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HW1_VarScalingAndRegularization

September 30, 2022

[156]:
```
import numpy as np
import pandas as pd

# For Data Visualization
import matplotlib.pyplot as plt
import seaborn as sns
```

[157]:
```
housing = pd.DataFrame(pd.read_csv("./Housing.csv"))
housing.head()
```

[157]:

	price	area	bedrooms	bathrooms	stories	mainroad	guestroom	basement	hotwaterheating	airconditioning	parking	prefarea	furnishingstatus
0	13300000	7420	4	2	3	yes	no	no	no	yes	2	yes	furnished
1	12250000	8960	4	4	4	yes	no	no	no	yes	3	no	furnished
2	12250000	9960	3	2	2	yes	no	yes	no	no	2	yes	semi-furnished
3	12215000	7500	4	2	2	yes	no	yes	no	yes	3	yes	furnished
4	11410000	7420	4	1	2	yes	yes	yes	no	yes	2	no	furnished

[158]:
```
varlist = ['mainroad', 'guestroom', 'basement', 'hotwaterheating',␣
 ↪'airconditioning', 'prefarea']
# Define map function
def binary_map(x):
    return x.map({'yes': 1, 'no': 0})

# Applying the function to housing list
housing[varlist] = housing[varlist].apply(binary_map)

housing.head()
```

[158]:

	price	area	bedrooms	bathrooms	stories	mainroad	guestroom	basement	hotwaterheating	airconditioning	parking	prefarea	furnishingstatus
0	13300000	7420	4	2	3	1	0	0	0	1	2	1	furnished
1	12250000	8960	4	4	4	1	0	0	0	1	3	0	furnished

```
2  12250000  9960         3          2        2         1          0
3  12215000  7500         4          2        2         1          0
4  11410000  7420         4          1        2         1          1

   basement  hotwaterheating  airconditioning  parking  prefarea  \
0         0                0                1        2         1
1         0                0                1        3         0
2         1                0                0        2         1
3         1                0                1        3         1
4         1                0                1        2         0

  furnishingstatus
0        furnished
1        furnished
2   semi-furnished
3        furnished
4        furnished
```

[159]:
```
# Splitting Data into Training and Validation Sets
from sklearn.model_selection import train_test_split

np.random.seed(0)
df_train, df_test = train_test_split(housing, train_size = 0.8, test_size = 0.2)
df_train.shape
```

[159]:
```
(436, 13)
```

[160]:
```
df_test.shape
```

[160]:
```
(109, 13)
```

[161]:
```
# Problem 1a
num_vars_1a = ['area', 'bedrooms', 'bathrooms', 'stories', 'parking', 'price']
df_newTrain_1a = df_train[num_vars_1a]
df_newTest_1a = df_test[num_vars_1a]
df_newTrain_1a.head()
```

[161]:

	area	bedrooms	bathrooms	stories	parking	price
542	3620	2	1	1	0	1750000
496	4000	2	1	1	0	2695000
484	3040	2	1	1	0	2870000
507	3600	2	1	1	0	2590000
252	9860	3	1	1	0	4515000

[162]:
```
def compute_cost(X, y, theta):
 predictions = X.dot(theta) # H = X * Theta
 errors = np.subtract(predictions, y) # H - Y
 sqrErrors = np.square(errors) # Square of above
```

```
    J = 1 / (2 * len(X)) * np.sum(sqrErrors) # Sum of above array, multiply by 1/
    ↪(2m)
    return J
```

[163]:
```
def gradient_descent(X, y, theta, alpha, iterations, xTest, yTest):
    cost_history = np.zeros(iterations) # Store loss calculations in array to be␣
    ↪able to plot gradient descent
    testCost_history = np.zeros(iterations) # Store validation loss
    for i in range(iterations):
        predictions = X.dot(theta) # H = X * Theta
        errors = np.subtract(predictions, y) # H - Y
        derivLoss = (1 / len(X)) * X.transpose().dot(errors); # Finishes derivative␣
    ↪of loss calculation
        theta = theta - (alpha * derivLoss); # Calculates for new thetas
        cost_history[i] = compute_cost(X, y, theta) # Stores new cost from the new␣
    ↪thetas
        testCost_history[i] = compute_cost(xTest, yTest, theta) # Stores validation␣
    ↪cost from new thetas
    return theta, cost_history, testCost_history
```

[164]:
```
m_1a = len(df_newTrain_1a)
testM_1a = len(df_newTest_1a)
m_1a
```

[164]:
```
436
```

[165]:
```
#y_newTrain_1a = df_newTrain_1a.pop('price')
#x_newTrain_1a = df_newTrain_1a.copy()

X0_1a = np.ones((m_1a,1))
testX0_1a = np.ones((testM_1a,1))
X0_1a[:5]
```

[165]:
```
array([[1.],
       [1.],
       [1.],
       [1.],
       [1.]])
```

[166]:
```
X_1a = df_newTrain_1a.values[:,0:5]
y_1a = df_newTrain_1a.values[:,5]

testX_1a = df_newTest_1a.values[:,0:5]
testy_1a = df_newTest_1a.values[:,5]

X = np.hstack((X0_1a, X_1a))
testX = np.hstack((testX0_1a, testX_1a))
```

```
X[:10]
```

[166]:
```
array([[1.000e+00, 3.620e+03, 2.000e+00, 1.000e+00, 1.000e+00, 0.000e+00],
       [1.000e+00, 4.000e+03, 2.000e+00, 1.000e+00, 1.000e+00, 0.000e+00],
       [1.000e+00, 3.040e+03, 2.000e+00, 1.000e+00, 1.000e+00, 0.000e+00],
       [1.000e+00, 3.600e+03, 2.000e+00, 1.000e+00, 1.000e+00, 0.000e+00],
       [1.000e+00, 9.860e+03, 3.000e+00, 1.000e+00, 1.000e+00, 0.000e+00],
       [1.000e+00, 3.968e+03, 3.000e+00, 1.000e+00, 2.000e+00, 0.000e+00],
       [1.000e+00, 3.840e+03, 3.000e+00, 1.000e+00, 2.000e+00, 1.000e+00],
       [1.000e+00, 9.800e+03, 4.000e+00, 2.000e+00, 2.000e+00, 2.000e+00],
       [1.000e+00, 3.640e+03, 2.000e+00, 1.000e+00, 1.000e+00, 0.000e+00],
       [1.000e+00, 3.520e+03, 2.000e+00, 2.000e+00, 1.000e+00, 0.000e+00]])
```

[167]:
```
y_1a[:5]
```

[167]:
```
array([1750000, 2695000, 2870000, 2590000, 4515000], dtype=int64)
```

[168]:
```
thetaX_1a = [0., 0., 0., 0., 0., 0.]
costX_1a = compute_cost(X, y_1a, thetaX_1a)
print('The cost for given values of theta_0, theta_1, theta_2, theta_3,␣
 ↪theta_4, and theta5 =', costX_1a)
alphaX_1a = 0.00000001;
iterations = 200;
```

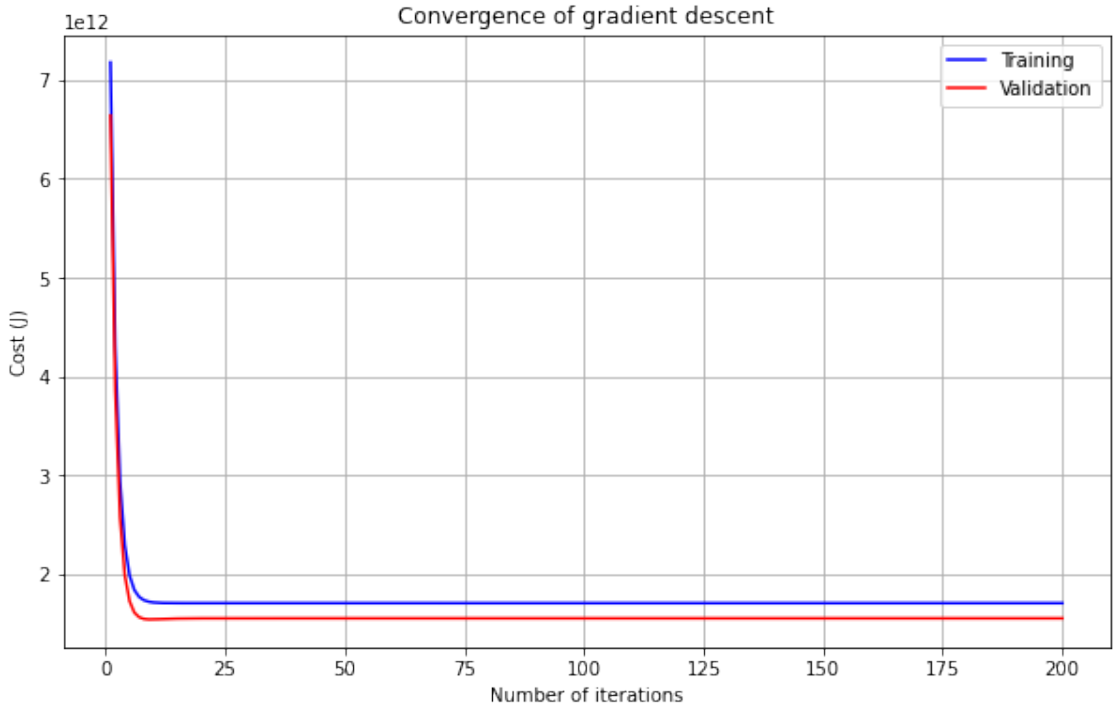
```
The cost for given values of theta_0, theta_1, theta_2, theta_3, theta_4, and
theta5 = 13234989983633.717
```

