
                                     3
                                                  2
                                                            2
     2
           12250000
                      9960
                                                                        1
                                                                                    0
     3
           12215000
                      7500
                                     4
                                                  2
                                                            2
                                                                        1
                                                                                     0
                                                             2
     4
           11410000
                      7420
                                     4
                                                  1
                                                                        1
                                                                                     1
     . .
                                     2
            1820000
                                                  1
                                                                        1
                                                                                     0
     540
                      3000
                                                             1
     541
                                     3
            1767150
                      2400
                                                  1
                                                             1
                                                                        0
                                                                                     0
     542
            1750000
                      3620
                                     2
                                                  1
                                                             1
                                                                        1
                                                                                    0
     543
                                     3
                                                  1
                                                                        0
            1750000
                      2910
                                                             1
                                                                                    0
     544
            1750000
                      3850
                                     3
                                                  1
                                                            2
                                                                        1
                                                                                    0
                                          airconditioning parking
           basement
                      hotwaterheating
     0
                   0
                                       0
                                                          1
                                                                    2
                   0
                                       0
                                                                    3
                                                                                0
     1
                                                          1
                                                                    2
     2
                   1
                                       0
                                                          0
                                                                                1
     3
                   1
                                       0
                                                          1
                                                                    3
                                                                                1
                                                                    2
     4
                   1
                                       0
                                                          1
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     . .
                                                           •••
                                                                    •••
                                                                    2
                                       0
                                                          0
                                                                                0
     540
                   1
     541
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     543
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                   0
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     544
                   0
                                       0
                                                          0
                                                                    0
                                                                                0
          furnishingstatus
     0
                  furnished
     1
                  furnished
     2
            semi-furnished
     3
                  furnished
     4
                  furnished
     540
               unfurnished
     541
            semi-furnished
     542
               unfurnished
     543
                  furnished
     544
               unfurnished
```

[545 rows x 13 columns]

[4]: # create a training set by randomly selecting 80% of the rows from the DataFrame train = df.sample(frac=0.8, random_state=1)

create a test set by dropping the rows in the training set from the DataFrame test = df.drop(train.index)

[5]: train

[5]:		price	area	bedrooms	bathrooms	stories	mainroad	guestroom	\
	62	7070000	6240	4	2	2	1	0	
	247	4550000	8400	4	1	4	1	0	
	142	5600000	10500	4	2	2	1	0	
	107	6125000	6420	3	1	3	1	0	
	483	2940000	6615	3	1	2	1	0	
		•••	•••	•••		•••	•••		
	359	3710000	3600	3	1	1	1	0	
	36	8043000	7482	3	2	3	1	0	
	30	8400000	7475	3	2	4	1	0	
	20	8750000	4320	3	1	2	1	0	
	527	2275000	1836	2	1	1	0	0	
		basement	hotwa	terheating	aircondit	ioning p	parking pr	refarea \	
	62	0		0		1	1	0	
	247	0		0		0	3	0	
	142	0		0		0	1	0	
	107	1		0		0	0	1	
	483	0		0		0	0	0	
		***		•••	•••	•••	•••		
	359	0		0		0	1	0	
	36	0		1		0	1	1	
	30	0		0		1	2	0	
	20	1		1		0	2	0	

furnished 62 247 unfurnished 142 semi-furnished 107 unfurnished semi-furnished 483 359 unfurnished 36 furnished 30 unfurnished

semi-furnished

semi-furnished

1

furnishingstatus

527

20

527

0

0

[436 rows x 13 columns]

: test	;								
:	price	area	bedrooms	bathrooms	storie	es main	road	guestroom	\
. 2	12250000	9960	3	2	2021	2	1	0	`
3	12215000	7500	4	2		2	1	0	
7	10150000	16200	5	3		2	1	0	
15	9100000	6000	4	1		2	1	0	
22	8645000	8050	3	1		1	1	1	
		•••	***			•			
508	2590000	4400	2	1		1	1	0	
513	2485000	4400	3	1		2	1	0	
520	2450000	7700	2	1		1	1	0	
537	1890000	1700	3	1		2	1	0	
539	1855000	2990	2	1		1	0	0	
	basement	hotwat	erheating	airconditi	oning	parking	pre	farea \	
2	1		0		0	2		1	
3	1		0		1	3		1	
7	0		0		0	0		0	
15	1		0		0	2		0	
22	1		0		1	1		0	
			•••	•••					
508	0		0		0	0		0	
513	0		0		0	0		0	
520	0		0		0	0		0	
537	0		0		0	0		0	
539	0		0		0	1		0	
	furnishing								
2	semi-fur								
3		nished							
7		nished							
15	semi-fur								
22	fur	nished							
	_								
508		nished							
513		nished							
520		nished							
537		nished							
539	untur	nished							

[7]: # select specific columns for the training set

[109 rows x 13 columns]

```
train = train[['price', 'area', 'bedrooms', 'bathrooms', 'stories', 'parking', \( \triangle \) 'mainroad', 'guestroom', 'basement', 'hotwaterheating', 'airconditioning', \( \triangle \) 'prefarea']]
# select specific columns for the test set
test = test[['price', 'area', 'bedrooms', 'bathrooms', 'stories', 'parking', \( \triangle \) 'mainroad', 'guestroom', 'basement', 'hotwaterheating', 'airconditioning', \( \triangle \) 'prefarea']]
```

[9]: train

[9]:		price	area	bedr	ooms	bathro	ooms	stories	parking	mainroad	\
	62	7070000	6240		4		2	2	1	1	
	247	4550000	8400		4		1	4	3	1	
	142	5600000	10500		4		2	2	1	1	
	107	6125000	6420		3		1	3	0	1	
	483	2940000	6615		3		1	2	0	1	
		•••	•••				•••	•••	•••		
	359	3710000	3600		3		1	1	1	1	
	36	8043000	7482		3		2	3	1	1	
	30	8400000	7475		3		2	4	2	1	
	20	8750000	4320		3		1	2	2	1	
	527	2275000	1836		2		1	1	0	0	
		guestroom	n base	ment	hotw	aterhea	ating	aircond	litioning	prefarea	
	62	(0	0			0		1	0	
	247	(0	0			0		0	0	
	142	(0	0			0		0	0	
	107	(0	1			0		0	1	
	483	(0	0			0		0	0	
		•••				•••		•••			
	359	(0	0			0		0	0	
	36	(0	0			1		0	1	

[436 rows x 12 columns]

```
X1_t = np.array(train['area'])
       # display the NumPy array
      X1_t
[10]: array([ 6240,
                        8400, 10500,
                                        6420,
                                                6615,
                                                         3600,
                                                                 3240,
                                                                         6600,
                                                                                 2700,
                5000,
                        2650,
                                4775,
                                        4800,
                                                3700,
                                                        7700,
                                                                7420,
                                                                         4280,
                                                                                 6000,
                6600,
                        3649,
                                3420,
                                        5500,
                                                3630,
                                                         3180,
                                                                3600,
                                                                         8400,
                                                                                 3000,
                8880,
                        5750,
                                2145,
                                        6360,
                                                6525,
                                                         1950,
                                                                5850,
                                                                         8372,
                                                                                 2870,
                                                                3210,
                4990,
                        2684,
                                5200,
                                        6321,
                                                4960,
                                                         3480,
                                                                         4950,
                                                                                 6840,
                                4410,
                4350,
                        5850,
                                        2500,
                                                3850,
                                                        3180,
                                                                3162,
                                                                         3500,
                                                                                 4340,
                6440,
                        5010,
                                3000,
                                        4920,
                                                3760,
                                                        3816,
                                                                6000,
                                                                         7000,
                                                                                 3640,
                4080,
                        4160,
                                2910,
                                        6060,
                                                3000,
                                                         2787,
                                                                4815,
                                                                         4785,
                                                                                 6600,
                5300,
                        3600,
                                6000,
                                        2176,
                                                3000,
                                                        7420,
                                                                7020,
                                                                         3480,
                                                                                 5960,
                3510,
                        6420,
                                6450,
                                        6210,
                                                4500,
                                                        3000,
                                                                3180,
                                                                         5700,
                                                                                 3520,
                4040,
                        5800,
                                2800,
                                        6480,
                                                4960,
                                                        4260,
                                                                7500,
                                                                         5880,
                                                                                10500,
                4500,
                        3850,
                                8500,
                                        3120,
                                                3990,
                                                        4095,
                                                                4800, 13200,
                                                                                 7770,
                6100,
                        4075,
                                6550,
                                        4100,
                                                4370,
                                                         3180,
                                                                7350,
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                                6600,
                                                2475,
                                                                4500,
                                                                                 4360,
                5500,
                        8250,
                                        8250,
                                                         3850,
                                                                         3720,
               10240,
                        5500,
                                3970,
                                        3450,
                                                3850,
                                                         5500,
                                                                 3520,
                                                                         2145,
                                                                                 6600,
                3640,
                        3986,
                                2953,
                                        8250,
                                                4130,
                                                        8580,
                                                                6000,
                                                                         3500.
                                                                                 5885,
                7680,
                        2430,
                                3150,
                                        6450,
                                                8100,
                                                         5500,
                                                                1650,
                                                                         3040,
                                                                                 4079,
                2747,
                        4600,
                                2325,
                                        7231,
                                                3520,
                                                        2145,
                                                                3450,
                                                                         3620,
                                                                                 4000,
                                4500,
                                                7200,
                6000,
                        6000,
                                        3540,
                                                        3120,
                                                                4000,
                                                                         2015,
                                                                                 4040,
                                                6060,
                8000,
                        2787,
                                3512,
                                        3420,
                                                        4500,
                                                                6360,
                                                                         5450,
                                                                                 8250,
                        7410, 10360,
                3960,
                                        3630,
                                                6020,
                                                        4100,
                                                                6254,
                                                                                 4560,
                                                                         4500,
                6710,
                        3500,
                                8880,
                                        3600,
                                                7152,
                                                         6000,
                                                                 4040,
                                                                         4000,
                                                                                 4040,
                5360,
                        6600,
                                3800,
                                        3960,
                                                4900,
                                                         3480,
                                                                3584,
                                                                         2275,
                                                                                 4000,
                                8960,
                                        3290,
                                                8875,
                                                                                 2800,
                6500, 10500,
                                                        8580,
                                                                3450,
                                                                         6600,
                                        6100, 12090,
                5640,
                        3745, 10269,
                                                        5880,
                                                                6750,
                                                                         6000,
                                                                                 5320,
                4000,
                        4040, 15600,
                                        3090,
                                                3970,
                                                        5450,
                                                                4770,
                                                                         4095,
                                                                                 6000,
                6540,
                        6550,
                                4320,
                                        3100,
                                                4050,
                                                        3650,
                                                                3850,
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                                                                                 2817,
                        3000,
                                4995, 11410,
                                                3000,
                                                         4840,
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                4510,
                                4840,
                                        3000,
                                                3480,
                                                                5828,
                                                                                 4040,
                7800,
                        5300,
                                                         2970,
                                                                         3800,
               10700,
                        7320,
                                5000,
                                        6325,
                                                2880,
                                                        4300,
                                                                3150,
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                4500,
                                3180,
                                                5400,
                                                         3630,
                                                                6750,
                                                                         4820,
                                                                                 5136,
                        3420,
                                        2145,
                                                5800,
                                                                5000,
                4120,
                        6825,
                                4600,
                                        6650,
                                                        5720,
                                                                         4352,
                                                                                 3300,
                2160,
                                3000,
                                        4500,
                                                3350,
                                                         5400,
                                                                4600,
                                                                         9800,
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                        5900,
                                        4000,
                2610,
                        9667,
                                3635,
                                                3180,
                                                        3630,
                                                                6600,
                                                                         2610,
                                                                                 4960,
                5150,
                        6000,
                                3640,
                                        2910,
                                                3650,
                                                        3450,
                                                                4032,
                                                                         7980,
                                                                                 1905,
                                9620,
                                        1950, 12900,
                                                        3240,
                                                                4320,
                                                                                 6000,
                6000,
                        3360,
                                                                         6540,
                                                                5200,
                7440,
                        3760,
                                8100,
                                        4880,
                                                6000,
                                                         2000,
                                                                         4050,
                                                                                 9166,
                7950,
                        5500,
                                2700,
                                        6000,
                                                6900,
                                                        3500,
                                                                5076,
                                                                         5985,
                                                                                 4300,
                8050,
                        5320,
                                5960,
                                        7000,
                                                7260,
                                                         6360,
                                                                3000,
                                                                         3460,
                                                                                12944,
                3880,
                        2400,
                                4080,
                                        6000,
                                                4500,
                                                         6050,
                                                                 7000,
                                                                         3930,
                                                                                 4600,
                7155,
                                2400,
                                        3460,
                                                4632,
                                                         4200,
                                                                 4640,
                                                                         8800,
                                                                                 3000,
                        4100,
```

[10]: # create a NumPy array of the 'area' column from the training set

```
6800,
                                                                  3400,
                                                                                       6420,
                                                                                                              3792,
                                                                                                                                    5500,
                                                                                                                                                          4600,
                                                                                                                                                                                 6800,
                                                                                                                                                                                                       6000,
                                                                                                                                                                                                                             8520,
                                                                                                                                   5830,
                                                                                                                                                          3410,
                                           6480,
                                                                 8150,
                                                                                       5948,
                                                                                                              3185,
                                                                                                                                                                                 3000,
                                                                                                                                                                                                       8400,
                                                                                                                                                                                                                             6350,
                                           8100,
                                                                 4800,
                                                                                       2856,
                                                                                                             3185,
                                                                                                                                   3780,
                                                                                                                                                          3640,
                                                                                                                                                                                 6000,
                                                                                                                                                                                                       6000,
                                                                                                                                                                                                                             4800,
                                           5800,
                                                                 6360,
                                                                                       4120,
                                                                                                              5400, 2850, 5400,
                                                                                                                                                                                 2145, 4500,
                                                                                                                                                                                                                             3240,
                                         13200,
                                                                  3900,
                                                                                       9000,
                                                                                                              4646,
                                                                                                                                    3840,
                                                                                                                                                          9000, 3520, 3640,
                                                                                                                                                                                                                             3600,
                                           7482,
                                                                 7475,
                                                                                       4320,
                                                                                                              1836])
[11]: X2_t = np.array(train.bedrooms)
                   X3 t = np.array(train.bathrooms)
                   X4_t = np.array(train.stories)
                   X5 t = np.array(train.parking)
                   X6_t = np.array(train.mainroad)
                   X7 t = np.array(train.guestroom)
                   X8_t = np.array(train.hotwaterheating)
                   X9_t = np.array(train.airconditioning)
                   X10 t = np.array(train.prefarea)
                   X11_t = np.array(train.basement)
                   X0_t = np.ones(436)
[12]: # stack the selected feature arrays vertically using np.vstack
                   X = np.vstack([X0_t, X1_t, X2_t, X3_t, X4_t, X5_t, ]
                     4 \times 10^{-4} \text{ M} \cdot 10^{-4} 
                   # transpose the stacked array to make it a 6 x 436 matrix
                   X = X.T
                   # convert the stacked array to a NumPy array
                   X = np.array(X)
                   # display the NumPy array
                   Х
[12]: array([[1.000e+00, 6.240e+03, 4.000e+00, ..., 1.000e+00, 0.000e+00,
                                           0.000e+00],
                                         [1.000e+00, 8.400e+03, 4.000e+00, ..., 0.000e+00, 0.000e+00,
                                           0.000e+00],
                                         [1.000e+00, 1.050e+04, 4.000e+00, ..., 0.000e+00, 0.000e+00,
                                           0.000e+00],
                                         [1.000e+00, 7.475e+03, 3.000e+00, ..., 1.000e+00, 0.000e+00,
                                           0.000e+00],
                                         [1.000e+00, 4.320e+03, 3.000e+00, ..., 0.000e+00, 0.000e+00,
                                           1.000e+00],
                                         [1.000e+00, 1.836e+03, 2.000e+00, ..., 0.000e+00, 0.000e+00,
                                           1.000e+00]])
```

6300, 7000,

6862, 11440,

7000,

4992,

6900,

3069,

3420,

3185,

3264,

3750,

2640,

5300,

3150,

7200,

4320,

6400,

```
[13]: # scale the feature matrix using the fit_transform() method of the scaler object
      X_scaled = scaler.fit_transform(X)
      \# assign the scaled feature matrix to the original variable name 'X'
      X = X \text{ scaled}
[14]: # create a 1D NumPy array of zeros with length 12
      theta = np.zeros(12)
      # reshape the 1D array to a column vector using np.reshape
      theta = np.reshape(theta, (12,1))
      # display the column vector
      theta
[14]: array([[0.],
             [0.],
             [0.],
             [0.],
             [0.],
             [0.],
             [0.].
             [0.],
             [0.],
             [0.],
             [0.],
             [0.]])
[15]: # create a 1D NumPy array 'Y_t' from the 'price' column of the training set
      →'train'
      Y_t = np.array(train.price)
      # create a copy of 'Y_t' to prevent changing the original data
      Y = Y_t.copy()
      # reshape 'Y' to a column vector using np.reshape
      Y = np.reshape(Y, (436,1))
      \# create an instance of the MinMaxScaler class for scaling the target variable.
      \hookrightarrowto a range of [0, 1]
      scaler = sklearn.preprocessing.MinMaxScaler()
      # scale the target variable using the fit_transform() method of the scaler_
       ⇔object
      Y_scaled = scaler.fit_transform(Y)
      # assign the scaled target variable to the original variable name 'Y'
```

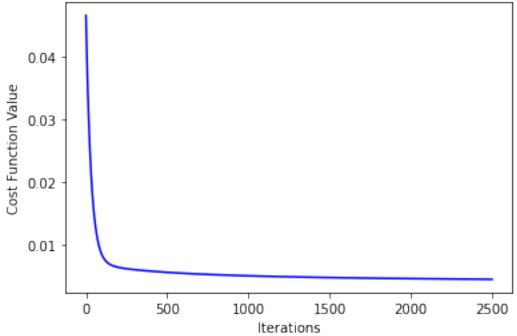
```
Y = Y_scaled
[16]: # create a NumPy array 'X T' containing the transpose of the feature matrix 'X'
      X T = np.array(X.T)
      \# retrieve the number of rows 'm' and the number of columns 'n' from the
       \hookrightarrow feature matrix 'X'
      m, n = X.shape
      # display the values of 'm' and 'n'
      print("Number of training examples (m): ", m)
      print("Number of features (n): ", n)
      # set the number of iterations for gradient descent
      iterations = 2500
      # create a counter variable 'count' and a NumPy array 'j' to store the cost,
      ⇔function values for each iteration
      count = 0
      j = np.zeros(shape=(iterations, 1), dtype=float)
      # display the shape of the 'j' array
      print("Shape of 'j' array: ", j.shape)
     Number of training examples (m): 436
     Number of features (n): 12
     Shape of 'j' array: (2500, 1)
[17]: # set the initial iteration count to zero
      count = 0
      # create a NumPy array 'j' to store the cost function values for each iteration
      j = np.zeros(shape=(iterations, 1), dtype=float)
      # perform gradient descent for the specified number of iterations
      while count < iterations:</pre>
          # calculate the predicted values 'h' using the current parameters 'theta'
          h = X.dot(theta)
          # calculate the cost function value 'j' using the current parameters 'theta'
          j[count] = (1/(2*m)) * np.sum((h-Y)**2)
          # calculate the gradient of the cost function with respect to 'theta'
          grad = (1/m) * X_T.dot(h-Y)
```

```
# update the parameters 'theta' using the learning rate 'alpha' and the_
gradient 'grad'
alpha = 0.01
theta = theta - alpha * grad

# increment the iteration count
count += 1

# plot the cost function values over the iterations
plt.plot(j,'b-')
plt.xlabel('Iterations')
plt.ylabel('Cost Function Value')
plt.title('Gradient Descent Convergence')
plt.show()
```





```
[18]: # extract the test set features into NumPy arrays
    N_X1_t = np.array(test.area)
    N_X2_t = np.array(test.bedrooms)
    N_X3_t = np.array(test.bathrooms)
    N_X4_t = np.array(test.stories)
    N_X5_t = np.array(test.parking)
    N_X6_t = np.array(test.mainroad)
    N_X7_t = np.array(test.guestroom)
```