[169]:
```
thetaX_1a, costX_1a_history, testCostX_1a_history = gradient_descent(X, y_1a,␣
 ↪thetaX_1a, alphaX_1a, iterations, testX, testy_1a)
print('Final value of theta for 1a =', thetaX_1a)
#print('cost_history for 1a =', costX_1a_history)
#print('testCost_history for 1a =', testCostX_1a_history)
```

```
Final value of theta for 1a = [8.26427521e-01 8.61034777e+02 3.09868836e+00
1.68933722e+00
 2.58304257e+00 7.84212996e-01]
```

[170]:
```
plt.plot(range(1, iterations + 1),costX_1a_history, color='blue',␣
 ↪label='Training')
plt.plot(range(1, iterations + 1),testCostX_1a_history, color='red',␣
 ↪label='Validation')
plt.rcParams["figure.figsize"] = (10,6)
plt.grid()
plt.xlabel('Number of iterations')
plt.ylabel('Cost (J)')
plt.title('Convergence of gradient descent')
plt.legend(loc="upper right")
```

[170]: <matplotlib.legend.Legend at 0x2f125021d60>



[ ]:

[171]:
```
# Problem 1b
num_vars_1b = ['area', 'bedrooms', 'bathrooms', 'stories', 'mainroad',␣
 ↪'guestroom', 'basement', 'hotwaterheating', 'airconditioning', 'parking',␣
 ↪'prefarea', 'price']
df_newTrain_1b = df_train[num_vars_1b]
df_newTest_1b = df_test[num_vars_1b]
df_newTrain_1b.head(10)
```

[171]:

	area	bedrooms	bathrooms	stories	mainroad	guestroom	basement	\
542	3620	2	1	1	1	0	0	
496	4000	2	1	1	1	0	0	
484	3040	2	1	1	0	0	0	
507	3600	2	1	1	1	0	0	
252	9860	3	1	1	1	0	0	
263	3968	3	1	2	0	0	0	
240	3840	3	1	2	1	0	0	
175	9800	4	2	2	1	1	0	
385	3640	2	1	1	1	0	0	
374	3520	2	2	1	1	0	1	

	hotwaterheating	airconditioning	parking	prefarea	price
542	0	0	0	0	1750000
496	0	0	0	0	2695000
484	0	0	0	0	2870000
507	0	0	0	0	2590000
252	0	0	0	0	4515000
263	0	0	0	0	4410000
240	0	0	1	1	4585000
175	0	0	2	0	5250000
385	0	0	0	0	3570000
374	0	0	0	0	3640000

[172]:
```
m_1b = len(df_newTrain_1b)
testM_1b = len(df_newTest_1b)
m_1b
```

[172]: 436

[173]:
```
X0_1b = np.ones((m_1b,1))
testX0_1b = np.ones((testM_1b,1))

X_1b = df_newTrain_1b.values[:,0:11]
y_1b = df_newTrain_1b.values[:,11]

testX_1b = df_newTest_1b.values[:,0:11]
testy_1b = df_newTest_1b.values[:,11]

X = np.hstack((X0_1b, X_1b))
testX = np.hstack((testX0_1b, testX_1b))
X[:10]
```

[173]:
```
array([[1.000e+00, 3.620e+03, 2.000e+00, 1.000e+00, 1.000e+00, 1.000e+00,
        0.000e+00, 0.000e+00, 0.000e+00, 0.000e+00, 0.000e+00, 0.000e+00],
       [1.000e+00, 4.000e+03, 2.000e+00, 1.000e+00, 1.000e+00, 1.000e+00,
        0.000e+00, 0.000e+00, 0.000e+00, 0.000e+00, 0.000e+00, 0.000e+00],
       [1.000e+00, 3.040e+03, 2.000e+00, 1.000e+00, 1.000e+00, 0.000e+00,
        0.000e+00, 0.000e+00, 0.000e+00, 0.000e+00, 0.000e+00, 0.000e+00],
       [1.000e+00, 3.600e+03, 2.000e+00, 1.000e+00, 1.000e+00, 1.000e+00,
        0.000e+00, 0.000e+00, 0.000e+00, 0.000e+00, 0.000e+00, 0.000e+00],
       [1.000e+00, 9.860e+03, 3.000e+00, 1.000e+00, 1.000e+00, 1.000e+00,
        0.000e+00, 0.000e+00, 0.000e+00, 0.000e+00, 0.000e+00, 0.000e+00],
       [1.000e+00, 3.968e+03, 3.000e+00, 1.000e+00, 2.000e+00, 0.000e+00,
        0.000e+00, 0.000e+00, 0.000e+00, 0.000e+00, 0.000e+00, 0.000e+00],
       [1.000e+00, 3.840e+03, 3.000e+00, 1.000e+00, 2.000e+00, 1.000e+00,
        0.000e+00, 0.000e+00, 0.000e+00, 0.000e+00, 1.000e+00, 1.000e+00],
       [1.000e+00, 9.800e+03, 4.000e+00, 2.000e+00, 2.000e+00, 1.000e+00,
        1.000e+00, 0.000e+00, 0.000e+00, 0.000e+00, 2.000e+00, 0.000e+00],
```

```
[1.000e+00, 3.640e+03, 2.000e+00, 1.000e+00, 1.000e+00, 1.000e+00,
 0.000e+00, 0.000e+00, 0.000e+00, 0.000e+00, 0.000e+00, 0.000e+00],
[1.000e+00, 3.520e+03, 2.000e+00, 2.000e+00, 1.000e+00, 1.000e+00,
 0.000e+00, 1.000e+00, 0.000e+00, 0.000e+00, 0.000e+00, 0.000e+00]])
```

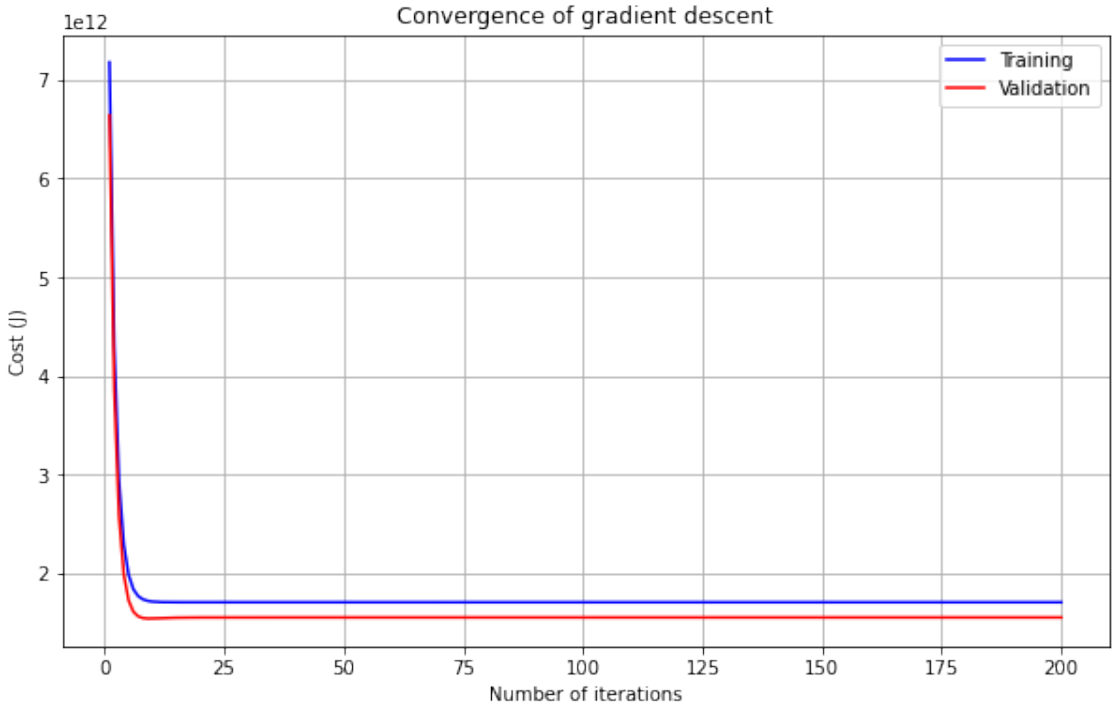
[174]:
```
thetaX_1b = np.zeros(12)
alphaX_1b = 0.00000001;
iterations = 200;
```

[175]:
```
thetaX_1b, costX_1b_history, testCostX_1b_history = gradient_descent(X, y_1b,␣
 ↪thetaX_1b, alphaX_1b, iterations, testX, testy_1b)
print('Final value of theta for 1a =', thetaX_1b)
#print('cost_history for 1a =', costX_1a_history)
#print('testCost_history for 1a =', testCostX_1a_history)
```

```
Final value of theta for 1a = [8.26427373e-01 8.61034564e+02 3.09868789e+00
1.68933700e+00
 2.58304225e+00 7.49235626e-01 3.48746484e-01 5.71781420e-01
 1.45670881e-01 6.66373716e-01 7.84212884e-01 3.66320406e-01]
```

[176]:
```
plt.plot(range(1, iterations + 1),costX_1b_history, color='blue',␣
 ↪label='Training')
plt.plot(range(1, iterations + 1),testCostX_1b_history, color='red',␣
 ↪label='Validation')
plt.rcParams["figure.figsize"] = (10,6)
plt.grid()
plt.xlabel('Number of iterations')
plt.ylabel('Cost (J)')
plt.title('Convergence of gradient descent')
plt.legend(loc="upper right")
```

[176]:
```
<matplotlib.legend.Legend at 0x2f125090100>
```


Convergence of gradient descent
1e12
Training
Validation
Cost (J)
Number of iterations
0
25
50
75
100
125
150
175
200
2
3
4
5
6
7

[ ]:

Problem2_and_3

September 30, 2022

[322]:
```
import numpy as np
import pandas as pd

# For Data Visualization
import matplotlib.pyplot as plt
import seaborn as sns
```

[323]:
```
housing = pd.DataFrame(pd.read_csv("./Housing.csv"))
housing.head()
```

[323]:

	price	area	bedrooms	bathrooms	stories	mainroad	guestroom	basement	hotwaterheating	airconditioning	parking	prefarea	furnishingstatus
0	13300000	7420	4	2	3	yes	no	no	no	yes	2	yes	furnished
1	12250000	8960	4	4	4	yes	no	no	no	yes	3	no	furnished
2	12250000	9960	3	2	2	yes	no	yes	no	no	2	yes	semi-furnished
3	12215000	7500	4	2	2	yes	no	yes	no	yes	3	yes	furnished
4	11410000	7420	4	1	2	yes	yes	yes	no	yes	2	no	furnished

[324]:
```
varlist = ['mainroad', 'guestroom', 'basement', 'hotwaterheating',␣
 ↪'airconditioning', 'prefarea']
# Define map function
def binary_map(x):
    return x.map({'yes': 1, 'no': 0})

# Applying the function to housing list
housing[varlist] = housing[varlist].apply(binary_map)

housing.head()
```

[324]:

	price	area	bedrooms	bathrooms	stories	mainroad	guestroom	basement	hotwaterheating	airconditioning	parking	prefarea	furnishingstatus
0	13300000	7420	4	2	3	1	0	0	0	1	2	1	furnished
1	12250000	8960	4	4	4	1	0	0	0	1	3	0	furnished

```
2  12250000  9960         3          2        2         1          0
3  12215000  7500         4          2        2         1          0
4  11410000  7420         4          1        2         1          1

   basement  hotwaterheating  airconditioning  parking  prefarea  \
0         0                0                1        2         1
1         0                0                1        3         0
2         1                0                0        2         1
3         1                0                1        3         1
4         1                0                1        2         0

  furnishingstatus
0        furnished
1        furnished
2   semi-furnished
3        furnished
4        furnished
```

[325]:
```
# Splitting Data into Training and Validation Sets
from sklearn.model_selection import train_test_split

np.random.seed(0)
df_train, df_test = train_test_split(housing, train_size = 0.8, test_size = 0.2)
df_train.shape
```

[325]:
```
(436, 13)
```

[326]:
```
df_test.shape
```

[326]:
```
(109, 13)
```

[327]:
```
from sklearn.preprocessing import MinMaxScaler, StandardScaler
normalScaler = MinMaxScaler()
standScaler = StandardScaler()
```

[328]:
```
def compute_cost(X, y, theta):
 predictions = X.dot(theta) # H = X * Theta
 errors = np.subtract(predictions, y) # H - Y
 sqrErrors = np.square(errors) # Square of above
 J = 1 / (2 * len(X)) * np.sum(sqrErrors) # Sum of above array, multiply by 1/
 ↪(2m)
 return J
```

[329]:
```
def gradient_descent(X, y, theta, alpha, iterations, xTest, yTest):
 cost_history = np.zeros(iterations) # Store loss calculations in array to be␣
 ↪able to plot gradient descent
 testCost_history = np.zeros(iterations) # Store validation loss
```

```
    for i in range(iterations):
        predictions = X.dot(theta) # H = X * Theta
        errors = np.subtract(predictions, y) # H - Y
        derivLoss = (1 / len(X)) * X.transpose().dot(errors); # Finishes derivative␣
    ↪of loss calculation
        theta = theta - (alpha * derivLoss); # Calculates for new thetas
        cost_history[i] = compute_cost(X, y, theta) # Stores new cost from the new␣
    ↪thetas
        testCost_history[i] = compute_cost(xTest, yTest, theta) # Stores validation␣
    ↪cost from new thetas
    return theta, cost_history, testCost_history
```

[330]:
```
#Problem 2a
```

[331]:
```
num_vars_2a = ['area', 'bedrooms', 'bathrooms', 'stories', 'parking', 'price']
df_newTrain_2aMinMax = df_train[num_vars_2a]
df_newTest_2aMinMax = df_test[num_vars_2a]

df_newTrain_2aStand = df_train[num_vars_2a]
df_newTest_2aStand = df_test[num_vars_2a]
df_newTrain_2aMinMax.head()
```

[331]:

	area	bedrooms	bathrooms	stories	parking	price
542	3620	2	1	1	0	1750000
496	4000	2	1	1	0	2695000
484	3040	2	1	1	0	2870000
507	3600	2	1	1	0	2590000
252	9860	3	1	1	0	4515000

[332]:
```
#y_2a = df_newTrain_2aMinMax.pop('price')
#X_newTrain_2aMinMax = df_newTrain_2aMinMax.copy()
#X_newTrain_2aMinMax.head()
```

[333]:
```
#import warnings
#warnings.filterwarnings('ignore')

# Min/Max Normalization
df_newTrain_2aMinMax[num_vars_2a] = normalScaler.
 ↪fit_transform(df_newTrain_2aMinMax[num_vars_2a])
df_newTest_2aMinMax[num_vars_2a] = normalScaler.
 ↪fit_transform(df_newTest_2aMinMax[num_vars_2a])
df_newTrain_2aMinMax.head(5)
```

[333]:

	area	bedrooms	bathrooms	stories	parking	price
542	0.124199	0.2	0.0	0.0	0.0	0.000000
496	0.150654	0.2	0.0	0.0	0.0	0.081818
484	0.083821	0.2	0.0	0.0	0.0	0.096970

```
507  0.122807       0.2        0.0       0.0       0.0  0.072727
252  0.558619       0.4        0.0       0.0       0.0  0.239394
```

[334]:
```
y_normTrain_2a = df_newTrain_2aMinMax.pop('price')
X_normTrain_2a = df_newTrain_2aMinMax.copy()

y_normTest_2a = df_newTest_2aMinMax.pop('price')
X_normTest_2a = df_newTest_2aMinMax.copy()
X_normTrain_2a.head()
```

[334]:
```
         area  bedrooms  bathrooms  stories  parking
542  0.124199       0.2        0.0       0.0      0.0
496  0.150654       0.2        0.0       0.0      0.0
484  0.083821       0.2        0.0       0.0      0.0
507  0.122807       0.2        0.0       0.0      0.0
252  0.558619       0.4        0.0       0.0      0.0
```

[335]:
```
y_2a = y_normTrain_2a.values
X_2a = X_normTrain_2a.values[:,0:5]

testy_2a = y_normTest_2a.values
testX_2a = X_normTest_2a.values[:, 0:5]

X0_2a = np.ones((len(df_newTrain_2aMinMax),1))
X = np.hstack((X0_2a, X_2a))
X0_2a = np.ones((len(df_newTest_2aMinMax),1))
testX = np.hstack((X0_2a, testX_2a))
X[:10]
```

[335]:
```
array([[1.        , 0.12419939, 0.2       , 0.        , 0.        ,
        0.        ],
       [1.        , 0.15065441, 0.2       , 0.        , 0.        ,
        0.        ],
       [1.        , 0.08382066, 0.2       , 0.        , 0.        ,
        0.        ],
       [1.        , 0.12280702, 0.2       , 0.        , 0.        ,
        0.        ],
       [1.        , 0.55861877, 0.4       , 0.        , 0.        ,
        0.        ],
       [1.        , 0.14842662, 0.4       , 0.        , 0.33333333,
        0.        ],
       [1.        , 0.13951546, 0.4       , 0.        , 0.33333333,
        0.33333333],
       [1.        , 0.55444166, 0.6       , 0.5       , 0.33333333,
        0.66666667],
       [1.        , 0.12559176, 0.2       , 0.        , 0.        ,
        0.        ],
```

```
       [1.        , 0.11723754, 0.2       , 0.5       , 0.        ,
        0.        ]])
```