```
N_X8_t = np.array(test.hotwaterheating)
      N_X9_t = np.array(test.airconditioning)
      N_X10_t = np.array(test.prefarea)
      N_X11_t = np.array(test.basement)
      N_X0_t = np.ones(109)
[19]: # stack the test set features into a design matrix
      N_X = np.vstack([N_X0_t,N_X1_t,N_X2_t,N_X3_t,N_X4_t,N_X5_t,__
       →N_X6_t,N_X7_t,N_X8_t,N_X9_t,N_X10_t,N_X11_t])
      N_X_T = N_X.T
      N_X = np.array(N_X_T)
      N_x = scaler.fit_transform(N_X)
      N X = N x
      N_X.shape
[19]: (109, 12)
[20]: # initialize the parameters for the test set
      N_{\text{theta}} = \text{np.array}([0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.])
      N_theta = N_theta.reshape(12,1)
      N theta
[20]: array([[0.],
             [0.],
             [0.],
             [0.],
             [0.],
             [0.],
             [0.],
             [0.],
             [0.],
             [0.],
             [0.],
             [0.]])
[21]: # initialize the target variable for the test set
      N_Y_t = np.array(test.price)
      N_Y = N_Y_t
      N_Y = N_Y_t.reshape(109,1)
      N_y = scaler.fit_transform(N_Y)
      N_Y=N_y
      N_Y.shape
[21]: (109, 1)
[22]: N_X_T = np.array(N_X.T)
      m,n = N_X.shape
```

m,n

```
[22]: (109, 12)
```

```
[23]: iterations = 2500
    count=0
    N_j = np.zeros(shape=(iterations, 1), dtype=float)

while(count < iterations):
    N_h_t = N_X.dot(N_theta)
    N_h = np.array(N_h_t)

    N_j[count] = (1/(2*m))*np.sum((N_h - N_Y)**2)

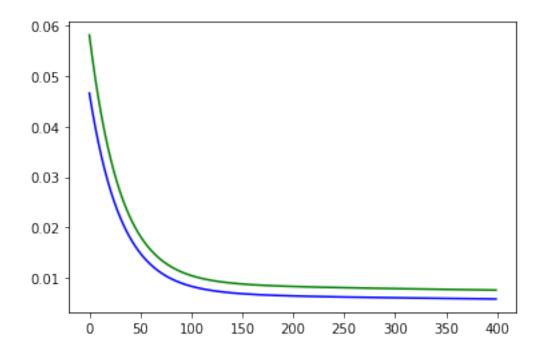
    grad_t = N_X_T.dot(N_h-N_Y)
    grad = grad_t*(1/m)

    N_theta = N_theta - 0.01*(grad)

    count += 1</pre>
```

```
[25]: plt.plot(N_j[:400],'g-')
plt.plot(j[:400],'b-')
```

[25]: [<matplotlib.lines.Line2D at 0x7ffb24cc4f70>]



hw1-2a-normalization

February 20, 2023

```
[]: import numpy as np # import numpy library
     import pandas as pd # import pandas library
     import matplotlib.pyplot as plt # import matplotlib library
     from sklearn import preprocessing # import scikit-learn library (source: https:
      →//scikit-learn.org/stable/index.html)
[]: df = pd.read_csv("/content/sample_data/Housing.csv")
     # display DataFrame
     df
[]:
                                                   stories mainroad guestroom basement
             price
                     area
                            bedrooms
                                      bathrooms
          13300000
                     7420
                                                         3
                                                                 yes
                                                                             no
     1
          12250000
                     8960
                                   4
                                               4
                                                         4
                                                                 yes
                                                                             no
                                                                                      no
     2
          12250000
                     9960
                                               2
                                                         2
                                   3
                                                                 yes
                                                                            no
                                                                                     yes
     3
          12215000
                     7500
                                   4
                                               2
                                                         2
                                                                 yes
                                                                             no
                                                                                     yes
     4
          11410000
                     7420
                                               1
                                                         2
                                                                 yes
                                                                            yes
                                                                                     yes
     540
           1820000
                                   2
                                               1
                                                         1
                     3000
                                                                                     yes
                                                                 yes
                                                                             no
     541
                                   3
           1767150
                     2400
                                               1
                                                         1
                                                                  no
                                                                             no
                                                                                      no
     542
                                   2
           1750000
                     3620
                                               1
                                                         1
                                                                 yes
                                                                             no
                                                                                      no
     543
           1750000
                     2910
                                   3
                                               1
                                                         1
                                                                  no
                                                                             no
                                                                                      no
     544
           1750000
                     3850
                                   3
                                               1
                                                         2
                                                                 yes
                                                                             no
                                                                                      no
         hotwaterheating airconditioning parking prefarea furnishingstatus
     0
                                                    2
                                        yes
                                                           yes
                                                                       furnished
                                                    3
     1
                       no
                                        yes
                                                            no
                                                                       furnished
                                                    2
     2
                       no
                                         no
                                                           yes
                                                                  semi-furnished
     3
                                                    3
                                                                       furnished
                                        yes
                       nο
                                                           yes
                                                                       furnished
     4
                       nο
                                        yes
                                                    2
                                                            no
     540
                                                    2
                                                                     unfurnished
                       no
                                         no
                                                            no
     541
                                                    0
                                                                  semi-furnished
                       no
                                         no
                                                            no
     542
                                                    0
                                                                     unfurnished
                       no
                                         no
                                                            no
     543
                                                    0
                                                                       furnished
                       no
                                         no
                                                            no
     544
                                                                     unfurnished
                       no
                                         no
                                                            no
```

[545 rows x 13 columns]

```
[]: df = df.replace(to_replace=['yes', 'no'], value=[1, 0])
[]:
                             bedrooms
                                        bathrooms
                                                     stories
                                                               mainroad
                                                                           guestroom
              price area
           13300000
     0
                      7420
                                                            3
                                                                        1
     1
           12250000
                      8960
                                     4
                                                  4
                                                            4
                                                                        1
                                                                                    0
                                     3
                                                  2
                                                            2
     2
           12250000
                      9960
                                                                        1
                                                                                    0
     3
           12215000
                      7500
                                     4
                                                  2
                                                            2
                                                                        1
                                                                                    0
     4
                                                            2
           11410000
                      7420
                                     4
                                                  1
                                                                        1
                                                                                    1
     . .
                                     2
            1820000
                                                  1
                                                                        1
                                                                                    0
     540
                      3000
                                                            1
     541
                                     3
            1767150
                      2400
                                                  1
                                                            1
                                                                        0
                                                                                    0
     542
            1750000
                      3620
                                     2
                                                  1
                                                            1
                                                                        1
                                                                                    0
     543
                                     3
                                                  1
                                                                        0
            1750000
                      2910
                                                            1
                                                                                    0
     544
            1750000
                      3850
                                     3
                                                  1
                                                            2
                                                                        1
                                                                                    0
                                          airconditioning parking
           basement
                      hotwaterheating
     0
                   0
                                      0
                                                          1
                                                                    2
                   0
                                      0
                                                                    3
                                                                                0
     1
                                                          1
     2
                                                                    2
                   1
                                      0
                                                          0
                                                                                1
     3
                   1
                                      0
                                                          1
                                                                    3
                                                                                1
                                                                    2
     4
                   1
                                      0
                                                          1
                                                                                0
     . .
                                                           •••
                                                                    •••
                                                                    2
                                      0
                                                          0
                                                                                0
     540
                   1
     541
                                      0
                                                          0
                                                                    0
                                                                                0
                   0
     542
                   0
                                      0
                                                          0
                                                                    0
                                                                                0
     543
                                      0
                                                                                0
                   0
                                                          0
                                                                    0
     544
                   0
                                      0
                                                          0
                                                                    0
                                                                                0
          furnishingstatus
     0
                  furnished
     1
                  furnished
     2
            semi-furnished
     3
                  furnished
     4
                  furnished
     540
               unfurnished
     541
            semi-furnished
     542
               unfurnished
     543
                  furnished
     544
               unfurnished
```

[545 rows x 13 columns]

[]: # create a training set by randomly selecting 80% of the rows from the DataFrame train = df.sample(frac=0.8, random_state=1)

create a test set by dropping the rows in the training set from the DataFrame test = df.drop(train.index)

[]: test

гэ.		nnico	0700	hadmaama	ha+hmaama	atomica	mainmaad		\
[]:	0	price	area		bathrooms		_	guestroom	\
	2	12250000	9960	3	2	2	1	0	
	3	12215000	7500	4	2	2	1	0	
	7	10150000	16200	5	3	2	1	0	
	15	9100000	6000	4	1	2	1	0	
	22	8645000	8050	3	1	1	1	1	
		•••	•••	•••			•••		
	508	2590000	4400	2	1	1	1	0	
	513	2485000	4400	3	1	2	1	0	
	520	2450000	7700	2	1	1	1	0	
	537	1890000	1700	3	1	2	1	0	
	539	1855000	2990	2	1	1	0	0	
		hasement	hotwat	erheating	airconditi	oning na	arking nre	farea \	
	2	basement	hotwat	_	airconditi			farea \	
	2	basement	hotwat	0	airconditi	0	2	farea \	
	3	_	hotwat	0	airconditi	0	2	1 1	
	3 7	_	hotwat	0	airconditi	0 1 0	2 3 0	farea \ 1 1 0	
	3 7 15	_	hotwat	0	airconditi	0	2	1 1	
	3 7	_	hotwat	0 0	airconditi	0 1 0	2 3 0	1 1 0	
	3 7 15	_	hotwat	0 0 0	airconditi 	0 1 0 0	2 3 0 2	1 1 0 0	
	3 7 15 22	1 1 0 1	hotwat	0 0 0 0		0 1 0 0 0	2 3 0 2	1 1 0 0	
	3 7 15 22	1 1 0 1 1	hotwat	0 0 0 0		0 1 0 0 0 1	2 3 0 2 1	1 1 0 0 0	
	3 7 15 22 508	1 0 1 1 	hotwat	0 0 0 0 0		0 1 0 0 1 0	2 3 0 2 1 	1 1 0 0 0	
	3 7 15 22 508 513	1 0 1 1 	hotwat	0 0 0 0 0		0 1 0 0 1 0	2 3 0 2 1 	1 1 0 0 0	

furnishingstatus

0

539

	•
2	semi-furnished
3	furnished
7	unfurnished
15	semi-furnished
22	furnished
• •	•••
508	unfurnished
508 513	unfurnished unfurnished
	a a a
513	unfurnished
513 520	unfurnished unfurnished

[109 rows x 13 columns]

```
[]: # select specific columns for the training set
     train = train[['price', 'area', 'bedrooms', 'bathrooms', 'stories', 'parking']]
     # select specific columns for the test set
     test = test[['price', 'area', 'bedrooms', 'bathrooms', 'stories', 'parking']]
[]: import sklearn.preprocessing # import scikit-learn library for data_
      →preprocessing
     # create an instance of the MinMaxScaler class for scaling features to a range_
     scaler = sklearn.preprocessing.MinMaxScaler()
[]: train
[]:
                                   bathrooms
                                               stories
           price
                    area
                         bedrooms
                                                        parking
     62
          7070000
                    6240
                                                     4
                                                              3
     247 4550000
                    8400
                                 4
                                            1
                                            2
                                                     2
     142 5600000
                   10500
                                 4
                                                              1
     107 6125000
                    6420
                                 3
                                            1
                                                     3
                                                              0
                                                     2
     483 2940000
                    6615
                                 3
                                            1
                                                              0
     359 3710000
                                 3
                                            1
                                                     1
                                                              1
                    3600
                                            2
     36
         8043000
                    7482
                                 3
                                                     3
                                                              1
                                 3
                                            2
                                                     4
                                                              2
     30
         8400000
                    7475
     20
         8750000
                    4320
                                 3
                                            1
                                                              2
                                 2
     527 2275000
                    1836
                                                     1
                                                              0
     [436 rows x 6 columns]
[]: # create a NumPy array of the 'area' column from the training set
     X1 t = np.array(train['area'])
     # display the NumPy array
     X1_t
                   8400, 10500,
[]: array([6240,
                                  6420,
                                         6615,
                                                3600,
                                                       3240,
                                                              6600,
                                                                     2700,
            5000,
                    2650, 4775,
                                  4800,
                                         3700,
                                                7700,
                                                       7420,
                                                              4280,
                                                                     6000,
                           3420,
                                                3180,
            6600,
                    3649,
                                  5500,
                                         3630,
                                                       3600,
                                                                     3000,
                                                              8400,
                           2145,
            8880,
                    5750,
                                  6360,
                                         6525,
                                                1950,
                                                       5850,
                                                              8372,
                                                                     2870,
            4990,
                    2684, 5200,
                                  6321,
                                         4960,
                                                3480,
                                                       3210,
                                                              4950,
                                                                     6840,
            4350,
                    5850,
                           4410,
                                  2500,
                                         3850,
                                                3180,
                                                       3162,
                                                              3500,
                                                                     4340,
            6440,
                    5010,
                           3000,
                                  4920,
                                         3760,
                                                3816,
                                                       6000,
                                                              7000,
                                                                     3640,
                                                2787,
            4080,
                   4160,
                                  6060,
                                         3000,
                                                       4815,
                                                              4785,
                                                                     6600,
                           2910,
            5300,
                    3600,
                           6000,
                                  2176,
                                         3000,
                                                7420,
                                                       7020, 3480,
                                                                     5960,
```

```
2747,
                      4600,
                              2325,
                                      7231,
                                              3520,
                                                      2145,
                                                              3450,
                                                                      3620,
                                                                              4000,
                                              7200,
              6000,
                      6000,
                              4500,
                                      3540,
                                                      3120,
                                                              4000,
                                                                      2015,
                                                                              4040,
                              3512,
                                              6060,
              8000,
                      2787,
                                      3420,
                                                      4500,
                                                              6360,
                                                                      5450,
                                                                              8250,
                      7410, 10360,
                                      3630,
                                              6020,
                                                      4100,
                                                              6254,
                                                                      4500,
                                                                              4560,
              3960,
              6710,
                      3500,
                              8880,
                                      3600,
                                              7152,
                                                      6000,
                                                              4040,
                                                                      4000,
                                                                              4040,
                              3800,
                                      3960,
              5360,
                      6600,
                                              4900,
                                                      3480,
                                                              3584,
                                                                      2275,
                                                                              4000,
              6500, 10500,
                              8960,
                                      3290,
                                              8875,
                                                      8580,
                                                              3450,
                                                                      6600,
                                                                              2800,
                                      6100, 12090,
              5640,
                      3745, 10269,
                                                      5880,
                                                              6750,
                                                                      6000,
                                                                              5320,
              4000,
                      4040, 15600,
                                      3090,
                                              3970,
                                                      5450,
                                                              4770,
                                                                      4095,
                                                                              6000,
              6540,
                      6550,
                              4320,
                                      3100,
                                              4050,
                                                      3650,
                                                              3850,
                                                                      5600,
                                                                              2817,
                              4995, 11410,
              4510,
                      3000,
                                              3000,
                                                      4840,
                                                              3600,
                                                                      4000,
                                                                              3500,
              7800,
                              4840,
                                              3480,
                                                                              4040,
                      5300,
                                      3000,
                                                      2970,
                                                              5828,
                                                                      3800,
             10700,
                      7320,
                              5000,
                                      6325,
                                              2880,
                                                      4300,
                                                              3150,
                                                                      4000,
                                                                              9500,
                                              5400,
              4500,
                      3420,
                              3180,
                                      2145,
                                                      3630,
                                                              6750,
                                                                      4820,
                                                                              5136,
              4120,
                              4600,
                                              5800,
                      6825,
                                      6650,
                                                      5720,
                                                              5000,
                                                                      4352,
                                                                              3300,
              2160,
                      5900,
                              3000,
                                      4500,
                                              3350,
                                                      5400,
                                                              4600,
                                                                      9800,
                                                                              3630,
                                      4000,
                                              3180,
              2610,
                      9667,
                              3635,
                                                      3630,
                                                              6600,
                                                                      2610,
                                                                              4960,
              5150,
                      6000,
                              3640,
                                      2910,
                                              3650,
                                                      3450,
                                                              4032,
                                                                      7980,
                                                                              1905,
                                      1950, 12900,
              6000,
                      3360,
                              9620,
                                                      3240,
                                                              4320,
                                                                      6540,
                                                                              6000,
                                      4880,
              7440,
                      3760,
                              8100,
                                              6000,
                                                      2000,
                                                              5200,
                                                                      4050,
                                                                              9166,
              7950,
                      5500,
                              2700,
                                      6000,
                                              6900,
                                                      3500,
                                                              5076,
                                                                      5985,
                                                                              4300,
                                              7260,
              8050,
                      5320,
                              5960,
                                      7000,
                                                      6360,
                                                              3000,
                                                                      3460,
                                                                             12944,
                              4080,
              3880,
                      2400,
                                      6000,
                                              4500,
                                                      6050,
                                                              7000,
                                                                      3930,
                                                                              4600,
              7155,
                              2400,
                                              4632,
                                                      4200,
                                                              4640,
                                                                      8800,
                                                                              3000,
                      4100,
                                      3460,
              6300,
                      7000,
                              7000,
                                      6900,
                                              3420,
                                                      3264,
                                                              2640,
                                                                      3150,
                                                                              4320,
              6862, 11440,
                              4992,
                                      3069,
                                              3185,
                                                      3750,
                                                              5300,
                                                                      7200,
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                                                              2145,
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                                                                              3240,
                      6360,
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                                      4646,
                                              3840,
                                                      9000,
                                                              3520,
                                                                      3640,
                                                                              3600,
                      3900,
                                      1836])
              7482,
                      7475,
                              4320,
[]: X1_t = np.array(train['area']) # 'area' column
     X2_t = np.array(train['bedrooms']) # 'bedrooms' column
     X3_t = np.array(train['bathrooms']) # 'bathrooms' column
     X4_t = np.array(train['stories']) # 'stories' column
     X5_t = np.array(train['parking']) # 'parking' column
```

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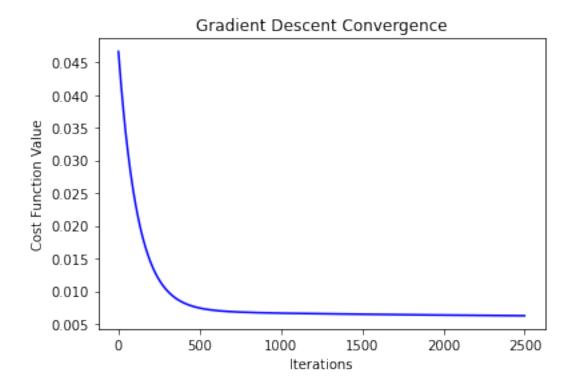
4079,

10500,

```
# create a NumPy array of ones to represent the bias term
     X0_t = np.ones(len(train))
[]: # stack the selected feature arrays vertically using np.vstack
     X = np.vstack([X0_t, X1_t, X2_t, X3_t, X4_t, X5_t])
     # transpose the stacked array to make it a 6 x 436 matrix
     X = X.T
     # convert the stacked array to a NumPy array
     X = np.array(X)
     # display the NumPy array
     Х
[]: array([[1.000e+00, 6.240e+03, 4.000e+00, 2.000e+00, 2.000e+00, 1.000e+00],
            [1.000e+00, 8.400e+03, 4.000e+00, 1.000e+00, 4.000e+00, 3.000e+00],
            [1.000e+00, 1.050e+04, 4.000e+00, 2.000e+00, 2.000e+00, 1.000e+00],
            [1.000e+00, 7.475e+03, 3.000e+00, 2.000e+00, 4.000e+00, 2.000e+00],
            [1.000e+00, 4.320e+03, 3.000e+00, 1.000e+00, 2.000e+00, 2.000e+00],
            [1.000e+00, 1.836e+03, 2.000e+00, 1.000e+00, 1.000e+00, 0.000e+00]])
[]: # scale the feature matrix using the fit_transform() method of the scaler object
     X_scaled = scaler.fit_transform(X)
     # assign the scaled feature matrix to the original variable name 'X'
     X = X \text{ scaled}
[]: # create a 1D NumPy array of zeros with length 6
     theta = np.zeros(6)
     # reshape the 1D array to a column vector using np.reshape
     theta = np.reshape(theta, (6,1))
     # display the column vector
     theta
[]: array([[0.],
            [0.],
            [0.],
            [0.],
            [0.],
            [0.11)
[]: # create a 1D NumPy array 'Y_t' from the 'price' column of the training set_
      →'train'
```

```
Y_t = np.array(train.price)
     # create a copy of 'Y_t' to prevent changing the original data
     Y = Y_t.copy()
     # reshape 'Y' to a column vector using np.reshape
     Y = np.reshape(Y, (436,1))
     # create an instance of the MinMaxScaler class for scaling the target variable_
     \rightarrowto a range of [0, 1]
     scaler = sklearn.preprocessing.MinMaxScaler()
     # scale the target variable using the fit_transform() method of the scaler
      ⇔object
     Y_scaled = scaler.fit_transform(Y)
     # assign the scaled target variable to the original variable name 'Y'
     Y = Y_scaled
[]: # create a NumPy array 'X_T' containing the transpose of the feature matrix 'X'
    X_T = np.array(X.T)
     \# retrieve the number of rows 'm' and the number of columns 'n' from the
      \hookrightarrow feature matrix 'X'
     m, n = X.shape
     # display the values of 'm' and 'n'
     print("Number of training examples (m): ", m)
     print("Number of features (n): ", n)
     # set the number of iterations for gradient descent
     iterations = 2500
     # create a counter variable 'count' and a NumPy array 'j' to store the cost_{\sqcup}
     →function values for each iteration
     count = 0
     j = np.zeros(shape=(iterations, 1), dtype=float)
     # display the shape of the 'j' array
     print("Shape of 'j' array: ", j.shape)
    Number of training examples (m): 436
    Number of features (n): 6
    Shape of 'j' array: (2500, 1)
[]: # set the initial iteration count to zero
     count = 0
```

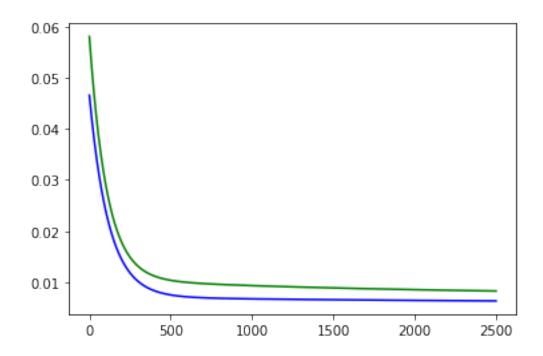
```
# create a NumPy array 'j' to store the cost function values for each iteration
j = np.zeros(shape=(iterations, 1), dtype=float)
# perform gradient descent for the specified number of iterations
while count < iterations:</pre>
    # calculate the predicted values 'h' using the current parameters 'theta'
    h = X.dot(theta)
    # calculate the cost function value 'j' using the current parameters 'theta'
    j[count] = (1/(2*m)) * np.sum((h-Y)**2)
    # calculate the gradient of the cost function with respect to 'theta'
    grad = (1/m) * X_T.dot(h-Y)
    # update the parameters 'theta' using the learning rate 'alpha' and the \Box
 ⇔gradient 'grad'
    alpha = 0.01
    theta = theta - alpha * grad
    # increment the iteration count
    count += 1
# plot the cost function values over the iterations
plt.plot(j,'b-')
plt.xlabel('Iterations')
plt.ylabel('Cost Function Value')
plt.title('Gradient Descent Convergence')
plt.show()
```



```
[]: # extract the test set features into NumPy arrays
     N_X1_t = np.array(test.area)
     N_X2_t = np.array(test.bedrooms)
     N_X3_t = np.array(test.bathrooms)
     N_X4_t = np.array(test.stories)
     N_X5_t = np.array(test.parking)
     N_X0_t = np.ones(109)
[]: # stack the test set features into a design matrix
     N_X = np.vstack([N_X0_t,N_X1_t,N_X2_t,N_X3_t,N_X4_t,N_X5_t])
     N_X_T = N_X.T
     N_X = np.array(N_X_T)
     N_x = scaler.fit_transform(N_X)
     N_X = N_x
     N_X.shape
[]: (109, 6)
[]: N_theta = np.array([0.,0.,0.,0.,0.])
     N_theta = N_theta.reshape(6,1)
     N_theta
```

```
[]: array([[0.],
            [0.],
            [0.],
            [0.],
            [0.],
            [0.]])
[]: N_Y_t = np.array(test.price)
     N_Y = N_Y_t
     N_Y = N_Y_t.reshape(109,1)
     N_y = scaler.fit_transform(N_Y)
     N_Y=N_y
     N_Y.shape
[]: (109, 1)
[]: N_X_T = np.array(N_X.T)
     m,n = N_X.shape
     m,n
[]: (109, 6)
[]: iterations = 2500
     count=0
     N_j = np.zeros(shape=(iterations, 1), dtype=float)
     while(count < iterations):</pre>
         N_h_t = N_X.dot(N_theta)
         N_h = np.array(N_h_t)
         N_j[count] = (1/(2*m))*np.sum((N_h - N_Y)**2)
         grad_t = N_X_T.dot(N_h-N_Y)
         grad = grad_t*(1/m)
         N_{\text{theta}} = N_{\text{theta}} - 0.01*(grad)
         count += 1
[]: plt.plot(N_j, 'g-')
     plt.plot(j,'b-')
```

[]: [<matplotlib.lines.Line2D at 0x7fdb15afbe20>]



hw1-2a-standardization

February 20, 2023

```
[]: import numpy as np # import numpy library
     import pandas as pd # import pandas library
     import matplotlib.pyplot as plt # import matplotlib library
     from sklearn import preprocessing
[]: df = pd.read_csv("/content/sample_data/Housing.csv")
     # display DataFrame
     df
[]:
                                       bathrooms
                                                   stories mainroad guestroom basement
              price
                     area
                            bedrooms
           13300000
                     7420
                                                                 yes
                                                                              no
          12250000
                                                4
                                                          4
     1
                     8960
                                    4
                                                                 yes
                                                                              no
                                                                                       no
     2
                                                2
                                                          2
          12250000
                     9960
                                    3
                                                                 yes
                                                                              no
                                                                                      yes
     3
          12215000
                     7500
                                    4
                                                2
                                                          2
                                                                 yes
                                                                             no
                                                                                      yes
          11410000
                     7420
                                    4
                                                1
                                                          2
                                                                 yes
                                                                             yes
                                                                                      yes
                                    2
     540
           1820000
                     3000
                                                1
                                                          1
                                                                 yes
                                                                             no
                                                                                      yes
     541
           1767150
                     2400
                                    3
                                                1
                                                          1
                                                                                        no
                                                                  no
                                                                              no
     542
                                    2
           1750000
                     3620
                                                          1
                                                                 yes
                                                                              no
                                                                                        no
     543
                                    3
            1750000
                     2910
                                                1
                                                          1
                                                                  no
                                                                              no
                                                                                        no
     544
            1750000
                     3850
                                    3
                                                1
                                                          2
                                                                 yes
                                                                              no
                                                                                        no
         hotwaterheating airconditioning
                                             parking prefarea furnishingstatus
     0
                                                    2
                                                                        furnished
                       no
                                                            yes
     1
                                                    3
                                        yes
                                                             no
                                                                        furnished
                                                    2
     2
                                         no
                                                            yes
                                                                   semi-furnished
                       no
     3
                       no
                                        yes
                                                    3
                                                            yes
                                                                        furnished
     4
                                                    2
                                                                        furnished
                                        yes
                                                             no
                       no
     . .
                                                    2
     540
                                                                      unfurnished
                       no
                                         no
                                                             no
     541
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                                                                   semi-furnished
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                                                             no
     542
                                                    0
                                                                      unfurnished
                       no
                                         no
                                                             no
     543
                                                    0
                                                                        furnished
                                                             no
                       no
                                         no
     544
                                                    0
                                                                      unfurnished
                       no
                                         no
                                                             no
```

[]: # create a training set by randomly selecting 80% of the rows from the DataFrame train = df.sample(frac=0.8, random_state=1)

create a test set by dropping the rows in the training set from the DataFrame test = df.drop(train.index)

[]: train

[]:	price	area	bedrooms	bathrooms	stories	mainroad	guestroom	basement	\
62	7070000	6240	4	2	2	yes	no	no	
247	4550000	8400	4	1	4	yes	no	no	
142	5600000	10500	4	2	2	yes	no	no	
107	6125000	6420	3	1	3	yes	no	yes	
483	2940000	6615	3	1	2	yes	no	no	
	•••	•••	•••		•••	•••	•••		
359	3710000	3600	3	1	1	yes	no	no	
36	8043000	7482	3	2	3	yes	no	no	
30	8400000	7475	3	2	4	yes	no	no	
20	8750000	4320	3	1	2	yes	no	yes	
527	2275000	1836	2	1	1	no	no	yes	

	${\tt hotwaterheating}$	airconditioning	parking	prefarea	furnishingstatus
62	no	yes	1	no	furnished
247	no	no	3	no	unfurnished
142	no	no	1	no	semi-furnished
107	no	no	0	yes	unfurnished
483	no	no	0	no	semi-furnished
	•••	•••		•	•••
 359	 no	 no		no	 unfurnished
			1 1		
359	no	no	1	no	unfurnished
359 36	no yes	no no	1 1	no yes	unfurnished furnished

[436 rows x 13 columns]

[]: test

[]:		price	area	bedrooms	bathrooms	stories	${\tt mainroad}$	guestroom	\
	2	12250000	9960	3	2	2	yes	no	
	3	12215000	7500	4	2	2	yes	no	
	7	10150000	16200	5	3	2	yes	no	
	15	9100000	6000	4	1	2	yes	no	
	22	8645000	8050	3	1	1	yes	yes	
		•••	•••	•••		•••	•••		
	508	2590000	4400	2	1	1	yes	no	
	513	2485000	4400	3	1	2	yes	no	

```
537
           1890000
                      1700
                                   3
                                                         2
                                               1
                                                                yes
                                                                            no
     539
                                   2
           1855000
                      2990
                                               1
                                                         1
                                                                 no
                                                                            no
         basement hotwaterheating airconditioning parking prefarea
     2
              yes
                                no
                                                            2
                                                 no
                                                                   yes
     3
                                                            3
              yes
                                                                   yes
                                no
                                                yes
     7
                                                            0
               no
                                                                    no
                                no
                                                 no
                                                            2
     15
              yes
                                no
                                                 no
                                                                    no
     22
                                                            1
              yes
                                no
                                                yes
                                                                    no
     . .
     508
                                                            0
               no
                                no
                                                 no
                                                                    no
     513
               no
                                no
                                                            0
                                                                    no
                                                 no
     520
                                                            0
               no
                                no
                                                 no
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     537
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     539
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         furnishingstatus
           semi-furnished
     2
     3
                furnished
     7
              unfurnished
     15
           semi-furnished
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                furnished
     . .
     508
              unfurnished
     513
              unfurnished
     520
              unfurnished
     537
              unfurnished
              unfurnished
     539
     [109 rows x 13 columns]
[]: # select specific columns for the training set
     train = train[['price', 'area', 'bedrooms', 'bathrooms', 'stories', 'parking']]
     # select specific columns for the test set
     test = test[['price', 'area', 'bedrooms', 'bathrooms', 'stories', 'parking']]
[]: scaler = preprocessing.StandardScaler()
[]: # create a NumPy array of the 'area' column from the training set
     X1_t = np.array(train['area'])
     # display the NumPy array
     X1 t
```

7700

2

1

1

yes

no

520

2450000

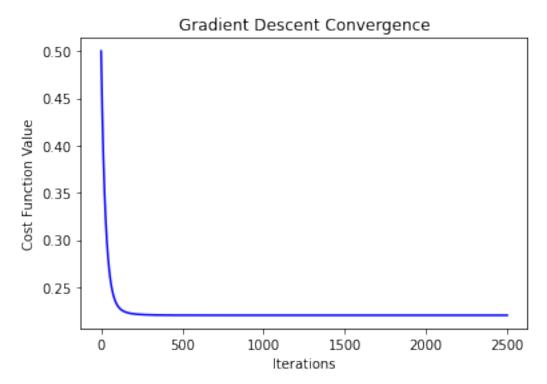
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[]: array([6240,
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                                                                                  9500,
                       7320,
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               4120,
                                4600,
                                                5800,
                                                         5720,
                                                                 5000,
                       6825,
                                        6650,
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               2160,
                       5900,
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                                        4500,
                                                3350,
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               8050,
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                       4100,
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               5800,
                                4120,
                                                2850,
                                                                 2145,
                                                                          4500,
                                                                                  3240,
                       6360,
                                        5400,
```

```
13200, 3900, 9000, 4646, 3840, 9000, 3520, 3640, 3600,
            7482, 7475, 4320, 1836])
[]: X1_t = np.array(train['area']) # 'area' column
    X2_t = np.array(train['bedrooms']) # 'bedrooms' column
    X3_t = np.array(train['bathrooms']) # 'bathrooms' column
    X4_t = np.array(train['stories']) # 'stories' column
    X5_t = np.array(train['parking']) # 'parking' column
     # create a NumPy array of ones to represent the bias term
    X0 t = np.ones(len(train))
[]: # stack the selected feature arrays vertically using np.vstack
    X = np.vstack([X0_t, X1_t, X2_t, X3_t, X4_t, X5_t])
     # transpose the stacked array to make it a 6 x 436 matrix
    X = X.T
    # convert the stacked array to a NumPy array
    X = np.array(X)
    # display the NumPy array
    Х
[]: array([[1.000e+00, 6.240e+03, 4.000e+00, 2.000e+00, 2.000e+00, 1.000e+00],
            [1.000e+00, 8.400e+03, 4.000e+00, 1.000e+00, 4.000e+00, 3.000e+00],
            [1.000e+00, 1.050e+04, 4.000e+00, 2.000e+00, 2.000e+00, 1.000e+00],
           ...,
            [1.000e+00, 7.475e+03, 3.000e+00, 2.000e+00, 4.000e+00, 2.000e+00],
            [1.000e+00, 4.320e+03, 3.000e+00, 1.000e+00, 2.000e+00, 2.000e+00],
            [1.000e+00, 1.836e+03, 2.000e+00, 1.000e+00, 1.000e+00, 0.000e+00]])
[]: x = scaler.fit_transform(X)
    X = X
[]: # create a 1D NumPy array of zeros with length 6
    theta = np.zeros(6)
     # reshape the 1D array to a column vector using np.reshape
    theta = np.reshape(theta, (6,1))
     # display the column vector
    theta
[]: array([[0.],
            [0.],
            [0.],
```

```
[0.],
            [0.]])
[]: # create a 1D NumPy array 'Y t' from the 'price' column of the training setu
     →'train'
     #h = np.matmul(X, theta)
     Y_t = np.array(train.price)
     Y = Y t
     Y = Y_t.reshape(436,1)
     y = scaler.fit_transform(Y)
     Y=y
[]: # create a NumPy array 'X_T' containing the transpose of the feature matrix 'X'
     X_T = np.array(X.T)
     # retrieve the number of rows 'm' and the number of columns 'n' from the
     \hookrightarrow feature matrix 'X'
     m, n = X.shape
     # display the values of 'm' and 'n'
     print("Number of training examples (m): ", m)
     print("Number of features (n): ", n)
     # set the number of iterations for gradient descent
     iterations = 2500
     # create a counter variable 'count' and a NumPy array 'j' to store the cost_{\sqcup}
     →function values for each iteration
     count = 0
     j = np.zeros(shape=(iterations, 1), dtype=float)
     # display the shape of the 'j' array
     print("Shape of 'j' array: ", j.shape)
    Number of training examples (m): 436
    Number of features (n): 6
    Shape of 'j' array: (2500, 1)
[]: # set the initial iteration count to zero
     count = 0
     # create a NumPy array 'j' to store the cost function values for each iteration
     j = np.zeros(shape=(iterations, 1), dtype=float)
     # perform gradient descent for the specified number of iterations
     while count < iterations:</pre>
```

[0.],

```
# calculate the predicted values 'h' using the current parameters 'theta'
   h = X.dot(theta)
   # calculate the cost function value 'j' using the current parameters 'theta'
   j[count] = (1/(2*m)) * np.sum((h-Y)**2)
    # calculate the gradient of the cost function with respect to 'theta'
   grad = (1/m) * X_T.dot(h-Y)
    # update the parameters 'theta' using the learning rate 'alpha' and the
 ⇔gradient 'grad'
   alpha = 0.01
   theta = theta - alpha * grad
    # increment the iteration count
   count += 1
# plot the cost function values over the iterations
plt.plot(j,'b-')
plt.xlabel('Iterations')
plt.ylabel('Cost Function Value')
plt.title('Gradient Descent Convergence')
plt.show()
```



```
[]: # extract the test set features into NumPy arrays
     N_X1_t = np.array(test.area)
     N_X2_t = np.array(test.bedrooms)
     N_X3_t = np.array(test.bathrooms)
     N_X4_t = np.array(test.stories)
     N_X5_t = np.array(test.parking)
     N_X0_t = np.ones(109)
[]: # stack the test set features into a design matrix
     N_X = np.vstack([N_X0_t, N_X1_t, N_X2_t, N_X3_t, N_X4_t, N_X5_t])
     N_X_T = N_X.T
     N_X = np.array(N_X_T)
     N_x = scaler.fit_transform(N_X)
     N_X = N_x
     N_X.shape
[]: (109, 6)
[]: N_{\text{theta}} = \text{np.array}([0.,0.,0.,0.,0.])
     N_theta = N_theta.reshape(6,1)
     N_{theta}
[]: array([[0.],
            [0.],
            [0.],
            [0.],
            [0.],
            [0.]])
[]: N_Y_t = np.array(test.price)
     N_Y = N_Y_t
     N_Y = N_Y_t.reshape(109,1)
     N_y = scaler.fit_transform(N_Y)
     N_Y=N_y
     N_Y.shape
[]: (109, 1)
[]: N_X_T = np.array(N_X.T)
     m,n = N_X.shape
     m,n
[]: (109, 6)
```

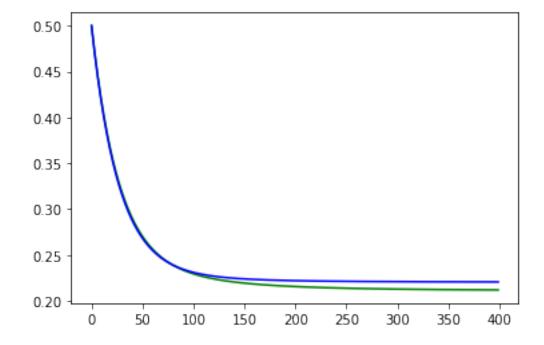
```
[]: iterations = 2500
count=0
N_j = np.zeros(shape=(iterations, 1), dtype=float)
while(count < iterations):
    N_h_t = N_X.dot(N_theta)
    N_h = np.array(N_h_t)

    N_j[count] = (1/(2*m))*np.sum((N_h - N_Y)**2)
    grad_t = N_X_T.dot(N_h-N_Y)
    grad = grad_t*(1/m)

    N_theta = N_theta - 0.01*(grad)
    count += 1</pre>
```

```
[]: plt.plot(N_j[:400], 'g-')
plt.plot(j[:400], 'b-')
```