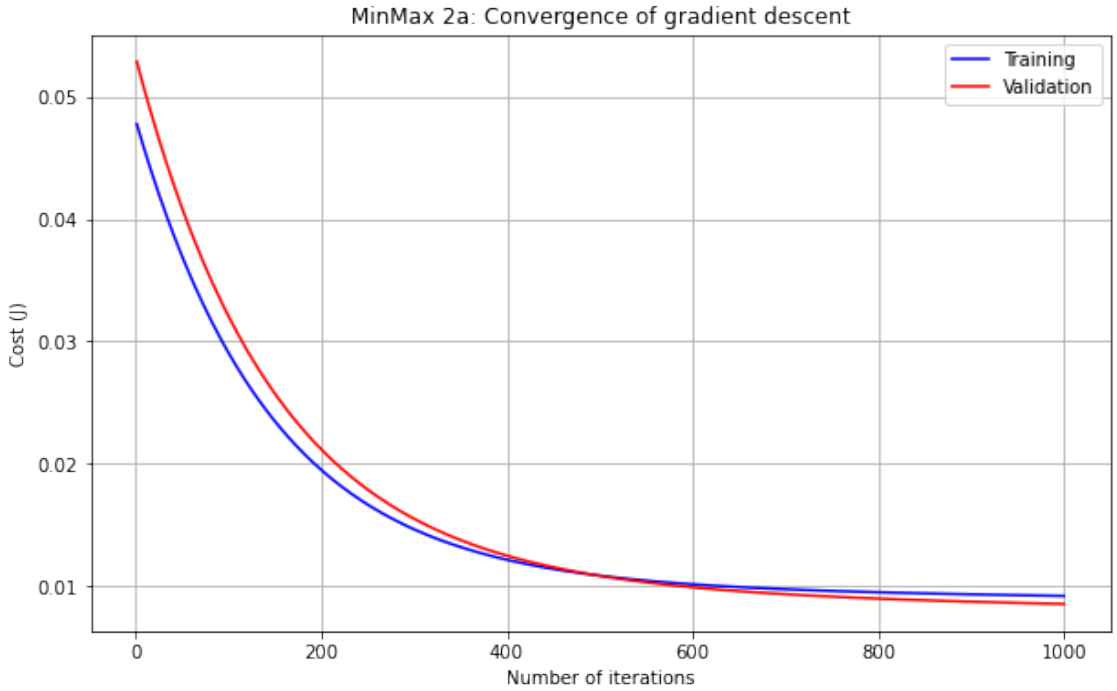
[336]:
```
thetaX_2a = np.zeros(6)
alphaX_2a = 0.0025
iterations = 1000
```

[337]:
```
thetaX_2a, costX_2a_history, testCostX_2a_history = gradient_descent(X, y_2a,␣
 ↪thetaX_2a, alphaX_2a, iterations, testX, testy_2a)
print('Final value of theta for 2a =', thetaX_2a)
```

```
Final value of theta for 2a = [0.1680599  0.06563284 0.08153202 0.06163319
0.07810329 0.07053487]
```

[338]:
```
plt.plot(range(1, iterations + 1),costX_2a_history, color='blue',␣
 ↪label='Training')
plt.plot(range(1, iterations + 1),testCostX_2a_history, color='red',␣
 ↪label='Validation')
plt.rcParams["figure.figsize"] = (10,6)
plt.grid()
plt.xlabel('Number of iterations')
plt.ylabel('Cost (J)')
plt.title('MinMax 2a: Convergence of gradient descent')
plt.legend(loc="upper right")
```

[338]:
```
<matplotlib.legend.Legend at 0x1c4176562e0>
```



[339]:
```
#import warnings
#warnings.filterwarnings('ignore')

# Standardization
df_newTrain_2aStand[num_vars_2a] = standScaler.
 ↪fit_transform(df_newTrain_2aStand[num_vars_2a])
df_newTest_2aStand[num_vars_2a] = standScaler.
 ↪fit_transform(df_newTest_2aStand[num_vars_2a])
df_newTrain_2aStand.head(5)
```

[339]:

	area	bedrooms	bathrooms	stories	parking	price
542	-0.716772	-1.294376	-0.573307	-0.933142	-0.819149	-1.586001
496	-0.538936	-1.294376	-0.573307	-0.933142	-0.819149	-1.090971
484	-0.988206	-1.294376	-0.573307	-0.933142	-0.819149	-0.999299
507	-0.726132	-1.294376	-0.573307	-0.933142	-0.819149	-1.145974
252	2.203478	0.052516	-0.573307	-0.933142	-0.819149	-0.137579

[340]:
```
y_standTrain_2a = df_newTrain_2aStand.pop('price')
X_standTrain_2a = df_newTrain_2aStand.copy()

y_standTest_2a = df_newTest_2aStand.pop('price')
X_standTest_2a = df_newTest_2aStand.copy()
X_standTrain_2a.head()
```

[340]:

	area	bedrooms	bathrooms	stories	parking
542	-0.716772	-1.294376	-0.573307	-0.933142	-0.819149
496	-0.538936	-1.294376	-0.573307	-0.933142	-0.819149
484	-0.988206	-1.294376	-0.573307	-0.933142	-0.819149
507	-0.726132	-1.294376	-0.573307	-0.933142	-0.819149
252	2.203478	0.052516	-0.573307	-0.933142	-0.819149

[341]:
```
y_2a = y_standTrain_2a.values
X_2a = X_standTrain_2a.values[:,0:5]

testy_2a = y_standTest_2a.values
testX_2a = X_standTest_2a.values[:, 0:5]

X0_2a = np.ones((len(df_newTrain_2aStand),1))
X = np.hstack((X0_2a, X_2a))
X0_2a = np.ones((len(df_newTest_2aStand),1))
testX = np.hstack((X0_2a, testX_2a))
X[:10]
```

[341]:
```
array([[ 1.        , -0.71677205, -1.29437561, -0.57330726, -0.93314164,
        -0.81914879],
       [ 1.        , -0.53893631, -1.29437561, -0.57330726, -0.93314164,
```

```
 -0.81914879],
[ 1.        , -0.98820554, -1.29437561, -0.57330726, -0.93314164,
 -0.81914879],
[ 1.        , -0.72613182, -1.29437561, -0.57330726, -0.93314164,
 -0.81914879],
[ 1.        ,  2.20347795,  0.05251643, -0.57330726, -0.93314164,
 -0.81914879],
[ 1.        , -0.55391195,  0.05251643, -0.57330726,  0.21291401,
 -0.81914879],
[ 1.        , -0.61381451,  0.05251643, -0.57330726,  0.21291401,
  0.32555914],
[ 1.        ,  2.17539862,  1.39940847,  1.4755613 ,  0.21291401,
  1.47026706],
[ 1.        , -0.70741227, -1.29437561, -0.57330726, -0.93314164,
 -0.81914879],
[ 1.        , -0.76357092, -1.29437561,  1.4755613 , -0.93314164,
 -0.81914879]])
```

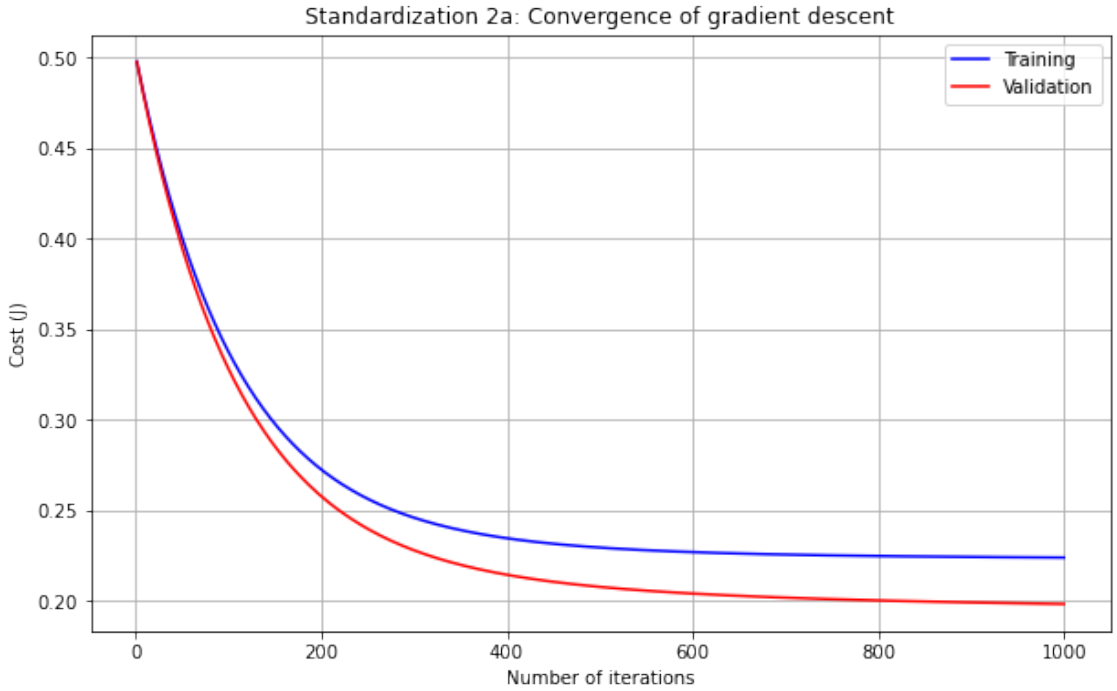
[342]:
```
thetaX_2a = np.zeros(6)
alphaX_2a = 0.0025
iterations = 1000
```