[]: [<matplotlib.lines.Line2D at 0x7f9ecbdcf5b0>]



hw1-2b-normalization

February 20, 2023

```
[5]: import numpy as np # import numpy library
     import pandas as pd # import pandas library
     import matplotlib.pyplot as plt # import matplotlib library
     from sklearn import preprocessing # import scikit-learn library (source: https:
      →//scikit-learn.org/stable/index.html)
[]: df = pd.read_csv("/content/sample_data/Housing.csv")
     # display DataFrame
     df
[8]: df = df.replace(to_replace=['yes', 'no'], value=[1, 0])
[8]:
             price area
                           bedrooms
                                      bathrooms stories
                                                           mainroad
                                                                      guestroom
          13300000
                     7420
                                                        3
                                                                   1
                                                                               0
     1
          12250000 8960
                                   4
                                              4
                                                        4
                                                                   1
                                                                              0
     2
                                   3
                                              2
                                                        2
          12250000
                     9960
                                                                   1
                                                                               0
                                              2
                                                        2
     3
          12215000
                     7500
                                   4
                                                                   1
                                                                               0
          11410000
                     7420
                                                        2
     4
                                              1
                                                                   1
                                                                               1
     . .
           1820000 3000
                                   2
                                                                   1
                                                                               0
     540
                                              1
                                                        1
     541
           1767150
                     2400
                                   3
                                              1
                                                        1
                                                                   0
                                                                              0
     542
           1750000
                     3620
                                   2
                                              1
                                                        1
                                                                   1
                                                                              0
     543
                                   3
                                               1
                                                        1
                                                                   0
           1750000
                     2910
                                                                              0
                                   3
                                               1
                                                        2
     544
           1750000
                     3850
                                                                   1
                                                                              0
                     hotwaterheating
          basement
                                       airconditioning parking
     0
                  0
                                    0
                                                      1
                                                               2
                                                                          1
                  0
                                    0
                                                      1
                                                               3
                                                                          0
     1
                                                               2
     2
                  1
                                    0
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     3
                  1
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     4
                  1
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```

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	544	0		0		0	0	0	
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	2	semi-fur	rnished						
	3		rnished						
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	540	unfun	nished						
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	543		rnished						
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	011	uiii ui	Inibnea						
	[545	rows x 13	3 colum	ns]					
5-7									
[9]:			_			_	s of the ro	ws from the l	DataFrame
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	# 67	reate a te	st set	bu droppin	a the rows	in the t	rainina se	t from the Do	ataFrame
		: = df.dro			9 1.12 . 1			<i>J. o.</i> 0100 20	
			, (0 = 0 =						
[10]:	trai	.n							
	trai		area	hedrooms	hathrooms	stories	mainroad	guestroom	\
[10]: [10]:		price	area	bedrooms	bathrooms			0	\
	62	price 7070000	6240	4	2	2	1	0	\
	62 247	price 7070000 4550000	6240 8400	4 4	2 1	2 4	1	0	\
	62 247 142	price 7070000 4550000 5600000	6240 8400 10500	4 4 4	2 1 2	2 4 2	1 1 1	0 0 0	\
	62 247 142 107	price 7070000 4550000 5600000 6125000	6240 8400 10500 6420	4 4 4 3	2 1 2 1	2 4 2 3	1 1 1 1	0 0 0 0	\
	62 247 142	price 7070000 4550000 5600000	6240 8400 10500	4 4 4	2 1 2	2 4 2	1 1 1 1	0 0 0	\
	62 247 142 107 483	price 7070000 4550000 5600000 6125000 2940000	6240 8400 10500 6420 6615	4 4 4 3 3	2 1 2 1 1	2 4 2 3 2	1 1 1 1 1	0 0 0 0	\
	62 247 142 107 483 	price 7070000 4550000 5600000 6125000 2940000 3710000	6240 8400 10500 6420 6615 	4 4 4 3 3 	2 1 2 1 1 	2 4 2 3 2 	1 1 1 1 	0 0 0 0 0	\
	62 247 142 107 483 359 36	price 7070000 4550000 5600000 6125000 2940000 3710000 8043000	6240 8400 10500 6420 6615 3600 7482	4 4 4 3 3 3	2 1 2 1 1 1 2	2 4 2 3 2 1 3	1 1 1 1 	0 0 0 0 0	\
	62 247 142 107 483 359 36 30	price 7070000 4550000 5600000 6125000 2940000 3710000 8043000 8400000	6240 8400 10500 6420 6615 3600 7482 7475	4 4 4 3 3 3 3	2 1 2 1 1 1 2 2	2 4 2 3 2 1 3 4	1 1 1 1 	0 0 0 0 0	\
	62 247 142 107 483 359 36 30 20	price 7070000 4550000 5600000 6125000 2940000 3710000 8043000 8400000 8750000	6240 8400 10500 6420 6615 3600 7482 7475 4320	4 4 4 3 3 3 3 3	2 1 2 1 1 1 2 2 1	2 4 2 3 2 1 3 4	1 1 1 1 	0 0 0 0 0	\
	62 247 142 107 483 359 36 30	price 7070000 4550000 5600000 6125000 2940000 3710000 8043000 8400000	6240 8400 10500 6420 6615 3600 7482 7475	4 4 4 3 3 3 3	2 1 2 1 1 1 2 2	2 4 2 3 2 1 3 4	1 1 1 1 	0 0 0 0 0	\
	62 247 142 107 483 359 36 30 20	price 7070000 4550000 5600000 6125000 2940000 3710000 8043000 8400000 8750000 2275000	6240 8400 10500 6420 6615 3600 7482 7475 4320 1836	4 4 4 3 3 3 3 3 3 2	2 1 2 1 1 1 2 2 2 1 1	2 4 2 3 2 1 3 4 2 1	1 1 1 1 	0 0 0 0 0 0	\
	62 247 142 107 483 359 36 30 20	price 7070000 4550000 5600000 6125000 2940000 3710000 8043000 8400000 8750000	6240 8400 10500 6420 6615 3600 7482 7475 4320 1836	4 4 4 3 3 3 3 3 3 2	2 1 2 1 1 1 2 2 2 1 1	2 4 2 3 2 1 3 4 2 1	1 1 1 1 	0 0 0 0 0 0	\
	62 247 142 107 483 359 36 30 20 527	price 7070000 4550000 5600000 6125000 2940000 3710000 8043000 8400000 8750000 2275000 basement	6240 8400 10500 6420 6615 3600 7482 7475 4320 1836	4 4 4 3 3 3 3 3 2 terheating	2 1 2 1 1 1 2 2 2 1 1	2 4 2 3 2 1 3 4 2 1 ioning 1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	0 0 0 0 0 0 0 0 0	
	62 247 142 107 483 359 36 30 20 527	price 7070000 4550000 5600000 6125000 2940000 3710000 8043000 8400000 8750000 2275000 basement 0	6240 8400 10500 6420 6615 3600 7482 7475 4320 1836	4 4 4 3 3 3 3 3 2 terheating 0	2 1 2 1 1 1 2 2 2 1 1	2 4 2 3 2 1 3 4 2 1 ioning 1 0	1 1 1 1 1 1 1 1 1 1 0 parking pr 1 3	0 0 0 0 0 0 0 0 0 0 0	
	62 247 142 107 483 359 36 30 20 527	price 7070000 4550000 5600000 6125000 2940000 3710000 8043000 8400000 8750000 2275000 basement 0 0	6240 8400 10500 6420 6615 3600 7482 7475 4320 1836	4 4 4 3 3 3 3 3 2 terheating 0 0	2 1 2 1 1 1 2 2 2 1 1	2 4 2 3 3 2 1 3 4 2 1 ioning 1 0 0	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	0 0 0 0 0 0 0 0 0 0 0 0	
	62 247 142 107 483 359 36 30 20 527 62 247 142 107	price 7070000 4550000 5600000 6125000 2940000 3710000 8043000 8400000 8750000 2275000 basement 0 0 0 1	6240 8400 10500 6420 6615 3600 7482 7475 4320 1836	4 4 4 3 3 3 3 3 2 terheating 0 0	2 1 2 1 1 1 2 2 2 1 1	2 4 2 3 3 2 2 1 3 4 2 2 1 1 ioning 1 0 0 0 0	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	0 0 0 0 0 0 0 0 0 0 0 0 0	
	62 247 142 107 483 359 36 30 20 527 62 247 142 107 483	price 7070000 4550000 5600000 6125000 2940000 3710000 8043000 8400000 8750000 2275000 basement 0 0	6240 8400 10500 6420 6615 3600 7482 7475 4320 1836	4 4 4 3 3 3 3 3 2 terheating 0 0	2 1 2 1 1 1 2 2 2 1 1	2 4 2 3 3 2 1 3 4 2 1 ioning 1 0 0	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	0 0 0 0 0 0 0 0 0 0 0 0	
	62 247 142 107 483 359 36 30 20 527 62 247 142 107	price 7070000 4550000 5600000 6125000 2940000 3710000 8043000 8400000 8750000 2275000 basement 0 0 0 1	6240 8400 10500 6420 6615 3600 7482 7475 4320 1836	4 4 4 3 3 3 3 3 2 terheating 0 0	2 1 2 1 1 1 2 2 2 1 1	2 4 2 3 3 2 2 1 3 4 2 2 1 1 ioning 1 0 0 0 0	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	0 0 0 0 0 0 0 0 0 0 0 0 0	

36 30 20 527	0 0 1 1	1 0 1 0	0 1 0 0	1 2 2 0	1 0 0 0
i	furnishingstatus				
62	furnished				
247	unfurnished				
142	semi-furnished				
107	unfurnished				
483	semi-furnished				
	•••				
359	unfurnished				
36	furnished				

[436 rows x 13 columns]

unfurnished

semi-furnished

semi-furnished

[11]: test

30

20

527

[11]:		price	area	bedrooms	bathrooms	stories	s mainro	oad gue	stroom	\
	2	12250000	9960	3	2	2	2	1	0	
	3	12215000	7500	4	2	2	2	1	0	
	7	10150000	16200	5	3	2	2	1	0	
	15	9100000	6000	4	1	2	2	1	0	
	22	8645000	8050	3	1	1	L	1	1	
			•••	•••		•••	•••			
	508	2590000	4400	2	1	1	L	1	0	
	513	2485000	4400	3	1	2	2	1	0	
	520	2450000	7700	2	1	1	L	1	0	
	537	1890000	1700	3	1	2	2	1	0	
	539	1855000	2990	2	1	1	L	0	0	
								_		
	_	basement	hotwat	erheating	airconditi		_	prefare	ea \	
	2	1		0		0	2		1	
	3	1		0		1	3		1	
	7	0		0		0	0		0	
	15	1		0		0	2		0	
	22	1		0		1	1		0	
	• •	•••		•••	•••	•••	•••			
	508	0		0		0	0		0	
	513	0		0		0	0		0	
	520	0		0		0	0		0	
	537	0		0		0	0		0	
	539	0		0		0	1		0	

```
furnishingstatus
     2
           semi-furnished
     3
                furnished
     7
              unfurnished
           semi-furnished
     15
     22
                furnished
     . .
              unfurnished
     508
     513
              unfurnished
              unfurnished
     520
     537
              unfurnished
              unfurnished
     539
     [109 rows x 13 columns]
[12]: # select specific columns for the training set
     train = train[['price', 'area', 'bedrooms', 'bathrooms', 'stories', 'parking', __
      ⇔'mainroad', 'guestroom', 'basement', 'hotwaterheating', 'airconditioning',⊔
      # select specific columns for the test set
     → 'mainroad', 'guestroom', 'basement', 'hotwaterheating', 'airconditioning', □

¬'prefarea']]
[13]: import sklearn.preprocessing # import scikit-learn library for data_
       →preprocessing
     # create an instance of the MinMaxScaler class for scaling features to a range_
      ⇔of [0, 1]
     scaler = sklearn.preprocessing.MinMaxScaler()
[14]: train
[14]:
                    area bedrooms bathrooms stories parking mainroad \
            price
     62
          7070000
                    6240
                                          2
                                                            1
     247 4550000
                    8400
                                4
                                          1
                                                   4
                                                            3
                                                                     1
     142 5600000 10500
                                4
                                          2
                                                   2
                                                            1
                                                                     1
     107 6125000
                    6420
                                3
                                           1
                                                   3
                                                            0
                                                                     1
     483 2940000
                    6615
                                3
                                           1
                                                            0
     359 3710000
                    3600
                                3
                                          1
                                                            1
                                                                     1
                                                   1
     36
          8043000
                   7482
                                3
                                          2
                                                   3
                                                            1
                                                                     1
          8400000
                   7475
                                3
                                          2
                                                   4
                                                            2
     30
                                                                     1
                                3
                                                   2
                                                            2
     20
          8750000
                    4320
                                          1
                                                                     1
                                2
     527 2275000
                    1836
                                          1
                                                   1
                                                            0
                                                                     0
```

	${ t guestroom}$	basement	hotwaterheating	airconditioning	prefarea
62	0	0	0	1	0
247	0	0	0	0	0
142	0	0	0	0	0
107	0	1	0	0	1
483	0	0	0	0	0
	•••	•••	•••		
359	0	0	0	0	0
36	0	0	1	0	1
30	0	0	0	1	0
20	0	1	1	0	0
527	0	1	0	0	0

[436 rows x 12 columns]

```
[15]: # create a NumPy array of the 'area' column from the training set
X1_t = np.array(train['area'])

# display the NumPy array
X1_t
```

```
[15]: array([ 6240,
                        8400, 10500,
                                         6420,
                                                 6615,
                                                         3600,
                                                                          6600,
                                                                                  2700,
                                                                  3240,
                5000,
                        2650,
                                 4775,
                                         4800,
                                                 3700,
                                                         7700,
                                                                  7420,
                                                                          4280,
                                                                                  6000,
                6600,
                        3649,
                                 3420,
                                         5500,
                                                 3630,
                                                         3180,
                                                                  3600,
                                                                          8400,
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                                 2145,
                                                 6525,
                                                          1950,
                8880,
                        5750,
                                         6360,
                                                                  5850,
                                                                          8372,
                                                                                  2870,
                4990,
                        2684,
                                 5200,
                                         6321,
                                                 4960,
                                                         3480,
                                                                  3210,
                                                                          4950,
                                                                                  6840,
                4350,
                        5850,
                                 4410,
                                         2500,
                                                 3850,
                                                         3180,
                                                                  3162,
                                                                          3500,
                                                                                  4340,
                6440,
                                 3000,
                                                 3760,
                                                         3816,
                                                                          7000,
                        5010,
                                         4920,
                                                                  6000,
                                                                                  3640,
                4080,
                        4160,
                                 2910,
                                         6060,
                                                 3000,
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                                                                  4815,
                                                                          4785,
                                                                                  6600,
                5300,
                                 6000,
                                                 3000,
                                                         7420,
                        3600,
                                         2176,
                                                                  7020,
                                                                          3480,
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              7482,
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                             4320,
                                    1836])
[16]: X2_t = np.array(train.bedrooms)
      X3 t = np.array(train.bathrooms)
      X4_t = np.array(train.stories)
      X5 t = np.array(train.parking)
      X6_t = np.array(train.mainroad)
      X7_t = np.array(train.guestroom)
      X8 t = np.array(train.hotwaterheating)
      X9_t = np.array(train.airconditioning)
      X10 t = np.array(train.prefarea)
      X11_t = np.array(train.basement)
      X0_t = np.ones(436)
[17]: # stack the selected feature arrays vertically using np.vstack
      X = np.vstack([X0_t, X1_t, X2_t, X3_t, X4_t, X5_t,]
       4X6_t, X7_t, X8_t, X9_t, X10_t, X11_t]
      # transpose the stacked array to make it a 6 x 436 matrix
      X = X.T
      # convert the stacked array to a NumPy array
      X = np.array(X)
      # display the NumPy array
```

6540,

4510,

6550,

3000,

4320, 3100,

4995, 11410,

4050,

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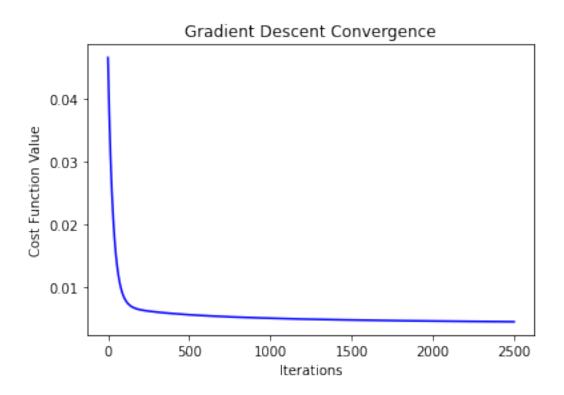
3500,

```
[17]: array([[1.000e+00, 6.240e+03, 4.000e+00, ..., 1.000e+00, 0.000e+00,
              0.000e+00],
             [1.000e+00, 8.400e+03, 4.000e+00, ..., 0.000e+00, 0.000e+00,
              0.000e+00],
             [1.000e+00, 1.050e+04, 4.000e+00, ..., 0.000e+00, 0.000e+00,
              0.000e+00],
             [1.000e+00, 7.475e+03, 3.000e+00, ..., 1.000e+00, 0.000e+00,
              0.000e+001.
             [1.000e+00, 4.320e+03, 3.000e+00, ..., 0.000e+00, 0.000e+00,
              1.000e+00],
             [1.000e+00, 1.836e+03, 2.000e+00, ..., 0.000e+00, 0.000e+00,
              1.000e+00]])
[18]: # scale the feature matrix using the fit_transform() method of the scaler object
      X_scaled = scaler.fit_transform(X)
      # assign the scaled feature matrix to the original variable name 'X'
      X = X \text{ scaled}
[19]: # create a 1D NumPy array of zeros with length 12
      theta = np.zeros(12)
      # reshape the 1D array to a column vector using np.reshape
      theta = np.reshape(theta, (12,1))
      # display the column vector
      theta
[19]: array([[0.],
             [0.],
             [0.],
             ſ0.1.
             [0.],
             [0.],
             [0.],
             [0.],
             [0.],
             [0.],
             [0.],
             [0.]])
[20]: # create a 1D NumPy array 'Y_t' from the 'price' column of the training set
       →'train'
      Y_t = np.array(train.price)
```

Х

```
# create a copy of 'Y_t' to prevent changing the original data
      Y = Y_t.copy()
      # reshape 'Y' to a column vector using np.reshape
      Y = np.reshape(Y, (436,1))
      # create an instance of the MinMaxScaler class for scaling the target variable_
       \hookrightarrow to a range of [0, 1]
      scaler = sklearn.preprocessing.MinMaxScaler()
      # scale the target variable using the fit_transform() method of the scaler_
       ⇔object
      Y_scaled = scaler.fit_transform(Y)
      # assign the scaled target variable to the original variable name 'Y'
      Y = Y \text{ scaled}
[21]:  \# \ create \ a \ NumPy \ array \ 'X_T' \ containing \ the \ transpose \ of \ the \ feature \ matrix \ 'X' 
      X_T = np.array(X.T)
      # retrieve the number of rows 'm' and the number of columns 'n' from the \Box
       \hookrightarrow feature matrix 'X'
      m, n = X.shape
      # display the values of 'm' and 'n'
      print("Number of training examples (m): ", m)
      print("Number of features (n): ", n)
      # set the number of iterations for gradient descent
      iterations = 2500
      \# create a counter variable 'count' and a NumPy array 'j' to store the cost
       ⇔function values for each iteration
      count = 0
      j = np.zeros(shape=(iterations, 1), dtype=float)
      # display the shape of the 'j' array
      print("Shape of 'j' array: ", j.shape)
     Number of training examples (m): 436
     Number of features (n): 12
     Shape of 'j' array: (2500, 1)
[22]: # set the initial iteration count to zero
      count = 0
```

```
# create a NumPy array 'j' to store the cost function values for each iteration
j = np.zeros(shape=(iterations, 1), dtype=float)
# perform gradient descent for the specified number of iterations
while count < iterations:</pre>
    # calculate the predicted values 'h' using the current parameters 'theta'
   h = X.dot(theta)
    # calculate the cost function value 'j' using the current parameters 'theta'
    j[count] = (1/(2*m)) * np.sum((h-Y)**2)
    # calculate the gradient of the cost function with respect to 'theta'
    grad = (1/m) * X_T.dot(h-Y)
    # update the parameters 'theta' using the learning rate 'alpha' and the \Box
 ⇔gradient 'grad'
    alpha = 0.01
    theta = theta - alpha * grad
    # increment the iteration count
    count += 1
# plot the cost function values over the iterations
plt.plot(j,'b-')
plt.xlabel('Iterations')
plt.ylabel('Cost Function Value')
plt.title('Gradient Descent Convergence')
plt.show()
```



```
N X2 t = np.array(test.bedrooms)
      N_X3_t = np.array(test.bathrooms)
      N_X4_t = np.array(test.stories)
      N_X5_t = np.array(test.parking)
      N_X6_t = np.array(test.mainroad)
      N_X7_t = np.array(test.guestroom)
      N_X8_t = np.array(test.hotwaterheating)
      N_X9_t = np.array(test.airconditioning)
      N_X10_t = np.array(test.prefarea)
      N_X11_t = np.array(test.basement)
      N_X0_t = np.ones(109)
[24]: # stack the test set features into a design matrix
      N_X = np.vstack([N_X0_t,N_X1_t,N_X2_t,N_X3_t,N_X4_t,N_X5_t,__
       →N_X6_t,N_X7_t,N_X8_t,N_X9_t,N_X10_t,N_X11_t])
      N_X_T = N_X.T
      N_X = np.array(N_X_T)
      N_x = scaler.fit_transform(N_X)
      N_X = N_x
      N_X.shape
```

[23]: # extract the test set features into NumPy arrays

N_X1_t = np.array(test.area)

```
[24]: (109, 12)
[25]: # initialize the parameters for the test set
      N_{\text{theta}} = \text{np.array}([0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.])
      N_theta = N_theta.reshape(12,1)
      N_{\text{theta}}
[25]: array([[0.],
              [0.],
              [0.],
              [0.],
              [0.],
              [0.],
              [0.],
              [0.],
              [0.],
              [0.],
              [0.],
              [0.]])
[26]: # initialize the target variable for the test set
      N_Y_t = np.array(test.price)
      N_Y = N_Y_t
      N_Y = N_Y_t.reshape(109,1)
      N_y = scaler.fit_transform(N_Y)
      N_Y=N_y
      N_Y.shape
[26]: (109, 1)
[27]: N_X_T = np.array(N_X.T)
      m,n = N_X.shape
      m,n
[27]: (109, 12)
[28]: iterations = 2500
      count=0
      N_j = np.zeros(shape=(iterations, 1), dtype=float)
      while(count < iterations):</pre>
          N_h_t = N_X.dot(N_theta)
          N_h = np.array(N_h_t)
          N_j[count] = (1/(2*m))*np.sum((N_h - N_Y)**2)
```

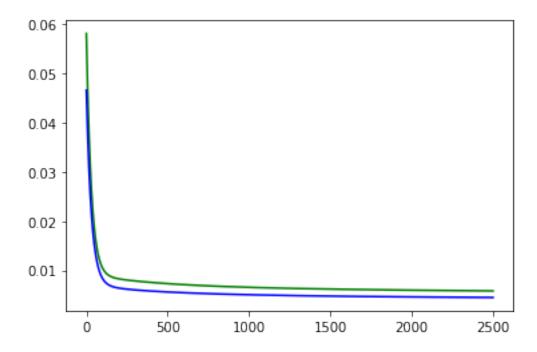
```
grad_t = N_X_T.dot(N_h-N_Y)
grad = grad_t*(1/m)