[343]:
```
thetaX_2a, costX_2a_history, testCostX_2a_history = gradient_descent(X, y_2a,␣
 ↪thetaX_2a, alphaX_2a, iterations, testX, testy_2a)
print('Final value of theta for 2a =', thetaX_2a)
```

```
Final value of theta for 2a = [2.27355723e-16 3.59558602e-01 1.21634716e-01
2.87552510e-01
 2.24160071e-01 1.73930844e-01]
```

[344]:
```
plt.plot(range(1, iterations + 1),costX_2a_history, color='blue',␣
 ↪label='Training')
plt.plot(range(1, iterations + 1),testCostX_2a_history, color='red',␣
 ↪label='Validation')
plt.rcParams["figure.figsize"] = (10,6)
plt.grid()
plt.xlabel('Number of iterations')
plt.ylabel('Cost (J)')
plt.title('Standardization 2a: Convergence of gradient descent')
plt.legend(loc="upper right")
```

[344]:
```
<matplotlib.legend.Legend at 0x1c4176d11c0>
```



[ ]:

[345]:
```
# Problem 2b
num_vars_2b = ['area', 'bedrooms', 'bathrooms', 'stories', 'mainroad',␣
 ↪'guestroom', 'basement', 'hotwaterheating', 'airconditioning', 'parking',␣
 ↪'prefarea', 'price']
df_newTrain_2b = df_train[num_vars_2b]
df_newTest_2b = df_test[num_vars_2b]
df_newTrain_2b.head(10)
```

[345]:

	area	bedrooms	bathrooms	stories	mainroad	guestroom	basement	\
542	3620	2	1	1	1	0	0	
496	4000	2	1	1	1	0	0	
484	3040	2	1	1	0	0	0	
507	3600	2	1	1	1	0	0	
252	9860	3	1	1	1	0	0	
263	3968	3	1	2	0	0	0	
240	3840	3	1	2	1	0	0	
175	9800	4	2	2	1	1	0	
385	3640	2	1	1	1	0	0	
374	3520	2	2	1	1	0	1	

	hotwaterheating	airconditioning	parking	prefarea	price
542	0	0	0	0	1750000

```
496                0                0         0          0  2695000
484                0                0         0          0  2870000
507                0                0         0          0  2590000
252                0                0         0          0  4515000
263                0                0         0          0  4410000
240                0                0         1          1  4585000
175                0                0         2          0  5250000
385                0                0         0          0  3570000
374                0                0         0          0  3640000
```

[346]:
```
# Min/Max Normalization
df_newTrain_2b[num_vars_2b] = normalScaler.
 ↪fit_transform(df_newTrain_2b[num_vars_2b])
df_newTest_2b[num_vars_2b] = normalScaler.
 ↪fit_transform(df_newTest_2b[num_vars_2b])
df_newTrain_2b.head(5)
```

[346]:
```
          area  bedrooms  bathrooms  stories  mainroad  guestroom  basement  \
542   0.124199       0.2        0.0      0.0       1.0        0.0       0.0
496   0.150654       0.2        0.0      0.0       1.0        0.0       0.0
484   0.083821       0.2        0.0      0.0       0.0        0.0       0.0
507   0.122807       0.2        0.0      0.0       1.0        0.0       0.0
252   0.558619       0.4        0.0      0.0       1.0        0.0       0.0

     hotwaterheating  airconditioning  parking  prefarea     price
542              0.0              0.0      0.0       0.0  0.000000
496              0.0              0.0      0.0       0.0  0.081818
484              0.0              0.0      0.0       0.0  0.096970
507              0.0              0.0      0.0       0.0  0.072727
252              0.0              0.0      0.0       0.0  0.239394
```

[347]:
```
y_normTrain_2b = df_newTrain_2b.pop('price')
X_normTrain_2b = df_newTrain_2b.copy()

y_normTest_2b = df_newTest_2b.pop('price')
X_normTest_2b = df_newTest_2b.copy()
X_normTrain_2b.head()
```

[347]:
```
          area  bedrooms  bathrooms  stories  mainroad  guestroom  basement  \
542   0.124199       0.2        0.0      0.0       1.0        0.0       0.0
496   0.150654       0.2        0.0      0.0       1.0        0.0       0.0
484   0.083821       0.2        0.0      0.0       0.0        0.0       0.0
507   0.122807       0.2        0.0      0.0       1.0        0.0       0.0
252   0.558619       0.4        0.0      0.0       1.0        0.0       0.0

     hotwaterheating  airconditioning  parking  prefarea
542              0.0              0.0      0.0       0.0
```

```
496             0.0             0.0      0.0       0.0
484             0.0             0.0      0.0       0.0
507             0.0             0.0      0.0       0.0
252             0.0             0.0      0.0       0.0
```

[348]:
```
y_2b = y_normTrain_2b.values
X_2b = X_normTrain_2b.values[:,0:11]

testy_2b = y_normTest_2b.values
testX_2b = X_normTest_2b.values[:, 0:11]

X0_2b = np.ones((len(df_newTrain_2b),1))
X = np.hstack((X0_2b, X_2b))
X0_2b = np.ones((len(df_newTest_2b),1))
testX = np.hstack((X0_2b, testX_2b))
X[:10]
```

[348]:
```
array([[1.        , 0.12419939, 0.2       , 0.        , 0.        ,
        1.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        ],
       [1.        , 0.15065441, 0.2       , 0.        , 0.        ,
        1.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        ],
       [1.        , 0.08382066, 0.2       , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        ],
       [1.        , 0.12280702, 0.2       , 0.        , 0.        ,
        1.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        ],
       [1.        , 0.55861877, 0.4       , 0.        , 0.        ,
        1.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        ],
       [1.        , 0.14842662, 0.4       , 0.        , 0.33333333,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        ],
       [1.        , 0.13951546, 0.4       , 0.        , 0.33333333,
        1.        , 0.        , 0.        , 0.        , 0.        ,
        0.33333333, 1.        ],
       [1.        , 0.55444166, 0.6       , 0.5       , 0.33333333,
        1.        , 1.        , 0.        , 0.        , 0.        ,
        0.66666667, 0.        ],
       [1.        , 0.12559176, 0.2       , 0.        , 0.        ,
        1.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        ],
       [1.        , 0.11723754, 0.2       , 0.5       , 0.        ,
        1.        , 0.        , 1.        , 0.        , 0.        ,
        0.        , 0.        ]])
```

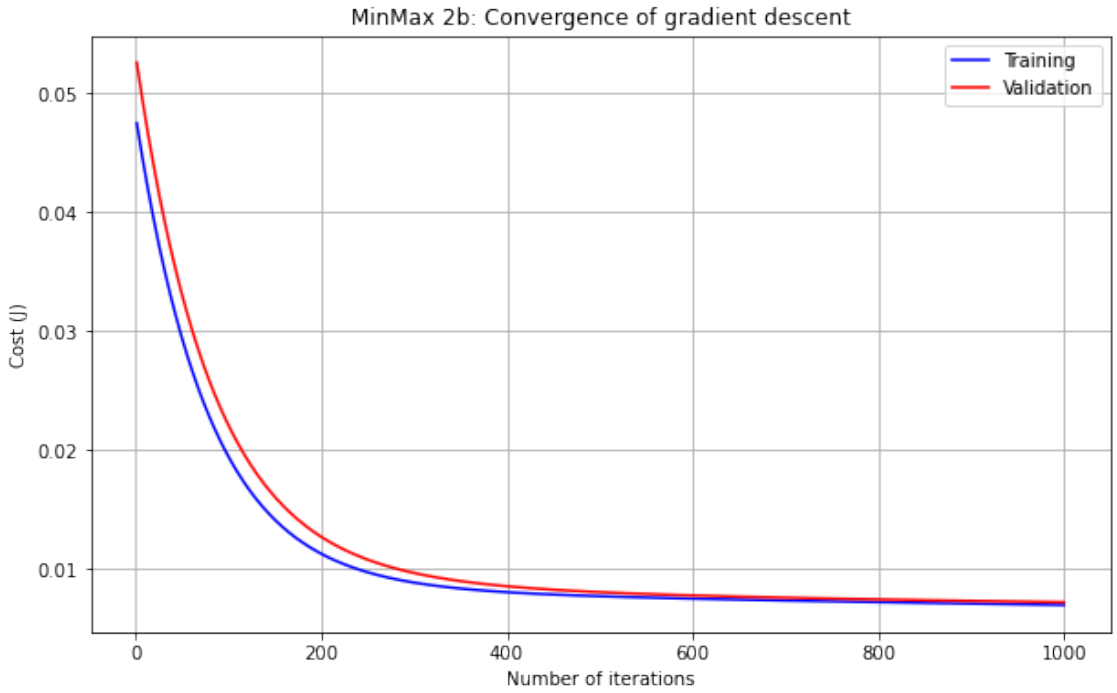
[349]:
```
thetaX_2b = np.zeros(12)
alphaX_2b = 0.0025
iterations = 1000
```