N_theta = N_theta - 0.01*(grad)

count += 1
```

```
[29]: plt.plot(N_j,'g-')
plt.plot(j,'b-')
```

[29]: [<matplotlib.lines.Line2D at 0x7fb76ca055b0>]



hw1-2b-standardization

February 20, 2023

```
[]: import numpy as np # import numpy library
     import pandas as pd # import pandas library
     import matplotlib.pyplot as plt # import matplotlib library
     from sklearn import preprocessing
[]: df = pd.read_csv("/content/sample_data/Housing.csv")
     # display DataFrame
     df
[]:
                                       bathrooms
                                                   stories mainroad guestroom basement
              price
                     area
                            bedrooms
           13300000
                     7420
                                                                 yes
                                                                             no
          12250000
                                                4
                                                          4
     1
                     8960
                                    4
                                                                 yes
                                                                             no
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                                                          2
          12250000
                     9960
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                                                                             no
                                                                                      yes
     3
          12215000
                     7500
                                    4
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                                                                 yes
                                                                             no
                                                                                      yes
          11410000
                     7420
                                    4
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                                                          2
                                                                 yes
                                                                            yes
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                                    2
     540
           1820000
                     3000
                                                1
                                                          1
                                                                 yes
                                                                             no
                                                                                      yes
     541
           1767150
                     2400
                                    3
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                                                                             no
     542
                                    2
           1750000
                     3620
                                                          1
                                                                 yes
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     543
                                    3
            1750000
                     2910
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     544
            1750000
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                                             parking prefarea furnishingstatus
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     1
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                                        yes
                                                             no
                                                                        furnished
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                                         no
                                                            yes
                                                                   semi-furnished
                       no
     3
                       no
                                        yes
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                                                                        furnished
     4
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     540
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     543
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                       no
                                         no
     544
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                                                                      unfurnished
                       no
                                         no
                                                             no
```

[545 rows x 13 columns]

```
[]: df = df.replace(to_replace=['yes', 'no'], value=[1, 0])
     df
[]:
                                        bathrooms
                                                    stories
                                                              mainroad
                                                                          guestroom
                             bedrooms
              price
                      area
           13300000
                      7420
                                     4
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                                         airconditioning parking
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          furnishingstatus
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     2
            semi-furnished
     3
                 furnished
     4
                  furnished
     . .
               unfurnished
     540
     541
            semi-furnished
     542
               unfurnished
     543
                  furnished
     544
               unfurnished
     [545 rows x 13 columns]
```

[]: # create a training set by randomly selecting 80% of the rows from the DataFrame train = df.sample(frac=0.8, random_state=1)

create a test set by dropping the rows in the training set from the DataFrame
test = df.drop(train.index)

[]: train

[]:		price	area	bedrooms	bathrooms	stories	mainroad	d guestr	oom	\
	62	7070000		4	2	2		1	0	`
	247	4550000	8400	4	1	4		1	0	
	142	5600000	10500	4	2	2		1	0	
	107	6125000	6420	3	1	3		1	0	
	483	2940000	6615	3	1	2		1	0	
		•••	•••	•••		•••	•••			
	359	3710000	3600	3	1	1		1	0	
	36	8043000	7482	3	2	3		1	0	
	30	8400000	7475	3	2	4		1	0	
	20	8750000	4320	3	1	2		1	0	
	527	2275000	1836	2	1	1	(C	0	
		h +	h . +	+ h +					`	
	62	basement	notwa		aircondit	10ning	parking]	prerarea O	\	
		0		0		1	1			
	247	0		0		0	3	0		
	142	0		0		0	1	0		
	107	1		0		0	0	1		
	483	0		0		0	0	0		
	 359				•••	· · · · · ·	 1	0		
		0		0		0	1	4		
	36	0		1		0	1	1		
	30	0		0		1	2	0		
	20	1		1		0	2	0		
	527	1		0		0	0	0		

furnishingstatus 62 furnished 247 unfurnished

142 semi-furnished

107 unfurnished483 semi-furnished

.. ...

359 unfurnished36 furnished

30 unfurnished

20 semi-furnished527 semi-furnished

[436 rows x 13 columns]

[]: test

```
[]:
                           bedrooms
                                      bathrooms
                                                 stories
                                                          mainroad
                                                                    guestroom
             price
                     area
          12250000
                     9960
                                                       2
     2
                                   3
                                              2
                                                                  1
                                                                             0
                                   4
                                              2
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                                                                  1
                                                                             0
     3
          12215000
                     7500
     7
          10150000
                    16200
                                   5
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                    hotwaterheating
          basement
                                      airconditioning
                                                       parking
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              unfurnished
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           semi-furnished
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                furnished
     . .
     508
              unfurnished
     513
              unfurnished
     520
              unfurnished
     537
              unfurnished
     539
              unfurnished
     [109 rows x 13 columns]
[]: # select specific columns for the training set
     train = train[['price', 'area', 'bedrooms', 'bathrooms', 'stories', 'parking', _

¬'prefarea']]
     # select specific columns for the test set
```

```
¬'mainroad', 'guestroom', 'basement', 'hotwaterheating', 'airconditioning',

      []: scaler = preprocessing.StandardScaler()
[]: train
[]:
                          bedrooms
                                    bathrooms
                                                         parking mainroad
            price
                    area
                                                stories
          7070000
                                 4
                                                      2
                    6240
     247 4550000
                                                      4
                                                                3
                    8400
                                 4
                                             1
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     142 5600000
                   10500
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     107
          6125000
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     483 2940000
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     359 3710000
                    3600
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                                             2
     36
          8043000
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                    7482
                                 3
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     30
          8400000
                    7475
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          8750000
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     527 2275000
                    1836
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                                                                0
                    basement hotwaterheating airconditioning prefarea
          guestroom
     62
                  0
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     527
                  0
                                              0
     [436 rows x 12 columns]
[]: # create a NumPy array of the 'area' column from the training set
     X1_t = np.array(train['area'])
     # display the NumPy array
     X1 t
                    8400, 10500,
                                  6420,
[]: array([6240,
                                         6615,
                                                 3600,
                                                        3240,
                                                                6600,
                                                                       2700,
             5000,
                    2650, 4775,
                                  4800,
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                                                        7420, 4280,
                                                                       6000,
                                          3630,
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                    3649,
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             8880,
                    5750,
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                                                 1950,
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                                                               8372,
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             4990,
                           5200,
                                  6321,
                                          4960,
                                                 3480,
                                                        3210,
                                                                4950,
                    2684,
                                                                       6840,
```

test = test[['price', 'area', 'bedrooms', 'bathrooms', 'stories', 'parking', __

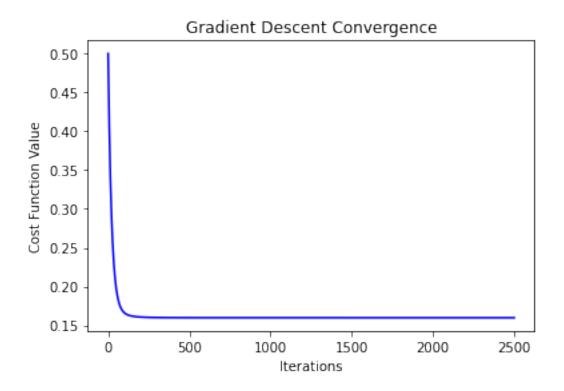
```
4350,
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7482,
                 4320,
         7475,
                          1836])
```

```
[ ]: X2_t = np.array(train.bedrooms)
X3_t = np.array(train.bathrooms)
```

```
X4_t = np.array(train.stories)
     X5_t = np.array(train.parking)
     X6_t = np.array(train.mainroad)
     X7_t = np.array(train.guestroom)
     X8_t = np.array(train.hotwaterheating)
     X9_t = np.array(train.airconditioning)
     X10_t = np.array(train.prefarea)
     X11_t = np.array(train.basement)
     X0_t = np.ones(436)
[]: X = np.vstack([X0_t,X1_t,X2_t,X3_t,X4_t,X5_t,X6_t,X7_t,X8_t,X9_t,X10_t,X11_t])
     X = X.T
     X = np.array(X)
     Х
[]: array([[1.000e+00, 6.240e+03, 4.000e+00, ..., 1.000e+00, 0.000e+00,
             0.000e+00],
            [1.000e+00, 8.400e+03, 4.000e+00, ..., 0.000e+00, 0.000e+00,
             0.000e+00],
            [1.000e+00, 1.050e+04, 4.000e+00, ..., 0.000e+00, 0.000e+00,
             0.000e+00],
            [1.000e+00, 7.475e+03, 3.000e+00, ..., 1.000e+00, 0.000e+00,
             0.000e+00].
            [1.000e+00, 4.320e+03, 3.000e+00, ..., 0.000e+00, 0.000e+00,
             1.000e+007.
            [1.000e+00, 1.836e+03, 2.000e+00, ..., 0.000e+00, 0.000e+00,
             1.000e+00]])
[]: # scale the feature matrix using the fit_transform() method of the scaler object
     X_scaled = scaler.fit_transform(X)
     # assign the scaled feature matrix to the original variable name 'X'
     X = X_scaled
[]: # create a 1D NumPy array of zeros with length 12
     theta = np.zeros(12)
     # reshape the 1D array to a column vector using np.reshape
     theta = np.reshape(theta, (12,1))
     # display the column vector
     theta
[]: array([[0.],
            [0.],
            [0.],
```

```
[0.],
            [0.],
            [0.],
            [0.],
            [0.],
            [0.],
            [0.],
            [0.],
            [0.11)
[]: # create a 1D NumPy array 'Y_t' from the 'price' column of the training set_
     →'train'
     #h = np.matmul(X, theta)
     Y_t = np.array(train.price)
     Y = Y t
     Y = Y_t.reshape(436,1)
     y = scaler.fit_transform(Y)
     Y=y
[]: | # create a NumPy array 'X_T' containing the transpose of the feature matrix 'X'
     X T = np.array(X.T)
     \# retrieve the number of rows 'm' and the number of columns 'n' from the \sqcup
     ⇔feature matrix 'X'
     m, n = X.shape
     # display the values of 'm' and 'n'
     print("Number of training examples (m): ", m)
     print("Number of features (n): ", n)
     # set the number of iterations for gradient descent
     iterations = 2500
     # create a counter variable 'count' and a NumPy array 'j' to store the cost_{\sqcup}
      ⇔function values for each iteration
     count = 0
     j = np.zeros(shape=(iterations, 1), dtype=float)
     # display the shape of the 'j' array
     print("Shape of 'j' array: ", j.shape)
    Number of training examples (m): 436
    Number of features (n): 12
    Shape of 'j' array: (2500, 1)
[]: # set the initial iteration count to zero
     count = 0
```

```
# create a NumPy array 'j' to store the cost function values for each iteration
j = np.zeros(shape=(iterations, 1), dtype=float)
# perform gradient descent for the specified number of iterations
while count < iterations:</pre>
    # calculate the predicted values 'h' using the current parameters 'theta'
    h = X.dot(theta)
    # calculate the cost function value 'j' using the current parameters 'theta'
    j[count] = (1/(2*m)) * np.sum((h-Y)**2)
    # calculate the gradient of the cost function with respect to 'theta'
    grad = (1/m) * X_T.dot(h-Y)
    # update the parameters 'theta' using the learning rate 'alpha' and the \Box
 ⇔gradient 'grad'
    alpha = 0.01
    theta = theta - alpha * grad
    # increment the iteration count
    count += 1
# plot the cost function values over the iterations
plt.plot(j,'b-')
plt.xlabel('Iterations')
plt.ylabel('Cost Function Value')
plt.title('Gradient Descent Convergence')
plt.show()
```



```
N_X1_t = np.array(test.area)
     N X2 t = np.array(test.bedrooms)
     N_X3_t = np.array(test.bathrooms)
     N_X4_t = np.array(test.stories)
     N_X5_t = np.array(test.parking)
     N_X6_t = np.array(test.mainroad)
     N_X7_t = np.array(test.guestroom)
     N_X8_t = np.array(test.hotwaterheating)
     N_X9_t = np.array(test.airconditioning)
     N_X10_t = np.array(test.prefarea)
     N_X11_t = np.array(test.basement)
     N_X0_t = np.ones(109)
[]: # stack the test set features into a design matrix
     N_X = np.vstack([N_X0_t,N_X1_t,N_X2_t,N_X3_t,N_X4_t,N_X5_t,__
      →N_X6_t,N_X7_t,N_X8_t,N_X9_t,N_X10_t,N_X11_t])
     N_X_T = N_X.T
     N_X = np.array(N_X_T)
     N_x = scaler.fit_transform(N_X)
     N_X = N_x
     N_X.shape
```

[]: # extract the test set features into NumPy arrays

```
[]: (109, 12)
[]: # initialize the parameters for the test set
     N_{\text{theta}} = \text{np.array}([0.,0.,0.,0.,0.,0.,0.,0.,0.,0.])
     N_theta = N_theta.reshape(12,1)
     N_{\text{theta}}
[]: array([[0.],
            [0.],
            [0.],
            [0.],
            [0.],
            [0.],
            [0.],
            [0.],
            [0.],
            [0.],
            [0.],
            [0.]])
[]: # initialize the target variable for the test set
     N_Y_t = np.array(test.price)
     N_Y = N_Y_t
     N_Y = N_Y_t.reshape(109,1)
     N_y = scaler.fit_transform(N_Y)
     N_Y=N_y
     N_Y.shape
[]: (109, 1)
[]: N_X_T = np.array(N_X.T)
     m,n = N_X.shape
     m,n
[]: (109, 12)
[]: iterations = 2500
     count=0
     N_j = np.zeros(shape=(iterations, 1), dtype=float)
     while(count < iterations):</pre>
         N_h_t = N_X.dot(N_theta)
         N_h = np.array(N_h_t)
         N_j[count] = (1/(2*m))*np.sum((N_h - N_Y)**2)
```

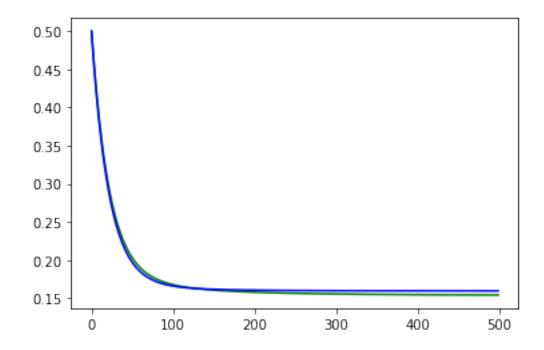
```
grad_t = N_X_T.dot(N_h-N_Y)
grad = grad_t*(1/m)

N_theta = N_theta - 0.01*(grad)

count += 1
```

```
[]: plt.plot(N_j[:500],'g-')
plt.plot(j[:500],'b-')
```

[]: [<matplotlib.lines.Line2D at 0x7f29d18e6df0>]



hw1-3a-normalization

February 20, 2023

```
[29]: import numpy as np # import numpy library
      import pandas as pd # import pandas library
      import matplotlib.pyplot as plt # import matplotlib library
      from sklearn import preprocessing # import scikit-learn library (source: https:
       →//scikit-learn.org/stable/index.html)
[30]: df = pd.read_csv("/content/sample_data/Housing.csv")
      # display DataFrame
      df
                                                    stories mainroad guestroom basement
[30]:
               price
                      area
                             bedrooms
                                        bathrooms
            13300000
                      7420
                                                          3
                                                                  yes
                                                                              no
           12250000
      1
                      8960
                                    4
                                                4
                                                          4
                                                                  yes
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                                                                                        no
      2
           12250000
                      9960
                                    3
                                                2
                                                          2
                                                                  yes
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                                                                                       yes
      3
           12215000
                      7500
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                                                          2
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                                                                                       yes
      4
           11410000
                      7420
                                                 1
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                                                                  yes
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                      3000
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      541
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      544
            1750000
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          hotwaterheating airconditioning parking prefarea furnishingstatus
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      541
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                                                                   semi-furnished
                        no
                                          no
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      542
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                                                                      unfurnished
                        no
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      543
                                                     0
                                                                         furnished
                        no
                                          no
                                                              no
      544
                                                                      unfurnished
                                                              no
                        no
                                          no
```

[545 rows x 13 columns]

[545 rows x 13 columns]

```
[31]: df = df.replace(to_replace=['yes', 'no'], value=[1, 0])
[31]:
                              bedrooms
                                         bathrooms
                                                      stories
                                                                mainroad
                                                                            guestroom
               price area
      0
            13300000
                       7420
                                                             3
                                                                         1
      1
            12250000
                       8960
                                      4
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            12250000
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            12215000
                       7500
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      4
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            11410000
                       7420
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                                                                         1
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                                      2
      540
             1820000
                                                   1
                                                                         1
                                                                                     0
                       3000
                                                             1
      541
                                      3
             1767150
                       2400
                                                   1
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                                                                         0
                                                                                     0
      542
             1750000
                       3620
                                      2
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                                                                         1
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      543
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             1750000
                       2910
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                                                                                     0
      544
             1750000
                       3850
                                      3
                                                   1
                                                             2
                                                                         1
                                                                                     0
                                           airconditioning parking
            basement
                       hotwaterheating
      0
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                                       0
                                                           1
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                    0
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                                                                     3
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      544
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                   furnished
      1
                   furnished
      2
             semi-furnished
      3
                   furnished
      4
                   furnished
      540
                 unfurnished
      541
             semi-furnished
      542
                 unfurnished
      543
                   furnished
      544
                 unfurnished
```

[32]: # create a training set by randomly selecting 80% of the rows from the DataFrame
train = df.sample(frac=0.8, random_state=1)

create a test set by dropping the rows in the training set from the DataFrame
test = df.drop(train.index)

[33]: test

[33]:		price	area	bedrooms	bathrooms	storios	mainro	and munat	room	\
[33].	2	-		bear ooms						\
	_	12250000	9960	-	2	2		1	0	
	3	12215000		4	2	2		1	0	
	7	10150000	16200	5	3	2		1	0	
	15	9100000	6000	4	1	2		1	0	
	22	8645000	8050	3	1	1		1	1	
			•••	•••		•••	•••			
	508	2590000	4400	2	1	1		1	0	
	513	2485000	4400	3	1	2		1	0	
	520	2450000	7700	2	1	1		1	0	
	537	1890000	1700	3	1	2		1	0	
	539	1855000	2990	2	1	1		0	0	
		basement	hotwat	erheating	airconditi	oning p	arking	prefarea	\	
	2	1		0		0	2	1		
	3	1		0		1	3	1		
	7	0		0		0	0	0		
	15	1		0		0	2	0		
	22	1		0		1	1	0		
		•••		•••		•••	•••			
	508	0		0		0	0	0		
	513	0		0		0	0	0		
	520	0		0		0	0	0		

furnishingstatus semi-furnished furnished unfurnished semi-furnished furnished unfurnished unfurnished unfurnished unfurnished unfurnished

[109 rows x 13 columns]