[350]:
```
thetaX_2b, costX_2b_history, testCostX_2b_history = gradient_descent(X, y_2b,␣
 ↪thetaX_2b, alphaX_2b, iterations, testX, testy_2b)
print('Final values of theta for 2b =', thetaX_2b)
```

```
Final values of theta for 2b = [0.08463254 0.04101946 0.04783239 0.04720978
0.05367438 0.08143048
 0.0337865  0.03850947 0.01360807 0.06859696 0.04558418 0.05092703]
```

[351]:
```
plt.plot(range(1, iterations + 1),costX_2b_history, color='blue',␣
 ↪label='Training')
plt.plot(range(1, iterations + 1),testCostX_2b_history, color='red',␣
 ↪label='Validation')
plt.rcParams["figure.figsize"] = (10,6)
plt.grid()
plt.xlabel('Number of iterations')
plt.ylabel('Cost (J)')
plt.title('MinMax 2b: Convergence of gradient descent')
plt.legend(loc="upper right")
```

[351]:
```
<matplotlib.legend.Legend at 0x1c417737bb0>
```



[352]:
```
# Standardization
num_vars_2b = ['area', 'bedrooms', 'bathrooms', 'stories', 'mainroad',␣
 ↪'guestroom', 'basement', 'hotwaterheating', 'airconditioning', 'parking',␣
 ↪'prefarea', 'price']
df_newTrain_2b = df_train[num_vars_2b]
df_newTest_2b = df_test[num_vars_2b]

df_newTrain_2b[num_vars_2b] = standScaler.
 ↪fit_transform(df_newTrain_2b[num_vars_2b])
df_newTest_2b[num_vars_2b] = standScaler.
 ↪fit_transform(df_newTest_2b[num_vars_2b])
df_newTrain_2b.head(5)
```

[352]:

	area	bedrooms	bathrooms	stories	mainroad	guestroom	basement	hotwaterheating	airconditioning	parking	prefarea	price
542	-0.716772	-1.294376	-0.573307	-0.933142	0.395599	-0.463125	-0.698609	-0.201427	-0.691351	-0.819149	-0.570288	-1.586001
496	-0.538936	-1.294376	-0.573307	-0.933142	0.395599	-0.463125	-0.698609	-0.201427	-0.691351	-0.819149	-0.570288	-1.090971
484	-0.988206	-1.294376	-0.573307	-0.933142	-2.527811	-0.463125	-0.698609	-0.201427	-0.691351	-0.819149	-0.570288	-0.999299
507	-0.726132	-1.294376	-0.573307	-0.933142	0.395599	-0.463125	-0.698609	-0.201427	-0.691351	-0.819149	-0.570288	-1.145974
252	2.203478	0.052516	-0.573307	-0.933142	0.395599	-0.463125	-0.698609	-0.201427	-0.691351	-0.819149	-0.570288	-0.137579

[353]:
```
y_normTrain_2b = df_newTrain_2b.pop('price')
X_normTrain_2b = df_newTrain_2b.copy()

y_normTest_2b = df_newTest_2b.pop('price')
X_normTest_2b = df_newTest_2b.copy()
X_normTrain_2b.head()
```

[353]:

	area	bedrooms	bathrooms	stories	mainroad	guestroom	basement	hotwaterheating	airconditioning	parking	prefarea
542	-0.716772	-1.294376	-0.573307	-0.933142	0.395599	-0.463125	-0.698609	-0.201427	-0.691351	-0.819149	-0.570288
496	-0.538936	-1.294376	-0.573307	-0.933142	0.395599	-0.463125	-0.698609	-0.201427	-0.691351	-0.819149	-0.570288
484	-0.988206	-1.294376	-0.573307	-0.933142	-2.527811	-0.463125	-0.698609	-0.201427	-0.691351	-0.819149	-0.570288
507	-0.726132	-1.294376	-0.573307	-0.933142	0.395599	-0.463125	-0.698609	-0.201427	-0.691351	-0.819149	-0.570288
252	2.203478	0.052516	-0.573307	-0.933142	0.395599	-0.463125	-0.698609	-0.201427	-0.691351	-0.819149	-0.570288

[354]:
```
y_2b = y_normTrain_2b.values
X_2b = X_normTrain_2b.values[:,0:11]

testy_2b = y_normTest_2b.values
testX_2b = X_normTest_2b.values[:, 0:11]

X0_2b = np.ones((len(df_newTrain_2b),1))
X = np.hstack((X0_2b, X_2b))
X0_2b = np.ones((len(df_newTest_2b),1))
testX = np.hstack((X0_2b, testX_2b))
X[:10]
```

[354]:
```
array([[ 1.        , -0.71677205, -1.29437561, -0.57330726, -0.93314164,
         0.39559913, -0.46312491, -0.69860905, -0.20142689, -0.69135093,
        -0.81914879, -0.57028761],
       [ 1.        , -0.53893631, -1.29437561, -0.57330726, -0.93314164,
         0.39559913, -0.46312491, -0.69860905, -0.20142689, -0.69135093,
        -0.81914879, -0.57028761],
       [ 1.        , -0.98820554, -1.29437561, -0.57330726, -0.93314164,
        -2.52781141, -0.46312491, -0.69860905, -0.20142689, -0.69135093,
        -0.81914879, -0.57028761],
       [ 1.        , -0.72613182, -1.29437561, -0.57330726, -0.93314164,
         0.39559913, -0.46312491, -0.69860905, -0.20142689, -0.69135093,
        -0.81914879, -0.57028761],
       [ 1.        ,  2.20347795,  0.05251643, -0.57330726, -0.93314164,
         0.39559913, -0.46312491, -0.69860905, -0.20142689, -0.69135093,
        -0.81914879, -0.57028761],
       [ 1.        , -0.55391195,  0.05251643, -0.57330726,  0.21291401,
        -2.52781141, -0.46312491, -0.69860905, -0.20142689, -0.69135093,
        -0.81914879, -0.57028761],
       [ 1.        , -0.61381451,  0.05251643, -0.57330726,  0.21291401,
         0.39559913, -0.46312491, -0.69860905, -0.20142689, -0.69135093,
         0.32555914,  1.75350117],
       [ 1.        ,  2.17539862,  1.39940847,  1.4755613 ,  0.21291401,
         0.39559913,  2.1592447 , -0.69860905, -0.20142689, -0.69135093,
         1.47026706, -0.57028761],
       [ 1.        , -0.70741227, -1.29437561, -0.57330726, -0.93314164,
         0.39559913, -0.46312491, -0.69860905, -0.20142689, -0.69135093,
        -0.81914879, -0.57028761],
       [ 1.        , -0.76357092, -1.29437561,  1.4755613 , -0.93314164,
         0.39559913, -0.46312491,  1.43141575, -0.20142689, -0.69135093,
        -0.81914879, -0.57028761]])
```

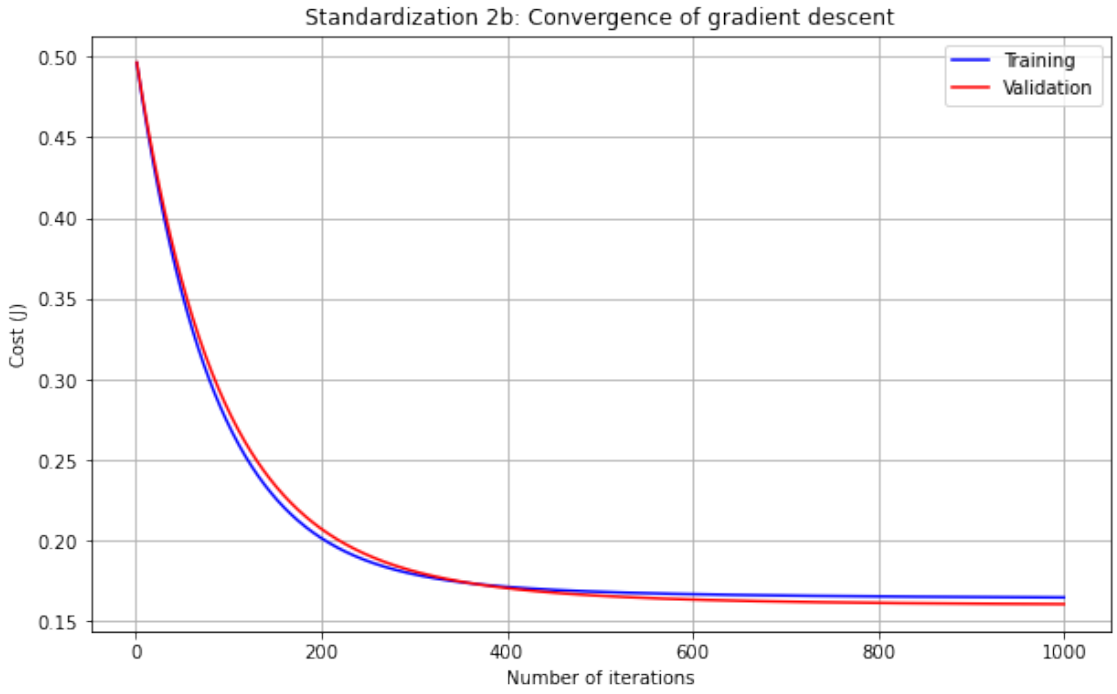
[355]:
```
thetaX_2b = np.zeros(12)
alphaX_2b = 0.0025
iterations = 1000
```