```
[34]: # select specific columns for the training set
     train = train[['price', 'area', 'bedrooms', 'bathrooms', 'stories', 'parking']]
      # select specific columns for the test set
     test = test[['price', 'area', 'bedrooms', 'bathrooms', 'stories', 'parking']]
[35]: import sklearn.preprocessing # import scikit-learn library for data_
       →preprocessing
      # create an instance of the MinMaxScaler class for scaling features to a range_
     scaler = sklearn.preprocessing.MinMaxScaler()
[36]: train
[36]:
                    area bedrooms bathrooms stories parking
            price
     62
          7070000
                    6240
     247 4550000
                                 4
                                                     4
                                                              3
                    8400
                                            1
                                            2
                                                     2
     142 5600000 10500
                                 4
                                                              1
     107 6125000
                    6420
                                 3
                                            1
                                                     3
                                                              0
                                 3
                                            1
                                                     2
     483 2940000
                    6615
                                                              0
     359 3710000
                                 3
                                            1
                                                     1
                                                              1
                    3600
                                            2
     36
          8043000
                    7482
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                                 3
                                            2
                                                     4
                                                              2
     30
          8400000
                    7475
                                 3
     20
          8750000
                    4320
                                            1
                                                              2
                                 2
     527 2275000
                    1836
                                            1
                                                     1
                                                              0
     [436 rows x 6 columns]
[37]: # create a NumPy array of the 'area' column from the training set
     X1 t = np.array(train['area'])
      # display the NumPy array
     X1_t
                    8400, 10500,
                                                                     2700,
[37]: array([ 6240,
                                  6420,
                                         6615,
                                                3600,
                                                       3240,
                                                              6600,
             5000,
                    2650, 4775,
                                  4800,
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                                                       7420, 4280,
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                                                              8400,
                                                                     3000,
                    5750,
                           2145,
                                  6360,
                                         6525,
                                                       5850,
                                                                     2870,
             8880,
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                                                              8372,
             4990,
                    2684, 5200,
                                  6321,
                                         4960,
                                                3480,
                                                       3210, 4950,
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                                         3000,
                                                2787,
                                                       4815,
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                           2910,
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                    3600,
                           6000,
                                  2176, 3000,
                                                7420,
                                                       7020, 3480,
                                                                     5960,
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                                3800,
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                                2700,
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                                                6900,
                                                        3500,
                                                                5076,
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                        5320,
                                5960,
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                        2400,
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                                4120,
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                        6360,
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                                        4646,
                                                3840,
                                                        9000,
                                                                3520,
                                                                        3640,
                                                                                3600,
                        3900,
                                        1836])
                7482,
                        7475,
                                4320,
[38]: X1_t = np.array(train['area']) # 'area' column
      X2 t = np.array(train['bedrooms']) # 'bedrooms' column
      X3_t = np.array(train['bathrooms']) # 'bathrooms' column
      X4_t = np.array(train['stories']) # 'stories' column
      X5_t = np.array(train['parking']) # 'parking' column
```

3510,

6420,

6450,

6210,

4500,

3000,

3180,

5700,

3520,

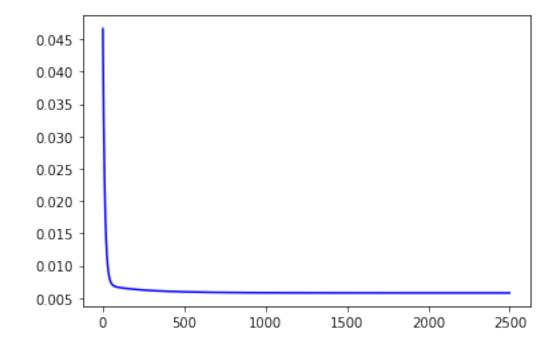
```
# create a NumPy array of ones to represent the bias term
      X0_t = np.ones(len(train))
[39]: # stack the selected feature arrays vertically using np.vstack
      X = np.vstack([X0_t, X1_t, X2_t, X3_t, X4_t, X5_t])
      # transpose the stacked array to make it a 6 x 436 matrix
      X = X.T
      # convert the stacked array to a NumPy array
      X = np.array(X)
      # display the NumPy array
      Х
[39]: array([[1.000e+00, 6.240e+03, 4.000e+00, 2.000e+00, 2.000e+00, 1.000e+00],
             [1.000e+00, 8.400e+03, 4.000e+00, 1.000e+00, 4.000e+00, 3.000e+00],
             [1.000e+00, 1.050e+04, 4.000e+00, 2.000e+00, 2.000e+00, 1.000e+00],
             [1.000e+00, 7.475e+03, 3.000e+00, 2.000e+00, 4.000e+00, 2.000e+00],
             [1.000e+00, 4.320e+03, 3.000e+00, 1.000e+00, 2.000e+00, 2.000e+00],
             [1.000e+00, 1.836e+03, 2.000e+00, 1.000e+00, 1.000e+00, 0.000e+00]])
[40]: # scale the feature matrix using the fit_transform() method of the scaler object
      X_scaled = scaler.fit_transform(X)
      # assign the scaled feature matrix to the original variable name 'X'
      X = X \text{ scaled}
[41]: # create a 1D NumPy array of zeros with length 6
      theta = np.zeros(6)
      # reshape the 1D array to a column vector using np.reshape
      theta = np.reshape(theta, (6,1))
      # display the column vector
      theta
[41]: array([[0.],
             [0.],
             [0.],
             [0.],
             [0.],
             [0.11)
[42]: | # create a 1D NumPy array 'Y_t' from the 'price' column of the training setu
       →'train'
```

```
# create a copy of 'Y_t' to prevent changing the original data
      Y = Y_t.copy()
      # reshape 'Y' to a column vector using np.reshape
      Y = np.reshape(Y, (436,1))
      # create an instance of the MinMaxScaler class for scaling the target variable_
       \rightarrowto a range of [0, 1]
      scaler = sklearn.preprocessing.MinMaxScaler()
      # scale the target variable using the fit_transform() method of the scaler
       ⇔object
      Y_scaled = scaler.fit_transform(Y)
      # assign the scaled target variable to the original variable name 'Y'
      Y = Y_scaled
[43]: # create a NumPy array 'X T' containing the transpose of the feature matrix 'X'
      X_T = np.array(X.T)
      \# retrieve the number of rows 'm' and the number of columns 'n' from the
       \hookrightarrow feature matrix 'X'
      m, n = X.shape
      # display the values of 'm' and 'n'
      print("Number of training examples (m): ", m)
      print("Number of features (n): ", n)
      # set the number of iterations for gradient descent
      iterations = 2500
      # create a counter variable 'count' and a NumPy array 'j' to store the cost_{\sqcup}
      →function values for each iteration
      count = 0
      j = np.zeros(shape=(iterations, 1), dtype=float)
      # display the shape of the 'j' array
      print("Shape of 'j' array: ", j.shape)
     Number of training examples (m): 436
     Number of features (n): 6
     Shape of 'j' array: (2500, 1)
[44]: # Initialize variables
      iterations = 2500
```

Y_t = np.array(train.price)

```
count = 0
alpha = 0.1
lambda_ = 0.001
j = np.zeros(iterations)
# Perform gradient descent
while count < iterations:</pre>
   h_t = X.dot(theta)
   h = np.array(h_t, float)
    j[count] = (1/(2*m)) * np.sum((h - Y)**2) + (lambda_ / (2*m)) * np.
 ⇒sum(theta**2)
    grad_t = X_T.dot(h - Y)
    grad = grad_t * (1/m)
    theta = theta * (1 - alpha * (lambda_ / m)) - alpha * grad
    count += 1
# Plot the cost function
plt.plot(j, 'b-')
```

[44]: [<matplotlib.lines.Line2D at 0x7f6e719f9700>]



```
[45]: # extract the test set features into NumPy arrays
      N_X1_t = np.array(test.area)
      N_X2_t = np.array(test.bedrooms)
      N_X3_t = np.array(test.bathrooms)
      N_X4_t = np.array(test.stories)
      N_X5_t = np.array(test.parking)
      N_X0_t = np.ones(109)
[46]: # stack the test set features into a design matrix
      N_X = np.vstack([N_X0_t,N_X1_t,N_X2_t,N_X3_t,N_X4_t,N_X5_t])
      N_X_T = N_X.T
      N_X = np.array(N_X_T)
      N_x = scaler.fit_transform(N_X)
      N_X = N_x
      N_X.shape
[46]: (109, 6)
[47]: N_theta = np.array([0.,0.,0.,0.,0.,0.])
      N_theta = N_theta.reshape(6,1)
      N_{theta}
[47]: array([[0.],
             [0.],
             [0.],
             [0.],
             [0.],
             [0.]])
[48]: N_Y_t = np.array(test.price)
      N_Y = N_Y_t
      N_Y = N_Y_t.reshape(109,1)
      N_y = scaler.fit_transform(N_Y)
      N_Y=N_y
      N Y.shape
[48]: (109, 1)
[49]: N_X_T = np.array(N_X.T)
      m,n = N_X.shape
      m,n
[49]: (109, 6)
[50]: iterations = 2500
      count=0
      N_j = np.zeros(shape=(iterations, 1), dtype=float)
```

```
while(count < iterations):
    N_h_t = N_X.dot(N_theta)
    N_h = np.array(N_h_t)

    N_j[count] = (1/(2*m))*np.sum((N_h - N_Y)**2)+(0.001)*(1/(2*m))*np.
    sum((N_theta)**2)

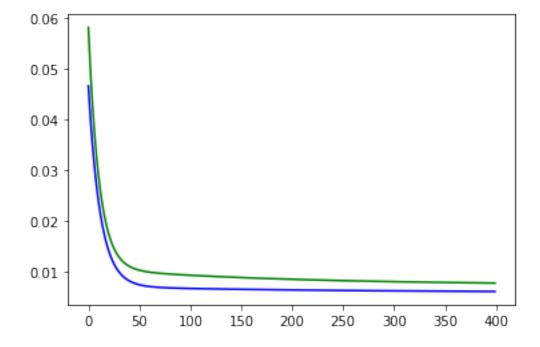
    grad_t = N_X_T.dot(N_h-N_Y)
    grad = grad_t*(1/m)

    N_theta = N_theta*(1-0.1*(0.001/m)) - 0.1*(grad)

    count += 1</pre>
```

```
[51]: plt.plot(N_j[:400],'g-')
plt.plot(j[:400],'b-')
```

[51]: [<matplotlib.lines.Line2D at 0x7f6e719beac0>]



hw1-3a-standardization

February 20, 2023

```
[1]: import numpy as np # import numpy library
     import pandas as pd # import pandas library
     import matplotlib.pyplot as plt # import matplotlib library
     from sklearn import preprocessing
[2]: df = pd.read_csv("/content/sample_data/Housing.csv")
     # display DataFrame
     df
[2]:
                                       bathrooms
                                                   stories mainroad guestroom basement
              price
                      area
                            bedrooms
           13300000
                      7420
                                                                  yes
                                                                              no
                                                4
                                                          4
     1
           12250000
                      8960
                                    4
                                                                  yes
                                                                              no
                                                                                        no
     2
                                                2
                                                          2
           12250000
                      9960
                                    3
                                                                  yes
                                                                              no
                                                                                       yes
     3
           12215000
                                    4
                                                2
                                                          2
                     7500
                                                                  yes
                                                                              no
                                                                                       yes
           11410000
                     7420
                                    4
                                                1
                                                          2
                                                                  yes
                                                                             yes
                                                                                       yes
                                    2
     540
            1820000
                      3000
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                                                          1
                                                                  yes
                                                                              no
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     541
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     542
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            1750000
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     544
            1750000
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                                                                  yes
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         hotwaterheating airconditioning
                                             parking prefarea furnishingstatus
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                                                             no
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                                                            yes
                                                                   semi-furnished
                        no
     3
                        no
                                         yes
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                                         no
     544
                                                     0
                                                                      unfurnished
                        no
                                         no
                                                             no
```

[545 rows x 13 columns]

[3]: # create a training set by randomly selecting 80% of the rows from the DataFrame train = df.sample(frac=0.8, random_state=1)

create a test set by dropping the rows in the training set from the DataFrame test = df.drop(train.index)

[4]: train

[4]:		price	area	bedrooms	bathrooms	stories	mainroad	guestroom	basement	\
	62	7070000	6240	4	2	2	yes	no	no	
	247	4550000	8400	4	1	4	yes	no	no	
	142	5600000	10500	4	2	2	yes	no	no	
	107	6125000	6420	3	1	3	yes	no	yes	
	483	2940000	6615	3	1	2	yes	no	no	
		•••	•••			•••	•••	•••		
	359	3710000	3600	3	1	1	yes	no	no	
	36	8043000	7482	3	2	3	yes	no	no	
	30	8400000	7475	3	2	4	yes	no	no	
	20	8750000	4320	3	1	2	yes	no	yes	
	527	2275000	1836	2	1	1	no	no	yes	

	${\tt hotwaterheating}$	${\tt airconditioning}$	parking	prefarea	furnishingstatus
62	no	yes	1	no	furnished
247	no	no	3	no	unfurnished
142	no	no	1	no	semi-furnished
107	no	no	0	yes	unfurnished
483	no	no	0	no	semi-furnished
	•••	•••			***
 359	 no	 no		no	 unfurnished
359	no	no		no	unfurnished
359 36	no yes	no no	1 1	no yes	unfurnished furnished

[436 rows x 13 columns]

[5]: test

[5]:		price	area	bedrooms	bathrooms	stories	${\tt mainroad}$	guestroom	\
	2	12250000	9960	3	2	2	yes	no	
	3	12215000	7500	4	2	2	yes	no	
	7	10150000	16200	5	3	2	yes	no	
	15	9100000	6000	4	1	2	yes	no	
	22	8645000	8050	3	1	1	yes	yes	
		•••	•••	•••		•••	•••		
	508	2590000	4400	2	1	1	yes	no	
	513	2485000	4400	3	1	2	yes	no	

```
7700
     520
           2450000
                                   2
                                               1
                                                         1
                                                                yes
                                                                            no
     537
           1890000
                      1700
                                    3
                                                         2
                                               1
                                                                yes
                                                                            no
     539
                                    2
           1855000
                      2990
                                               1
                                                                 no
                                                                            no
         basement hotwaterheating airconditioning parking prefarea
     2
                                no
                                                            2
              yes
                                                 no
                                                                    yes
     3
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                                                 no
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              yes
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     22
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              yes
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     508
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     539
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         furnishingstatus
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           semi-furnished
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                 furnished
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     15
           semi-furnished
     22
                furnished
     . .
     508
              unfurnished
     513
              unfurnished
     520
              unfurnished
     537
              unfurnished
              unfurnished
     539
     [109 rows x 13 columns]
[6]: # select specific columns for the training set
     train = train[['price', 'area', 'bedrooms', 'bathrooms', 'stories', 'parking']]
     # select specific columns for the test set
     test = test[['price', 'area', 'bedrooms', 'bathrooms', 'stories', 'parking']]
[7]: scaler = preprocessing.StandardScaler()
[8]: # create a NumPy array of the 'area' column from the training set
     X1_t = np.array(train['area'])
     # display the NumPy array
     X1 t
```

```
[8]: array([ 6240,
                       8400, 10500,
                                                                                  2700,
                                        6420,
                                                6615,
                                                         3600,
                                                                 3240,
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               4350,
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               5800,
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                                                                                  3240,
                       6360,
                                        5400,
```

```
13200, 3900, 9000, 4646, 3840, 9000, 3520, 3640, 3600,
             7482, 7475, 4320, 1836])
 [9]: X1_t = np.array(train['area']) # 'area' column
      X2_t = np.array(train['bedrooms']) # 'bedrooms' column
      X3_t = np.array(train['bathrooms']) # 'bathrooms' column
      X4_t = np.array(train['stories']) # 'stories' column
      X5_t = np.array(train['parking']) # 'parking' column
      # create a NumPy array of ones to represent the bias term
      X0 t = np.ones(len(train))
[10]: # stack the selected feature arrays vertically using np.vstack
      X = np.vstack([X0_t, X1_t, X2_t, X3_t, X4_t, X5_t])
      # transpose the stacked array to make it a 6 x 436 matrix
      X = X.T
      # convert the stacked array to a NumPy array
      X = np.array(X)
      # display the NumPy array
      Х
[10]: array([[1.000e+00, 6.240e+03, 4.000e+00, 2.000e+00, 2.000e+00, 1.000e+00],
             [1.000e+00, 8.400e+03, 4.000e+00, 1.000e+00, 4.000e+00, 3.000e+00],
             [1.000e+00, 1.050e+04, 4.000e+00, 2.000e+00, 2.000e+00, 1.000e+00],
             ...,
             [1.000e+00, 7.475e+03, 3.000e+00, 2.000e+00, 4.000e+00, 2.000e+00],
             [1.000e+00, 4.320e+03, 3.000e+00, 1.000e+00, 2.000e+00, 2.000e+00],
             [1.000e+00, 1.836e+03, 2.000e+00, 1.000e+00, 1.000e+00, 0.000e+00]])
[11]: x = scaler.fit_transform(X)
      X = X
[12]: # create a 1D NumPy array of zeros with length 6
      theta = np.zeros(6)
      # reshape the 1D array to a column vector using np.reshape
      theta = np.reshape(theta, (6,1))
      # display the column vector
      theta
[12]: array([[0.],
             [0.],
             [0.],
```

```
[0.],
             [0.]])
[13]: | # create a 1D NumPy array 'Y t' from the 'price' column of the training set
      →'train'
      #h = np.matmul(X, theta)
      Y_t = np.array(train.price)
      Y = Y t
      Y = Y_t.reshape(436,1)
      y = scaler.fit_transform(Y)
      Y=y
[14]: # create a NumPy array 'X_T' containing the transpose of the feature matrix 'X'
      X_T = np.array(X.T)
      # retrieve the number of rows 'm' and the number of columns 'n' from the
      \hookrightarrow feature matrix 'X'
      m, n = X.shape
      # display the values of 'm' and 'n'
      print("Number of training examples (m): ", m)
      print("Number of features (n): ", n)
      # set the number of iterations for gradient descent
      iterations = 1000
      # create a counter variable 'count' and a NumPy array 'j' to store the cost_{\sqcup}
      →function values for each iteration
      count = 0
      j = np.zeros(shape=(iterations, 1), dtype=float)
      # display the shape of the 'j' array
      print("Shape of 'j' array: ", j.shape)
     Number of training examples (m): 436
     Number of features (n): 6
     Shape of 'j' array: (1000, 1)
[15]: # Initialize variables
      iterations = 1000
      count = 0
      alpha = 0.1
      lambda_ = 0.001
      j = np.zeros(iterations)
      # Perform gradient descent
```

[0.],

```
while count < iterations:
    h_t = X.dot(theta)
    h = np.array(h_t, float)

    j[count] = (1/(2*m)) * np.sum((h - Y)**2) + (lambda_ / (2*m)) * np.
    sum(theta**2)

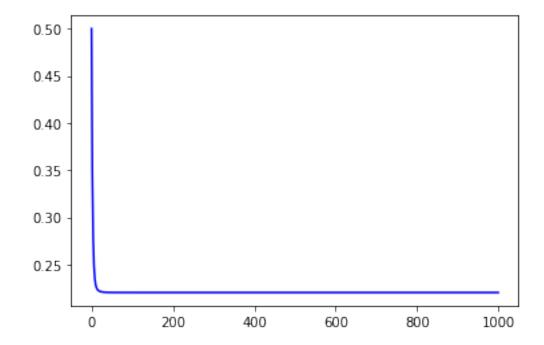
    grad_t = X_T.dot(h - Y)
    grad = grad_t * (1/m)

    theta = theta * (1 - alpha * (lambda_ / m)) - alpha * grad

    count += 1

# Plot the cost function
plt.plot(j, 'b-')</pre>
```

[15]: [<matplotlib.lines.Line2D at 0x7f153537e520>]



```
[16]: # extract the test set features into NumPy arrays
    N_X1_t = np.array(test.area)
    N_X2_t = np.array(test.bedrooms)
    N_X3_t = np.array(test.bathrooms)
    N_X4_t = np.array(test.stories)
    N_X5_t = np.array(test.parking)
```

```
N_X0_t = np.ones(109)
[17]: # stack the test set features into a design matrix
      N_X = np.vstack([N_X0_t, N_X1_t, N_X2_t, N_X3_t, N_X4_t, N_X5_t])
      N_X_T = N_X.T
      N_X = np.array(N_X_T)
      N_x = scaler.fit_transform(N_X)
      N_X = N_x
      N_X.shape
[17]: (109, 6)
[18]: N_{\text{theta}} = \text{np.array}([0.,0.,0.,0.,0.])
      N_theta = N_theta.reshape(6,1)
      N theta
[18]: array([[0.],
              [0.],
              [0.],
              [0.],
              [0.],
              [0.11)
[19]: N_Y_t = np.array(test.price)
      N_Y = N_Y_t
      N_Y = N_Y_{\text{t.reshape}}(109,1)
      N_y = scaler.fit_transform(N_Y)
      N_Y=N_y
      N_Y.shape
[19]: (109, 1)
[20]: N_X_T = np.array(N_X.T)
      m,n = N_X.shape
      m,n
[20]: (109, 6)
[22]: iterations = 2500
      count=0
      N_j = np.zeros(shape=(iterations, 1), dtype=float)
      while(count < iterations):</pre>
          N_h_t = N_X.dot(N_theta)
          N_h = np.array(N_h_t)
```

```
N_j[count] = (1/(2*m))*np.sum((N_h - N_Y)**2)+(0.001)*(1/(2*m))*np.
sum((N_theta)**2)

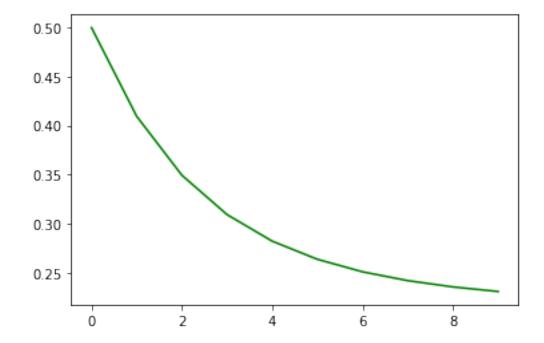
grad_t = N_X_T.dot(N_h-N_Y)
grad = grad_t*(1/m)

N_theta = N_theta*(1-0.1*(0.001/m)) - 0.1*(grad)

count += 1
```

```
[25]: plt.plot(N_j[:10],'g-')
#plt.plot(j[:10],'b-')
```

[25]: [<matplotlib.lines.Line2D at 0x7f1534d59070>]



hw1-3b-normalization

February 20, 2023

```
[100]: import numpy as np # import numpy library
       import pandas as pd # import pandas library
       import matplotlib.pyplot as plt # import matplotlib library
       from sklearn import preprocessing # import scikit-learn library (source: https:
         →//scikit-learn.org/stable/index.html)
[101]: df = pd.read_csv("/content/sample_data/Housing.csv")
       # display DataFrame
       df
                                                     stories mainroad guestroom basement
[101]:
                price
                       area
                              bedrooms
                                         bathrooms
             13300000
                       7420
                                                            3
                                                                   yes
                                                                               no
             12250000
       1
                       8960
                                      4
                                                  4
                                                            4
                                                                   yes
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       2
             12250000
                       9960
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       3
             12215000
                       7500
                                      4
                                                  2
                                                           2
                                                                   yes
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                                                                                        yes
       4
             11410000
                       7420
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                                                                   yes
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       540
              1820000
                       3000
                                      2
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                                                                                        yes
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       541
                                      3
              1767150
                       2400
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                                      2
       542
              1750000
                       3620
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       543
              1750000
                       2910
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                                                                    no
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       544
              1750000
                       3850
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                                                  1
                                                            2
                                                                   yes
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           hotwaterheating airconditioning parking prefarea furnishingstatus
       0
                                                      2
                                          yes
                                                              yes
                                                                          furnished
                                                      3
       1
                         no
                                          yes
                                                              no
                                                                          furnished
                                                      2
       2
                         no
                                           no
                                                              yes
                                                                    semi-furnished
       3
                                                      3
                                                                          furnished
                                          yes
                                                              yes
                         nο
                                                                          furnished
       4
                         nο
                                          yes
                                                      2
                                                              no
       540
                                                      2
                                                                       unfurnished
                         no
                                           no
                                                               no
       541
                                                      0
                                                                    semi-furnished
                         no
                                           no
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       542
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                         no
                                           no
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       543
                                                      0
                                                                          furnished
                         no
                                           no
                                                               no
       544
                                                                       unfurnished
                                                               no
                         no
                                           no
```

[545 rows x 13 columns]

```
[102]: df = df.replace(to_replace=['yes', 'no'], value=[1, 0])
[102]:
                               bedrooms
                                           bathrooms
                                                       stories
                                                                 mainroad
                                                                             guestroom
                 price area
        0
             13300000
                        7420
                                                              3
                                                                          1
        1
             12250000
                         8960
                                       4
                                                    4
                                                              4
                                                                          1
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                                                    2
                                                              2
        2
             12250000
                        9960
                                                                          1
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             12215000
                        7500
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             11410000
                        7420
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        540
              1820000
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                         3000
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        541
                                       3
              1767150
                        2400
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        542
              1750000
                         3620
                                       2
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        543
                                       3
                                                    1
                                                                          0
              1750000
                        2910
                                                              1
                                                                                      0
        544
              1750000
                         3850
                                       3
                                                    1
                                                              2
                                                                          1
                                                                                      0
                                            airconditioning parking
             basement
                        hotwaterheating
        0
                     0
                                         0
                                                            1
                                                                      2
                     0
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                                                                      3
                                                                                  0
        1
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        2
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            furnishingstatus
        0
                    furnished
        1
                    furnished
        2
              semi-furnished
        3
                    furnished
        4
                    furnished
        540
                  unfurnished
        541
              semi-furnished
        542
                  unfurnished
        543
                    furnished
        544
                  unfurnished
        [545 rows x 13 columns]
```

[103]: # create a training set by randomly selecting 80% of the rows from the DataFrame
train = df.sample(frac=0.8, random_state=1)

create a test set by dropping the rows in the training set from the DataFrame
test = df.drop(train.index)

[104]: train

[104]:		price	area	bedrooms	bathrooms	stories	mainroad	l guestro	om	\
	62	7070000	6240	4	2	2		L	0	
	247	4550000	8400	4	1	4		<u>[</u>	0	
	142	5600000	10500	4	2	2		[0	
	107	6125000	6420	3	1	3		<u>[</u>	0	
	483	2940000	6615	3	1	2		L	0	
		•••				•••	•••			
	359	3710000	3600	3	1	1	-	[0	
	36	8043000	7482	3	2	3	-	[0	
	30	8400000	7475	3	2	4	-	<u> </u>	0	
	20	8750000	4320	3	1	2	-	<u> </u>	0	
	527	2275000	1836	2	1	1	()	0	
									_	
		basement	hotwa	terheating	aircondit	ioning]	parking p	orefarea	\	
	62	0		0		1	1	0		
	247	0		0		0	3	0		
	142	0		0		0	1	0		
	107	1		0		0	0	1		
	483	0		0		0	0	0		
					•••			•		
	359	0		0		0	1	0		
	36	0		1		0	1	1		
	30	0		0		1	2	0		
	20	1		1		0	2	0		
	527	1		0		0	0	0		

247 unfurnished
142 semi-furnished
107 unfurnished
483 semi-furnished

62

furnishingstatus

furnished

.. 359 unfurnished

36 furnished 30 unfurnished 20 semi-furnished 527 semi-furnished

[436 rows x 13 columns]

	nnico	0700	hadmaama	ha+hmaama	a+ omi e		d	mı oatı		
2	price 12250000	area 9960	bedrooms 3	bathrooms 2	storie	s mainr 2	0au 1	guestr	0	\
3	12215000	7500	4	2		2	1		0	
7	10150000	16200	5	3		2	1		0	
, 15	9100000	6000	4	1		2	1		0	
22	8645000	8050	3	1		1	1		1	
		8030							1	
 508	 2590000	 4400	 2	1	•••	1	1		0	
513	2485000	4400	3	1		2	1		0	
520	2450000	7700	2	1		1	1		0	
537	1890000	1700	3	1		2	1		0	
539	1855000	2990	2	1		1	0		0	
	basement	hotwat	erheating	airconditi	oning	parking	pre	farea	\	
2	1		0		0	2		1		
3	1		0		1	3		1		
7	0		0		0	0		0		
15	1		0		0	2		0		
22	1		0		1	1		0		
	•••		•••	•••		•••				
508	0		0		0	0		0		
513	0		0		0	0		0		
520	0		0		0	0		0		
537	0		0		0	0		0		
539	0		0		0	1		0		
	furnishing semi-fur									
2		nished								
3 7		nished								
15 22	semi-fur	nished								
	Tur									
 508	unfur	mished								
513		nished								
520		nished								
537		nished								
539		nished								

[106]: # select specific columns for the training set

```
train = train[['price', 'area', 'bedrooms', 'bathrooms', 'stories', 'parking', __
       ⇔'mainroad', 'guestroom', 'basement', 'hotwaterheating', 'airconditioning',⊔
       # select specific columns for the test set

¬'prefarea']]

[107]: | import sklearn.preprocessing # import scikit-learn library for data__
       →preprocessing
      # create an instance of the MinMaxScaler class for scaling features to a range
      scaler = sklearn.preprocessing.MinMaxScaler()
[108]: train
[108]:
            price
                   area bedrooms bathrooms stories parking mainroad \
          7070000
                   6240
      62
      247 4550000
                   8400
                               4
                                         1
                                                 4
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      142 5600000 10500
                               4
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      107 6125000
                               3
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                   6420
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                   6615
      483 2940000
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      359 3710000
                   3600
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      36
          8043000
                   7482
                               3
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                                                 3
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                                                                  1
          8400000
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      30
                   7475
                                                 4
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          8750000
                   4320
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      527 2275000
                   1836
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                                                                  0
          guestroom basement hotwaterheating airconditioning prefarea
      62
                 0
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      247
                 0
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      142
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      107
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```

[436 rows x 12 columns]

```
X1_t = np.array(train['area'])
        # display the NumPy array
       X1_t
[109]: array([ 6240,
                         8400, 10500,
                                         6420,
                                                 6615,
                                                          3600,
                                                                  3240,
                                                                          6600,
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                 5000,
                         2650,
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                                                                                  3000,
                 8880,
                         5750,
                                 2145,
                                         6360,
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                                                          1950,
                                                                 5850,
                                                                          8372,
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                 4990,
                         2684,
                                 5200,
                                         6321,
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                                                          3480,
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                                                                 6254,
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                         4100,
                                         3460,
                                                                                  3000,
```

[109]: | # create a NumPy array of the 'area' column from the training set

```
6800,
                                                                     3400,
                                                                                          6420,
                                                                                                                 3792,
                                                                                                                                      5500,
                                                                                                                                                             4600,
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                                                                                          2856,
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                                                                                                                 4646,
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                                                                                                                                                                                                                               3600,
                                                                     3900,
                                              7482, 7475,
                                                                                          4320,
                                                                                                                 1836])
[110]: X2_t = np.array(train.bedrooms)
                     X3 t = np.array(train.bathrooms)
                     X4_t = np.array(train.stories)
                     X5 t = np.array(train.parking)
                     X6_t = np.array(train.mainroad)
                     X7 t = np.array(train.guestroom)
                     X8_t = np.array(train.hotwaterheating)
                     X9_t = np.array(train.airconditioning)
                     X10_t = np.array(train.prefarea)
                     X11_t = np.array(train.basement)
                     X0_t = np.ones(436)
[111]: | # stack the selected feature arrays vertically using np.vstack
                     X = np.vstack([X0_t, X1_t, X2_t, X3_t, X4_t, X5_t, __
                        4 \times 10^{-4} \text{ M} \cdot 10^{-4} 
                     # transpose the stacked array to make it a 6 x 436 matrix
                     X = X.T
                     # convert the stacked array to a NumPy array
                     X = np.array(X)
                     # display the NumPy array
                     Х
[111]: array([[1.000e+00, 6.240e+03, 4.000e+00, ..., 1.000e+00, 0.000e+00,
                                              0.000e+00],
                                            [1.000e+00, 8.400e+03, 4.000e+00, ..., 0.000e+00, 0.000e+00,
                                              0.000e+00],
                                            [1.000e+00, 1.050e+04, 4.000e+00, ..., 0.000e+00, 0.000e+00,
                                              0.000e+00],
                                            [1.000e+00, 7.475e+03, 3.000e+00, ..., 1.000e+00, 0.000e+00,
                                              0.000e+00],
                                            [1.000e+00, 4.320e+03, 3.000e+00, ..., 0.000e+00, 0.000e+00,
                                              1.000e+00],
                                            [1.000e+00, 1.836e+03, 2.000e+00, ..., 0.000e+00, 0.000e+00,
                                              1.000e+00]])
```

6300, 7000,

6862, 11440,

7000,

4992,

6900,

3069,

3420,

3185,

3264,

3750,

2640,

5300,

3150,

7200,

4320,

6400,

```
[112]: # scale the feature matrix using the fit_transform() method of the scaler object
       X_scaled = scaler.fit_transform(X)
       \# assign the scaled feature matrix to the original variable name 'X'
       X = X \text{ scaled}
[113]: # create a 1D NumPy array of zeros with length 12
       theta = np.zeros(12)
       # reshape the 1D array to a column vector using np.reshape
       theta = np.reshape(theta, (12,1))
       # display the column vector
       theta
[113]: array([[0.],
              [0.],
              [0.],
              [0.],
              [0.],
              [0.],
              [0.].
              [0.],
              [0.],
              [0.],
              [0.],
              [0.]])
[114]: # create a 1D NumPy array 'Y_t' from the 'price' column of the training set
       ⇔'train'
       Y_t = np.array(train.price)
       # create a copy of 'Y_t' to prevent changing the original data
       Y = Y_t.copy()
       # reshape 'Y' to a column vector using np.reshape
       Y = np.reshape(Y, (436,1))
       \# create an instance of the MinMaxScaler class for scaling the target variable.
       \hookrightarrowto a range of [0, 1]
       scaler = sklearn.preprocessing.MinMaxScaler()
       # scale the target variable using the fit_transform() method of the scaler_
        ⇔object
       Y_scaled = scaler.fit_transform(Y)
       # assign the scaled target variable to the original variable name 'Y'
```

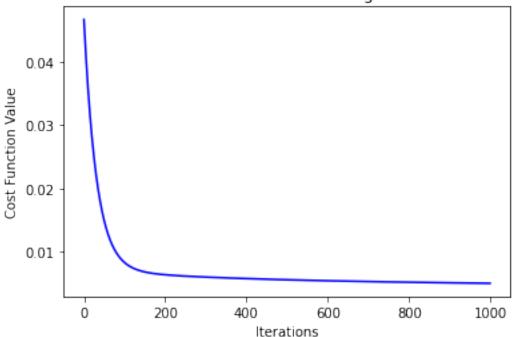
```
Y = Y_scaled
[115]: | # create a NumPy array 'X T' containing the transpose of the feature matrix 'X'
      X T = np.array(X.T)
       \# retrieve the number of rows 'm' and the number of columns 'n' from the
        \hookrightarrow feature matrix 'X'
       m, n = X.shape
       # display the values of 'm' and 'n'
       print("Number of training examples (m): ", m)
       print("Number of features (n): ", n)
       # set the number of iterations for gradient descent
       iterations = 1000
       # create a counter variable 'count' and a NumPy array 'j' to store the cost,
       ⇔function values for each iteration
       count = 0
       j = np.zeros(shape=(iterations, 1), dtype=float)
       # display the shape of the 'j' array
       print("Shape of 'j' array: ", j.shape)
      Number of training examples (m): 436
      Number of features (n): 12
      Shape of 'j' array: (1000, 1)
[116]: # set the initial iteration count to zero
       count = 0
       # create a NumPy array 'j' to store the cost function values for each iteration
       j = np.zeros(shape=(iterations, 1), dtype=float)
       # perform gradient descent for the specified number of iterations
       while count < iterations:</pre>
           # calculate the predicted values 'h' using the current parameters 'theta'
           h = X.dot(theta)
           # calculate the cost function value 'j' using the current parameters 'theta'
           j[count] = (1/(2*m)) * np.sum((h-Y)**2)
           # calculate the gradient of the cost function with respect to 'theta'
           grad = (1/m) * X_T.dot(h-Y)
```

```
# update the parameters 'theta' using the learning rate 'alpha' and the_
gradient 'grad'
alpha = 0.01
theta = theta - alpha * grad

# increment the iteration count
count += 1

# plot the cost function values over the iterations
plt.plot(j,'b-')
plt.xlabel('Iterations')
plt.ylabel('Cost Function Value')
plt.title('Gradient Descent Convergence')
plt.show()
```





```
[117]: # extract the test set features into NumPy arrays
N_X1_t = np.array(test.area)
N_X2_t = np.array(test.bedrooms)
N_X3_t = np.array(test.bathrooms)
N_X4_t = np.array(test.stories)
N_X5_t = np.array(test.parking)
N_X6_t = np.array(test.mainroad)
N_X7_t = np.array(test.guestroom)
```

```
N_X8_t = np.array(test.hotwaterheating)
       N_X9_t = np.array(test.airconditioning)
       N_X10_t = np.array(test.prefarea)
       N_X11_t = np.array(test.basement)
       N_X0_t = np.ones(109)
[118]: # stack the test set features into a design matrix
       N_X = np.vstack([N_X0_t,N_X1_t,N_X2_t,N_X3_t,N_X4_t,N_X5_t,__
        →N_X6_t,N_X7_t,N_X8_t,N_X9_t,N_X10_t,N_X11_t])
       N_X_T = N_X.T
       N_X = np.array(N_X_T)
       N_x = scaler.fit_transform(N_X)
       N X = N x
       N_X.shape
[118]: (109, 12)
[119]: # initialize the parameters for the test set
       N_{\text{theta}} = \text{np.array}([0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.])
       N_theta = N_theta.reshape(12,1)
       N theta
[119]: array([[0.],
              [0.],
              [0.],
              [0.],
              [0.],
              [0.],
              [0.],
              [0.],
              [0.],
              [0.],
              [0.],
              [0.]])
[120]: # initialize the target variable for the test set
       N_Y_t = np.array(test.price)
       N_Y = N_Y_t
       N_Y = N_Y_t.reshape(109,1)
       N_y = scaler.fit_transform(N_Y)
       N_Y=N_y
       N_Y.shape
[120]: (109, 1)
[121]: N_X_T = np.array(N_X.T)
       m,n = N_X.shape
```

m,n

```
[121]: (109, 12)
```

```
[122]: iterations = 1000
    count=0
    N_j = np.zeros(shape=(iterations, 1), dtype=float)

while(count < iterations):

    N_h_t = N_X.dot(N_theta)
    N_h = np.array(N_h_t)

    N_j[count] = (1/(2*m))*np.sum((N_h - N_Y)**2)

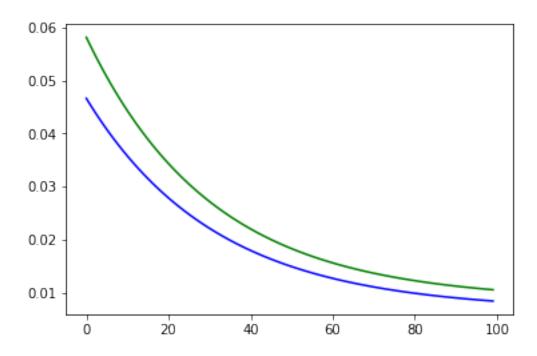
    grad_t = N_X_T.dot(N_h-N_Y)
    grad = grad_t*(1/m)

    N_theta = N_theta - 0.01*(grad)

    count += 1</pre>
```

```
[127]: plt.plot(N_j[:100],'g-')
plt.plot(j[:100],'b-')
```

[127]: [<matplotlib.lines.Line2D at 0x7faee47df520>]



hw1-3b-standardization

February 20, 2023

```
[1]: import numpy as np # import numpy library
     import pandas as pd # import pandas library
     import matplotlib.pyplot as plt # import matplotlib library
     from sklearn import preprocessing
[2]: df = pd.read_csv("/content/sample_data/Housing.csv")
     # display DataFrame
     df
[2]:
                                       bathrooms
                                                   stories mainroad guestroom basement
              price
                      area
                            bedrooms
           13300000
                      7420
                                                                  yes
                                                                              no
           12250000
                                                4
                                                          4
     1
                      8960
                                    4
                                                                  yes
                                                                              no
                                                                                        no
     2
                                                2
                                                          2
           12250000
                      9960
                                    3
                                                                  yes
                                                                              no
                                                                                       yes
     3
           12215000
                     7500
                                    4
                                                2
                                                          2
                                                                  yes
                                                                              no
                                                                                       yes
           11410000
                     7420
                                    4
                                                1
                                                          2
                                                                  yes
                                                                             yes
                                                                                       yes
                                    2
     540
            1820000
                      3000
                                                1
                                                          1
                                                                  yes
                                                                              no
                                                                                       yes
     541
            1767150
                      2400
                                    3
                                                1
                                                          1
                                                                                        no
                                                                   no
                                                                              no
     542
                                    2
            1750000
                      3620
                                                          1
                                                                  yes
                                                                              no
                                                                                        no
     543
                                    3
            1750000
                      2910
                                                1
                                                          1
                                                                   no
                                                                              no
                                                                                        no
     544
            1750000
                      3850
                                    3
                                                1
                                                          2
                                                                  yes
                                                                              no
                                                                                        no
         hotwaterheating airconditioning
                                             parking prefarea furnishingstatus
     0
                                                     2
                                                                         furnished
                        no
                                                            yes
     1
                                                     3
                                        yes
                                                             no
                                                                         furnished
                                                     2
     2
                                         no
                                                            yes
                                                                   semi-furnished
                        no
     3
                        no
                                        yes
                                                     3
                                                            yes
                                                                         furnished
     4
                                                     2
                                                                         furnished
                                        yes
                                                             no
                        no
     . .
                                                     2
     540
                                                                      unfurnished
                        no
                                         no
                                                             no
     541
                                                     0
                                                                   semi-furnished
                        no
                                         no
                                                             no
     542
                                                     0
                                                                      unfurnished
                        no
                                         no
                                                             no
     543
                                                     0
                                                                         furnished
                                                             no
                        no
                                         no
     544
                                                     0
                                                                      unfurnished
                        no
                                         no
                                                             no
```