[356]:
```
thetaX_2b, costX_2b_history, testCostX_2b_history = gradient_descent(X, y_2b,␣
↪thetaX_2b, alphaX_2b, iterations, testX, testy_2b)
print('Final values of theta for 2b =', thetaX_2b)
```

```
Final values of theta for 2b = [2.26737589e-16 2.65860994e-01 8.91541758e-02
2.46738932e-01
 1.85909858e-01 9.49708605e-02 9.56415353e-02 7.96716462e-02
 1.10048184e-01 2.11600417e-01 1.26435097e-01 1.60306721e-01]
```

[357]:
```
plt.plot(range(1, iterations + 1),costX_2b_history, color='blue',␣
↪label='Training')
plt.plot(range(1, iterations + 1),testCostX_2b_history, color='red',␣
↪label='Validation')
plt.rcParams["figure.figsize"] = (10,6)
plt.grid()
plt.xlabel('Number of iterations')
plt.ylabel('Cost (J)')
plt.title('Standardization 2b: Convergence of gradient descent')
plt.legend(loc="upper right")
```

[357]:
```
<matplotlib.legend.Legend at 0x1c412c9d340>
```



[358]:
```
# Problem 3
```

[359]:
```
def gradient_descent_penalties(X, y, theta, alpha, iterations, xTest, yTest,␣
 ↪penaltyRate):
 cost_history = np.zeros(iterations) # Store loss calculations in array to be␣
 ↪able to plot gradient descent
 testCost_history = np.zeros(iterations) # Store validation loss
 for i in range(iterations):
    predictions = X.dot(theta) # H = X * Theta
    errors = np.subtract(predictions, y) # H - Y
    penalty = np.multiply((penaltyRate/len(X)), theta)
    derivLoss = (1 / len(X)) * (X.transpose().dot(errors) + penalty); #␣
 ↪Finishes derivative of loss calculation
    theta = theta - (alpha * derivLoss); # Calculates for new thetas
    cost_history[i] = compute_cost(X, y, theta) # Stores new cost from the new␣
 ↪thetas
    testCost_history[i] = compute_cost(xTest, yTest, theta) # Stores validation␣
 ↪cost from new thetas
 return theta, cost_history, testCost_history
```

[360]:
```
# Problem 3a
num_vars_3a = ['area', 'bedrooms', 'bathrooms', 'stories', 'parking', 'price']
df_newTrain_3a = df_train[num_vars_3a]
df_newTest_3a = df_test[num_vars_3a]
```

[361]:
```
# Min/Max Normalization
df_newTrain_3a[num_vars_3a] = normalScaler.
 ↪fit_transform(df_newTrain_3a[num_vars_3a])
df_newTest_3a[num_vars_3a] = normalScaler.
 ↪fit_transform(df_newTest_3a[num_vars_3a])
df_newTrain_3a.head(5)
```

[361]:

	area	bedrooms	bathrooms	stories	parking	price
542	0.124199	0.2	0.0	0.0	0.0	0.000000
496	0.150654	0.2	0.0	0.0	0.0	0.081818
484	0.083821	0.2	0.0	0.0	0.0	0.096970
507	0.122807	0.2	0.0	0.0	0.0	0.072727
252	0.558619	0.4	0.0	0.0	0.0	0.239394

[362]:
```
y_normTrain_3a = df_newTrain_3a.pop('price')
X_normTrain_3a = df_newTrain_3a.copy()

y_normTest_3a = df_newTest_3a.pop('price')
X_normTest_3a = df_newTest_3a.copy()
X_normTrain_3a.head()
```

[362]:

	area	bedrooms	bathrooms	stories	parking
542	0.124199	0.2	0.0	0.0	0.0
496	0.150654	0.2	0.0	0.0	0.0

```
484  0.083821       0.2        0.0       0.0       0.0
507  0.122807       0.2        0.0       0.0       0.0
252  0.558619       0.4        0.0       0.0       0.0
```

[363]:
```
y_3a = y_normTrain_3a.values
X_3a = X_normTrain_3a.values[:,0:5]

testy_3a = y_normTest_3a.values
testX_3a = X_normTest_3a.values[:, 0:5]

X0_3a = np.ones((len(df_newTrain_3a),1))
X = np.hstack((X0_3a, X_3a))
X0_3a = np.ones((len(df_newTest_3a),1))
testX = np.hstack((X0_3a, testX_3a))
X[:10]
```

[363]:
```
array([[1.        , 0.12419939, 0.2       , 0.        , 0.        ,
        0.        ],
       [1.        , 0.15065441, 0.2       , 0.        , 0.        ,
        0.        ],
       [1.        , 0.08382066, 0.2       , 0.        , 0.        ,
        0.        ],
       [1.        , 0.12280702, 0.2       , 0.        , 0.        ,
        0.        ],
       [1.        , 0.55861877, 0.4       , 0.        , 0.        ,
        0.        ],
       [1.        , 0.14842662, 0.4       , 0.        , 0.33333333,
        0.        ],
       [1.        , 0.13951546, 0.4       , 0.        , 0.33333333,
        0.33333333],
       [1.        , 0.55444166, 0.6       , 0.5       , 0.33333333,
        0.66666667],
       [1.        , 0.12559176, 0.2       , 0.        , 0.        ,
        0.        ],
       [1.        , 0.11723754, 0.2       , 0.5       , 0.        ,
        0.        ]])
```

[364]:
```
thetaX_3a = np.zeros(6)
alphaX_3a = 0.0025
iterations = 1500
lambdaPen = 0.5
```

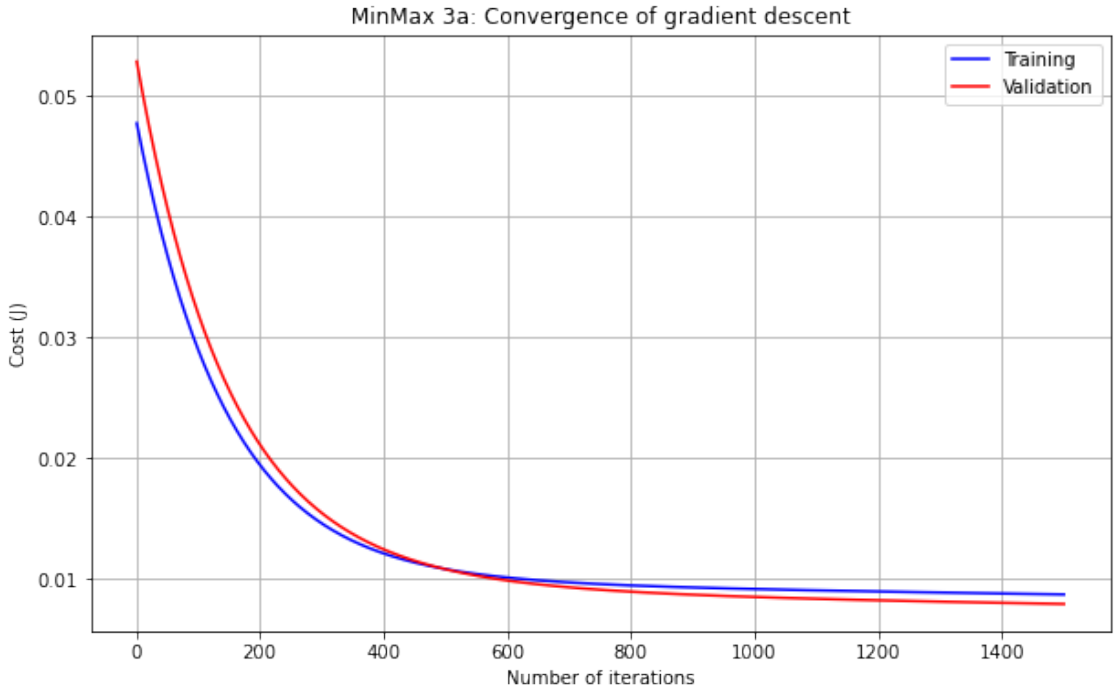
[365]:
```
thetaX_3a, costX_3a_history, testCostX_3a_history =␣
 ↪gradient_descent_penalties(X, y_3a, thetaX_3a, alphaX_3a, iterations, testX,␣
 ↪testy_3a, lambdaPen)
print('Final values of theta for 3a =', thetaX_3a)
```

```
Final values of theta for 3a = [0.16332631 0.07620808 0.08529764 0.07592121
```

```
0.08824125 0.08029126]
```