[545 rows x 13 columns]

```
[3]: df = df.replace(to_replace=['yes', 'no'], value=[1, 0])
     df
[3]:
                                        bathrooms
                                                               mainroad
                                                                          guestroom
                             bedrooms
                                                     stories
              price
                      area
           13300000
                                     4
                                                 2
                                                            3
     0
                      7420
                                                                       1
                                                                                    0
     1
           12250000
                      8960
                                     4
                                                 4
                                                            4
                                                                       1
                                                                                    0
                                                 2
     2
           12250000
                      9960
                                     3
                                                            2
                                                                       1
                                                                                    0
     3
           12215000
                      7500
                                     4
                                                            2
                                                                       1
                                                                                    0
           11410000
                      7420
                                     4
                                                 1
                                                            2
                                                                       1
                                                                                    1
     540
                                     2
                                                  1
            1820000
                      3000
                                                            1
                                                                       1
                                                                                    0
     541
                                     3
                                                  1
                                                                       0
            1767150
                      2400
                                                            1
                                                                                    0
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     542
                                                  1
            1750000
                      3620
                                                            1
                                                                       1
                                                                                    0
     543
            1750000
                                     3
                                                 1
                                                                       0
                      2910
                                                            1
                                                                                    0
     544
                                     3
                                                            2
            1750000
                      3850
                                                                       1
           basement
                      hotwaterheating
                                         airconditioning parking
                                                                       prefarea
     0
                   0
                                                         1
                                                                    2
     1
                   0
                                      0
                                                         1
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                                                                               0
     2
                                      0
                                                         0
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                                                                    3
     3
                   1
                                      0
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     4
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                                      0
                                                         1
     540
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     541
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                   0
          furnishingstatus
     0
                  furnished
     1
                  furnished
     2
            semi-furnished
     3
                  furnished
     4
                  furnished
     . .
               unfurnished
     540
     541
            semi-furnished
     542
               unfurnished
     543
                  furnished
     544
               unfurnished
     [545 rows x 13 columns]
```

[4]: # create a training set by randomly selecting 80% of the rows from the DataFrame train = df.sample(frac=0.8, random_state=1)

create a test set by dropping the rows in the training set from the DataFrame
test = df.drop(train.index)

[5]: train

[5]:		price	area	bedrooms	bathrooms	stories	mainroad	guestroom	\
	62	7070000	6240	4	2	2		0	
	247	4550000	8400	4	1	4	. 1	0	
	142	5600000	10500	4	2	2	. 1	0	
	107	6125000	6420	3	1	3	1	0	
	483	2940000	6615	3	1	2	. 1	0	
		•••	•••	•••			•••		
	359	3710000	3600	3	1	1	. 1	0	
	36	8043000	7482	3	2	3	1	0	
	30	8400000	7475	3	2	4	: 1	0	
	20	8750000	4320	3	1	2	. 1	0	
	527	2275000	1836	2	1	1	. 0	0	
		basement	hotwa	terheating	aircondit	ioning	parking p	refarea \	
	62	0		0		1	1	0	
	247	0		0		0	3	0	
	142	0		0		0	1	0	
	107	1		0		0	0	1	
	483	0		0		0	0	0	
		•••		•••	••		•••		
	359	0		0		0	1	0	
	36	0		1		0	1	1	
	30	0		0		1	2	0	
	20	1		1		0	2	0	
	527	1		0		0	0	0	

furnishingstatus 62 furnished 247 unfurnished 142 semi-furnished 107 unfurnished 483 semi-furnished unfurnished 359 36 furnished unfurnished 30

[436 rows x 13 columns]

semi-furnished

semi-furnished

[6]: test

20

527

```
[6]:
                           bedrooms
                                     bathrooms
                                                stories
                                                         mainroad
                                                                   guestroom
             price
                     area
          12250000
                     9960
                                                      2
     2
                                  3
                                             2
                                                                 1
                                                                            0
                                  4
                                             2
                                                      2
                                                                 1
                                                                            0
     3
          12215000
                     7500
     7
          10150000
                    16200
                                  5
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                                                      2
                                                                 1
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                                                       2
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                     6000
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                     4400
                                             1
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                                                                 1
                                                                            0
     513
           2485000
                     4400
                                  3
                                                      2
                                                                            0
                                             1
                                                                 1
     520
                                  2
           2450000
                     7700
                                             1
                                                       1
                                                                 1
                                                                            0
                                                      2
     537
           1890000
                     1700
                                  3
                                             1
                                                                 1
                                                                            0
     539
           1855000
                     2990
                                  2
                                             1
                                                       1
                                                                 0
                                                                            0
                    hotwaterheating
                                                      parking
                                     airconditioning
          basement
                                                               prefarea
     2
                                  0
                                  0
                                                             3
     3
                 1
                                                   1
                                                                       1
     7
                 0
                                  0
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                                                             0
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                                                   0
                                                             2
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                 1
                                  0
                                                                       0
     22
                 1
                                  0
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                                                             •••
                                                             0
     508
                 0
                                  0
                                                   0
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     513
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     539
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         furnishingstatus
     2
           semi-furnished
     3
                furnished
     7
              unfurnished
     15
           semi-furnished
     22
                furnished
     . .
     508
              unfurnished
     513
              unfurnished
     520
              unfurnished
     537
              unfurnished
     539
              unfurnished
     [109 rows x 13 columns]
[7]: # select specific columns for the training set
     train = train[['price', 'area', 'bedrooms', 'bathrooms', 'stories', 'parking', _
      # select specific columns for the test set
```

```
¬'mainroad', 'guestroom', 'basement', 'hotwaterheating', 'airconditioning',

       [8]: scaler = preprocessing.StandardScaler()
 [9]: train
 [9]:
                           bedrooms
                                      bathrooms
             price
                     area
                                                 stories
                                                          parking mainroad
           7070000
                                              2
                                                        2
      62
                     6240
                                   4
      247 4550000
                                                        4
                                                                 3
                     8400
                                   4
                                              1
                                                                            1
      142 5600000
                    10500
                                   4
                                              2
                                                        2
                                                                 1
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      107
           6125000
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                                   3
                                              1
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                                                                 0
                                                                            1
                                                        2
      483 2940000
                     6615
                                   3
                                              1
                                                                 0
                                                                            1
      . .
      359 3710000
                     3600
                                   3
                                              1
                                                        1
                                                                 1
                                                                            1
                                              2
      36
           8043000
                                   3
                                                        3
                                                                 1
                                                                            1
                     7482
                                   3
                                              2
                                                                 2
      30
           8400000
                     7475
                                                        4
                                                                            1
                                   3
                                                        2
      20
           8750000
                     4320
                                              1
                                                                 2
                                                                            1
      527 2275000
                     1836
                                   2
                                              1
                                                        1
                                                                            0
                                                                 0
                     basement hotwaterheating airconditioning prefarea
           guestroom
      62
                   0
                              0
                                               0
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                              0
                                               0
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      247
                   0
                              0
                                               0
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      142
      107
                   0
                              1
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      483
                   0
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                                                                            0
      . .
      359
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      36
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      527
                   0
      [436 rows x 12 columns]
[10]: # create a NumPy array of the 'area' column from the training set
      X1_t = np.array(train['area'])
      # display the NumPy array
      X1 t
                     8400, 10500,
                                    6420,
[10]: array([ 6240,
                                           6615,
                                                  3600,
                                                          3240,
                                                                 6600,
                                                                        2700,
              5000,
                     2650, 4775,
                                    4800,
                                           3700,
                                                  7700,
                                                          7420, 4280,
                                                                        6000,
                                           3630,
              6600,
                            3420,
                                    5500,
                     3649,
                                                  3180,
                                                          3600,
                                                                 8400,
                                                                        3000,
              8880,
                     5750,
                            2145,
                                    6360,
                                           6525,
                                                   1950,
                                                          5850,
                                                                 8372,
                                                                        2870,
              4990,
                            5200,
                                    6321,
                                           4960,
                                                  3480,
                                                          3210,
                                                                 4950,
                     2684,
                                                                        6840,
```

test = test[['price', 'area', 'bedrooms', 'bathrooms', 'stories', 'parking', __

```
4350,
                 4410,
                                  3850,
                                                   3162,
                                                                   4340,
         5850,
                         2500,
                                          3180,
                                                           3500,
6440,
                 3000,
                                  3760,
                                          3816,
                                                   6000,
                                                           7000,
         5010,
                         4920,
                                                                   3640,
4080,
         4160,
                 2910,
                         6060,
                                  3000,
                                          2787,
                                                   4815,
                                                           4785,
                                                                   6600,
5300,
         3600,
                 6000,
                         2176,
                                  3000,
                                          7420,
                                                   7020,
                                                           3480,
                                                                   5960,
3510,
         6420,
                 6450,
                         6210,
                                  4500,
                                          3000,
                                                   3180,
                                                           5700,
                                                                   3520,
                 2800,
                                  4960,
                                                   7500,
4040,
         5800,
                         6480,
                                          4260,
                                                           5880,
                                                                  10500,
                 8500,
                         3120,
                                  3990,
                                          4095,
                                                   4800, 13200,
4500,
         3850,
                                                                   7770,
6100,
                 6550,
                         4100,
                                  4370,
                                          3180,
                                                   7350,
                                                           3510,
                                                                   3640,
         4075,
5500,
                 6600,
                                  2475,
                                                   4500,
                                                           3720,
         8250,
                         8250,
                                          3850,
                                                                   4360,
10240,
         5500,
                 3970,
                         3450,
                                  3850,
                                          5500,
                                                   3520,
                                                           2145,
                                                                   6600,
3640,
         3986,
                 2953,
                         8250,
                                  4130,
                                          8580,
                                                   6000,
                                                           3500,
                                                                   5885,
                                  8100,
7680,
         2430,
                 3150,
                         6450,
                                          5500,
                                                   1650,
                                                           3040,
                                                                   4079,
2747,
         4600,
                 2325,
                         7231,
                                  3520,
                                          2145,
                                                   3450,
                                                           3620,
                                                                   4000,
                                  7200,
6000,
         6000,
                 4500,
                         3540,
                                          3120,
                                                   4000,
                                                           2015,
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                                                   6360,
                 3512,
                         3420,
                                  6060,
                                          4500,
8000,
         2787,
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                                                                   8250,
3960,
         7410, 10360,
                         3630,
                                  6020,
                                          4100,
                                                   6254,
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                                                                   4560,
                 8880,
                                  7152,
6710,
         3500,
                         3600,
                                          6000,
                                                   4040,
                                                           4000,
                                                                   4040,
                 3800,
5360,
         6600,
                         3960,
                                  4900,
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                                                   3584,
                                                           2275,
                                                                   4000,
6500,
                 8960,
                         3290,
                                  8875,
                                                           6600,
       10500,
                                          8580,
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5640,
         3745, 10269,
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                                          5880,
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4000,
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                                                           4095,
                                                                   6000,
6540,
                 4320,
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                 4995, 11410,
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7800,
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                                                                   9500,
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         3420,
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                                  5400,
                                          3630,
                                                   6750,
                                                           4820,
                                                                   5136,
4120,
         6825,
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                                                   6600,
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                 3640,
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                                                           7980,
5150,
         6000,
                                                   4032,
                                                                   1905,
6000,
         3360,
                 9620,
                          1950, 12900,
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                 8100,
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                                                           4050,
7440,
         3760,
                         4880,
                                          2000,
                                                                   9166,
7950,
         5500,
                 2700,
                         6000,
                                  6900,
                                          3500,
                                                   5076,
                                                           5985,
                                                                   4300,
8050,
         5320,
                 5960,
                         7000,
                                  7260,
                                          6360,
                                                   3000,
                                                           3460,
                                                                  12944,
3880,
         2400,
                 4080,
                         6000,
                                  4500,
                                          6050,
                                                   7000,
                                                           3930,
                                                                   4600,
7155,
         4100,
                 2400,
                         3460,
                                  4632,
                                          4200,
                                                   4640,
                                                           8800,
                                                                   3000,
6300,
         7000,
                 7000,
                         6900,
                                  3420,
                                          3264,
                                                   2640,
                                                           3150,
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                 4992,
6862, 11440,
                         3069,
                                  3185,
                                          3750,
                                                   5300,
                                                           7200,
                                                                   6400,
6800,
         3400,
                 6420,
                         3792,
                                  5500,
                                          4600,
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                                                           6000,
                                                                   8520,
                 5948,
6480,
         8150,
                         3185,
                                  5830,
                                          3410,
                                                   3000,
                                                           8400,
                                                                   6350,
8100,
         4800,
                 2856,
                         3185,
                                  3780,
                                          3640,
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                                          5400,
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         6360,
                 4120,
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                                  2850,
                                                   2145,
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                                                                   3240,
                                                   3520,
13200,
         3900,
                 9000,
                         4646,
                                  3840,
                                          9000,
                                                           3640,
                                                                   3600,
7482,
                 4320,
         7475,
                          1836])
```

```
[11]: X2_t = np.array(train.bedrooms)
X3_t = np.array(train.bathrooms)
```

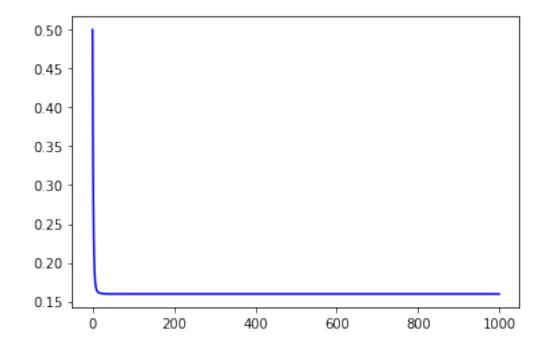
```
X4_t = np.array(train.stories)
      X5_t = np.array(train.parking)
      X6_t = np.array(train.mainroad)
      X7_t = np.array(train.guestroom)
      X8_t = np.array(train.hotwaterheating)
      X9_t = np.array(train.airconditioning)
      X10_t = np.array(train.prefarea)
      X11_t = np.array(train.basement)
      X0_t = np.ones(436)
[12]: X = np.vstack([X0_t,X1_t,X2_t,X3_t,X4_t,X5_t,X6_t,X7_t,X8_t,X9_t,X10_t,X11_t])
      X = X.T
      X = np.array(X)
      Х
[12]: array([[1.000e+00, 6.240e+03, 4.000e+00, ..., 1.000e+00, 0.000e+00,
              0.000e+00],
             [1.000e+00, 8.400e+03, 4.000e+00, ..., 0.000e+00, 0.000e+00,
              0.000e+00],
             [1.000e+00, 1.050e+04, 4.000e+00, ..., 0.000e+00, 0.000e+00,
              0.000e+00],
             [1.000e+00, 7.475e+03, 3.000e+00, ..., 1.000e+00, 0.000e+00,
              0.000e+001.
             [1.000e+00, 4.320e+03, 3.000e+00, ..., 0.000e+00, 0.000e+00,
              1.000e+007.
             [1.000e+00, 1.836e+03, 2.000e+00, ..., 0.000e+00, 0.000e+00,
              1.000e+00]])
[13]: # scale the feature matrix using the fit_transform() method of the scaler object
      X_scaled = scaler.fit_transform(X)
      # assign the scaled feature matrix to the original variable name 'X'
      X = X_scaled
[14]: # create a 1D NumPy array of zeros with length 12
      theta = np.zeros(12)
      # reshape the 1D array to a column vector using np.reshape
      theta = np.reshape(theta, (12,1))
      # display the column vector
      theta
[14]: array([[0.],
             [0.],
             [0.],
```

```
[0.],
             [0.],
             [0.],
             [0.],
             [0.],
             [0.],
             [0.11)
[15]: # create a 1D NumPy array 'Y_t' from the 'price' column of the training set
      →'train'
      #h = np.matmul(X, theta)
      Y_t = np.array(train.price)
      Y = Y t
      Y = Y_t.reshape(436,1)
      y = scaler.fit_transform(Y)
      Y=y
[16]: | # create a NumPy array 'X_T' containing the transpose of the feature matrix 'X'
      X T = np.array(X.T)
      \# retrieve the number of rows 'm' and the number of columns 'n' from the \sqcup
      ⇔feature matrix 'X'
      m, n = X.shape
      # display the values of 'm' and 'n'
      print("Number of training examples (m): ", m)
      print("Number of features (n): ", n)
      # set the number of iterations for gradient descent
      iterations = 1000
      \# create a counter variable 'count' and a NumPy array 'j' to store the cost
       ⇔function values for each iteration
      count = 0
      j = np.zeros(shape=(iterations, 1), dtype=float)
      # display the shape of the 'j' array
      print("Shape of 'j' array: ", j.shape)
     Number of training examples (m): 436
     Number of features (n): 12
     Shape of 'j' array: (1000, 1)
[17]: # Initialize variables
      iterations = 1000
```

[0.], [0.],

```
count = 0
alpha = 0.1
lambda_ = 0.001
j = np.zeros(iterations)
# Perform gradient descent
while count < iterations:</pre>
   h_t = X.dot(theta)
   h = np.array(h_t, float)
    j[count] = (1/(2*m)) * np.sum((h - Y)**2) + (lambda_ / (2*m)) * np.
 ⇒sum(theta**2)
    grad_t = X_T.dot(h - Y)
    grad = grad_t * (1/m)
    theta = theta * (1 - alpha * (lambda_ / m)) - alpha * grad
    count += 1
# Plot the cost function
plt.plot(j, 'b-')
```

[17]: [<matplotlib.lines.Line2D at 0x7f03efeffd60>]



```
[18]: # extract the test set features into NumPy arrays
      N_X1_t = np.array(test.area)
      N_X2_t = np.array(test.bedrooms)
      N_X3_t = np.array(test.bathrooms)
      N_X4_t = np.array(test.stories)
      N_X5_t = np.array(test.parking)
      N_X6_t = np.array(test.mainroad)
      N_X7_t = np.array(test.guestroom)
      N_X8_t = np.array(test.hotwaterheating)
      N_X9_t = np.array(test.airconditioning)
      N X10 t = np.array(test.prefarea)
      N_X11_t = np.array(test.basement)
      N_X0_t = np.ones(109)
[19]: # stack the test set features into a design matrix
      N_X = np.vstack([N_X0_t,N_X1_t,N_X2_t,N_X3_t,N_X4_t,N_X5_t,__
       →N_X6_t,N_X7_t,N_X8_t,N_X9_t,N_X10_t,N_X11_t])
      N_X_T = N_X.T
      N_X = np.array(N_X_T)
      N_x = scaler.fit_transform(N_X)
      N_X = N_x
      N_X.shape
[19]: (109, 12)
[20]: # initialize the parameters for the test set
      N_{\text{theta}} = \text{np.array}([0.,0.,0.,0.,0.,0.,0.,0.,0.,0.])
      N_theta = N_theta.reshape(12,1)
      N_{theta}
[20]: array([[0.],
             [0.],
             [0.],
             [0.],
             [0.],
             [0.],
             [0.],
             [0.],
             [0.],
             [0.],
             [0.],
             [0.11)
[21]: # initialize the target variable for the test set
      N_Y_t = np.array(test.price)
      N_Y = N_Y_t
      N_Y = N_Y_t.reshape(109,1)
```

```
N_y = scaler.fit_transform(N_Y)
      N_Y=N_y
      N_Y.shape
[21]: (109, 1)
[22]: N_X_T = np.array(N_X.T)
      m,n = N_X.shape
      m,n
[22]: (109, 12)
[24]: iterations = 2500
      count=0
      N_j = np.zeros(shape=(iterations, 1), dtype=float)
      while(count < iterations):</pre>
          N_h_t = N_X.dot(N_theta)
          N_h = np.array(N_h_t)
          N_j[count] = (1/(2*m))*np.sum((N_h - N_Y)**2)+(0.001)*(1/(2*m))*np.
       ⇒sum((N_theta)**2)
          grad_t = N_X_T.dot(N_h-N_Y)
          grad = grad_t*(1/m)
          N_{\text{theta}} = N_{\text{theta}} * (1-0.1*(0.001/m)) - 0.1*(grad)
          count += 1
[26]: plt.plot(N_j[:80],'g-')
      plt.plot(j[:80],'b-')
```

[26]: [<matplotlib.lines.Line2D at 0x7f03ef903eb0>]