[366]:
```
plt.plot(range(1, iterations + 1),costX_3a_history, color='blue',␣
 ↪label='Training')
plt.plot(range(1, iterations + 1),testCostX_3a_history, color='red',␣
 ↪label='Validation')
plt.rcParams["figure.figsize"] = (10,6)
plt.grid()
plt.xlabel('Number of iterations')
plt.ylabel('Cost (J)')
plt.title('MinMax 3a: Convergence of gradient descent')
plt.legend(loc="upper right")
```

[366]:
```
<matplotlib.legend.Legend at 0x1c41776d490>
```



[367]:
```
#Problem 3b
# Min/Max Normalization
num_vars_3b = ['area', 'bedrooms', 'bathrooms', 'stories', 'mainroad',␣
 ↪'guestroom', 'basement', 'hotwaterheating', 'airconditioning', 'parking',␣
 ↪'prefarea', 'price']
df_newTrain_3b = df_train[num_vars_3b]
df_newTest_3b = df_test[num_vars_3b]
```

```
df_newTrain_3b[num_vars_3b] = normalScaler.
 ↪fit_transform(df_newTrain_3b[num_vars_3b])
df_newTest_3b[num_vars_3b] = normalScaler.
 ↪fit_transform(df_newTest_3b[num_vars_3b])
df_newTrain_3b.head(5)
```

[367]:

	area	bedrooms	bathrooms	stories	mainroad	guestroom	basement	\
542	0.124199	0.2	0.0	0.0	1.0	0.0	0.0	
496	0.150654	0.2	0.0	0.0	1.0	0.0	0.0	
484	0.083821	0.2	0.0	0.0	0.0	0.0	0.0	
507	0.122807	0.2	0.0	0.0	1.0	0.0	0.0	
252	0.558619	0.4	0.0	0.0	1.0	0.0	0.0	

	hotwaterheating	airconditioning	parking	prefarea	price
542	0.0	0.0	0.0	0.0	0.000000
496	0.0	0.0	0.0	0.0	0.081818
484	0.0	0.0	0.0	0.0	0.096970
507	0.0	0.0	0.0	0.0	0.072727
252	0.0	0.0	0.0	0.0	0.239394

[368]:
```
y_normTrain_3b = df_newTrain_3b.pop('price')
X_normTrain_3b = df_newTrain_3b.copy()

y_normTest_3b = df_newTest_3b.pop('price')
X_normTest_3b = df_newTest_3b.copy()
X_normTrain_3b.head()
```

[368]:

	area	bedrooms	bathrooms	stories	mainroad	guestroom	basement	\
542	0.124199	0.2	0.0	0.0	1.0	0.0	0.0	
496	0.150654	0.2	0.0	0.0	1.0	0.0	0.0	
484	0.083821	0.2	0.0	0.0	0.0	0.0	0.0	
507	0.122807	0.2	0.0	0.0	1.0	0.0	0.0	
252	0.558619	0.4	0.0	0.0	1.0	0.0	0.0	

	hotwaterheating	airconditioning	parking	prefarea
542	0.0	0.0	0.0	0.0
496	0.0	0.0	0.0	0.0
484	0.0	0.0	0.0	0.0
507	0.0	0.0	0.0	0.0
252	0.0	0.0	0.0	0.0

[369]:
```
y_3b = y_normTrain_3b.values
X_3b = X_normTrain_3b.values[:,0:11]

testy_3b = y_normTest_3b.values
testX_3b = X_normTest_3b.values[:, 0:11]
```

```
X0_3b = np.ones((len(df_newTrain_3b),1))
X = np.hstack((X0_3b, X_3b))
X0_3b = np.ones((len(df_newTest_3b),1))
testX = np.hstack((X0_3b, testX_3b))
X[:10]
```

[369]:
```
array([[1.        , 0.12419939, 0.2       , 0.        , 0.        ,
        1.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        ],
       [1.        , 0.15065441, 0.2       , 0.        , 0.        ,
        1.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        ],
       [1.        , 0.08382066, 0.2       , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        ],
       [1.        , 0.12280702, 0.2       , 0.        , 0.        ,
        1.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        ],
       [1.        , 0.55861877, 0.4       , 0.        , 0.        ,
        1.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        ],
       [1.        , 0.14842662, 0.4       , 0.        , 0.33333333,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        ],
       [1.        , 0.13951546, 0.4       , 0.        , 0.33333333,
        1.        , 0.        , 0.        , 0.        , 0.        ,
        0.33333333, 1.        ],
       [1.        , 0.55444166, 0.6       , 0.5       , 0.33333333,
        1.        , 1.        , 0.        , 0.        , 0.        ,
        0.66666667, 0.        ],
       [1.        , 0.12559176, 0.2       , 0.        , 0.        ,
        1.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        ],
       [1.        , 0.11723754, 0.2       , 0.5       , 0.        ,
        1.        , 0.        , 1.        , 0.        , 0.        ,
        0.        , 0.        ]])
```

[370]:
```
thetaX_3b = np.zeros(12)
alphaX_3b = 0.0025
iterations = 1000
lambdaPen = 0.5
```

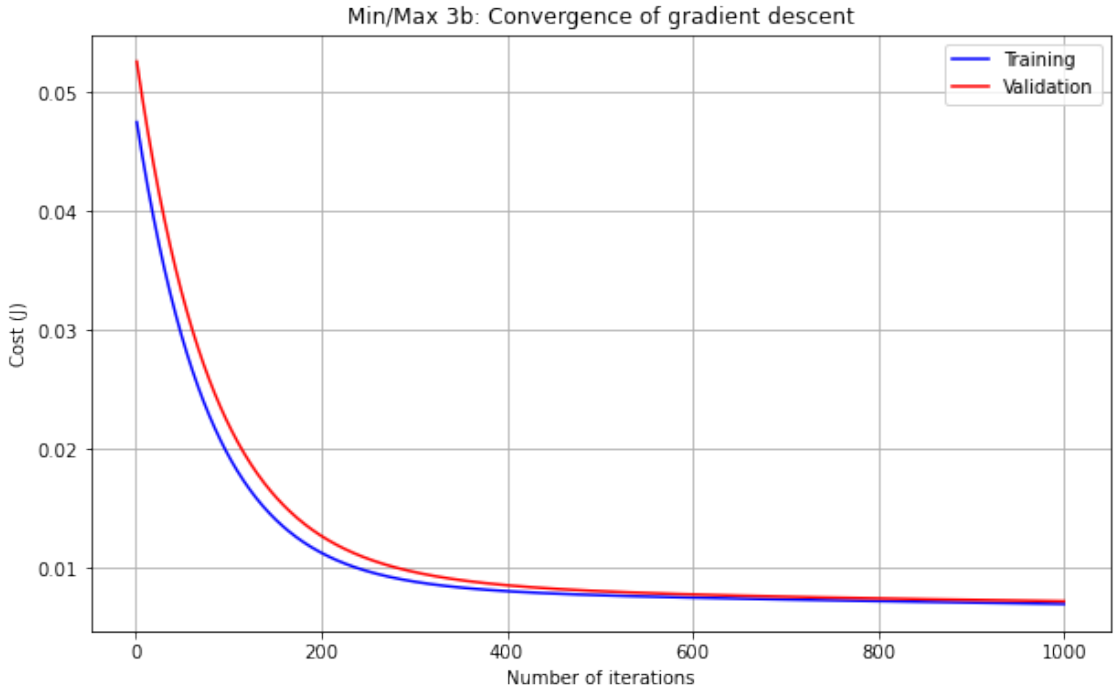
[371]:
```
thetaX_3b, costX_3b_history, testCostX_3b_history =␣
 ↪gradient_descent_penalties(X, y_3b, thetaX_3b, alphaX_3b, iterations, testX,␣
 ↪testy_3b, lambdaPen)
print('Final values of theta for 3b =', thetaX_3b)
```

```
Final values of theta for 3b = [0.0846325  0.04101939 0.04783233 0.04720967
```

```
0.05367428 0.08143043
 0.03378644 0.03850944 0.01360803 0.06859683 0.04558409 0.05092694]
```

[372]:
```
plt.plot(range(1, iterations + 1),costX_3b_history, color='blue',␣
 ↪label='Training')
plt.plot(range(1, iterations + 1),testCostX_3b_history, color='red',␣
 ↪label='Validation')
plt.rcParams["figure.figsize"] = (10,6)
plt.grid()
plt.xlabel('Number of iterations')
plt.ylabel('Cost (J)')
plt.title('Min/Max 3b: Convergence of gradient descent')
plt.legend(loc="upper right")
```

[372]:
```
<matplotlib.legend.Legend at 0x1c4177e18e0>
```



[ ]:

[ ]: