Assignment 1

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In [ ]:
```python
# import all the necessary libraries here
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
```

In [ ]:
```python
df = pd.read_csv('../../dataset/linear-regression.csv')
X = df.iloc[:, :-1].values
y = df.iloc[:, -1].values
# taking a column of 1's in order to represent the constant term in the loss function
column_of_ones = np.ones((X.shape[0],1))

# normalising the data
st = StandardScaler()
X_norm = st.fit_transform(X)
# adding the column of ones to the normalised dataset
X_norm = np.hstack((column_of_ones,X_norm))
```

In [ ]:
```python
# splitting the  dataset into training , validation and testing wihtout normalising the data
X_train,X_test,y_train,y_test = train_test_split(X,y,random_state=104,train_size=0.8,shuffle=True)
X_train,X_validation,y_train,y_validation = train_test_split(X_train,y_train,random_state=104,train_size=5/8,shuffle=True)
```

In [ ]:
```python
# function that the predicted y for the linear regression model

def hypothesis_func(w,x) :
    return np.dot(w,x)
```

In [ ]:
```python
# Analytical solution using mean squared error loss function


X_train_transpose = np.transpose(X_train)
y_train_transpose = np.transpose(y_train)

theta = np.matmul(X_train_transpose,X_train)
theta = np.linalg.inv(theta)
theta = np.matmul(theta , X_train_transpose)
theta = np.matmul(theta,y_train_transpose)
print("Theta =",theta)
```

```
Theta = [ 1.21762041e-02 -1.27511735e+00 -3.74713311e-01  7.66865125e-04
 -1.99780775e+00  3.03006732e-03 -1.98454143e-03  4.99004471e+00
 -6.50803240e-01  8.08006093e-01  3.02820901e-01]
```

In [ ]:
```python
# calculating the Root Mean Squared Error on the test set

m = X_test.shape[0]

rmse = 0
for i in range(m) :
    rmse = rmse + np.square(hypothesis_func(theta ,X_test[i])-y_test[i])
rmse = rmse/m
rmse = np.sqrt(rmse)
print(rmse)
```

```
0.6065917865695509
```

In [ ]:
```python
# Calculating the R-score
num = 0
den = 0
m = X_test.shape[0]
mean = np.mean(y_test)
for i in range(m) :
    num = num + np.square(hypothesis_func(theta,X_test[i])-y_test[i])
    den = den + np.square(y_test[i]-mean)
r_sqr = 1 - num/den
print(r_sqr)
```

```
0.37534693574752964
```

In [ ]:
```python
# training the model using gradient descent

# training the model using gradient descent
# using normalised data for this
# splitting the  dataset into training , validation and testing
X_train,X_test,y_train,y_test = train_test_split(X_norm,y,random_state=104,train_size=0.8)
X_train,X_validation,y_train,y_validation = train_test_split(X_train,y_train,random_state=104,train_size=5/8)
```

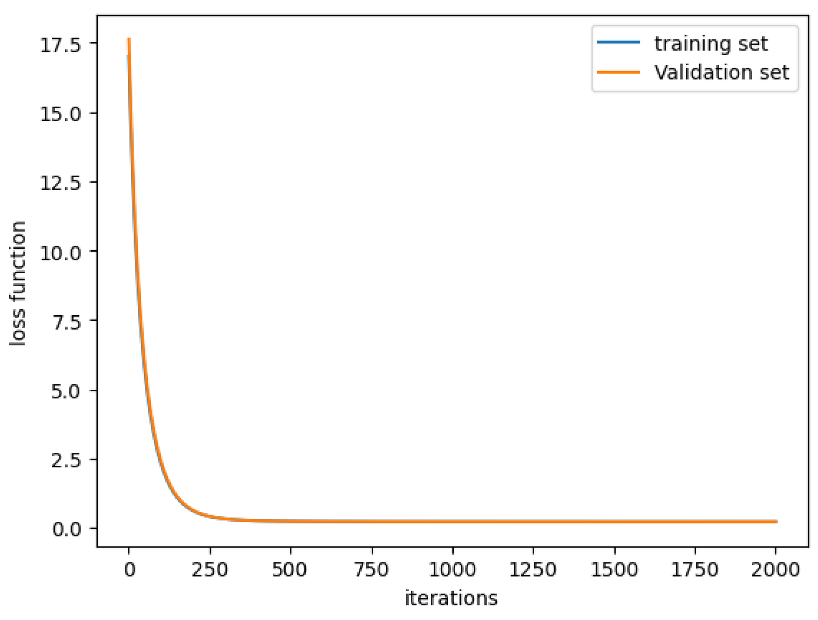
In [ ]:
```python
def cost_func(x,y,theta) :
    m = x.shape[0]

    cost = 0.0
    for i in  range(m) :
        cost = cost + np.square(np.dot(theta,x[i])-y[i])
    cost=cost / (2*m)
    return cost
```

In [ ]:
```python
# def find_gradient(x,y,theta) :
#     m  = x.shape[0]
#     n  = x.shape[1]

#     dl_d0 = np.zeros((n,))

#     for j in range(n) :
#         err_sum = 0
#         for i in range(m) :
#             err = np.dot(theta,x[i])-y[i]
#             err = err * x[i][j]
#             err_sum = err_sum + err
#         dl_d0[j] = err_sum/m

#     return dl_d0


def find_gradient(x,y,theta) :
    m = x.shape[0]
    n = x.shape[1]

    dl_d0=np.zeros((n,))
    theta_transpose = np.transpose(theta)

    for j in range(n) :
         err = np.matmul(x,theta_transpose)-y
         err = np.dot(err,x[:,j])
         dl_d0[j] = err/m

    return dl_d0
```

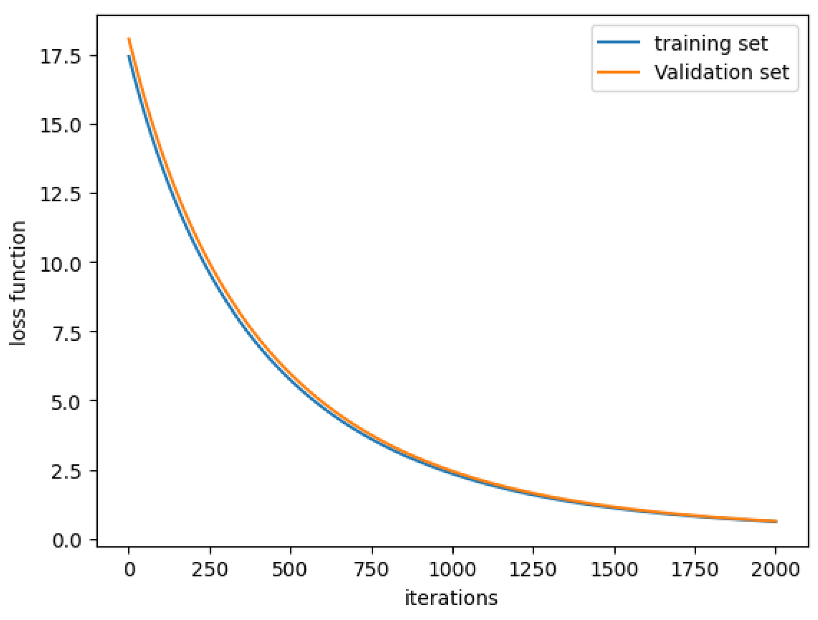
In [ ]:
```python
def gradient_descent(x_train,y_train,x_vali,y_vali,alpha,iterations,find_gradient,cost)  :
    m = x_train.shape[0]
    n = x_train.shape[1]

    costs_train = [] # to maintain the cost on training set after each iteration
    cost_validation = [] # to maintain the cost on validation set after each iteration
    #initial theta
    theta = np.ones(n)
    for i in range(iterations) :
        gradient = find_gradient(x_train,y_train,theta)
        theta = theta - alpha*gradient
        train_cost = cost_func(x_train,y_train,theta)
        costs_train.append(train_cost)
        vali_cost = cost_func(x_vali,y_vali,theta)
        cost_validation.append(vali_cost)

    return theta , costs_train,cost_validation
```

In [ ]:
```python
alpha = [0.01, 0.001 ,0.0001 ]
interations_no = 2000
iterations = [j for j in range(1,2001)]
for i in range(3) :
    print("alpha = ",alpha[i])
    theta , cost_train,cost_validation = gradient_descent(X_train,y_train,X_validation,y_validation,alpha[i],interations_no,find_gradient,cost_func)
    print("theta = " , theta )

    # plotting the loss function on training set  with number of iterations
    cost_arr = np.array(cost_train)

    plt.plot(iterations,cost_arr,label="training set")
    plt.xlabel("iterations")
    plt.ylabel("loss function")

    cost_arr = np.array(cost_validation)
    plt.plot(iterations,cost_arr,label = "Validation set")
    plt.legend()
    plt.show()

    # calculating the Root Mean Squared Error on the test set
    m = X_test.shape[0]

    rmse = 0
    for i in range(m) :
        rmse = rmse + np.square(hypothesis_func(theta ,X_test[i])-y_test[i])
    rmse = rmse/m
    rmse = np.sqrt(rmse)
    print("RMSE = " ,rmse)

    # Calculating the R-score
    num = 0
    den = 0
    m = X_test.shape[0]
    mean = np.mean(y_test)
    for i in range(m) :
        num = num + np.square(hypothesis_func(theta,X_test[i])-y_test[i])
        den = den + np.square(y_test[i]-mean)
    r_sqr = 1 - num/den
    print("R square = ",r_sqr)
    print("\n\n\n")
```

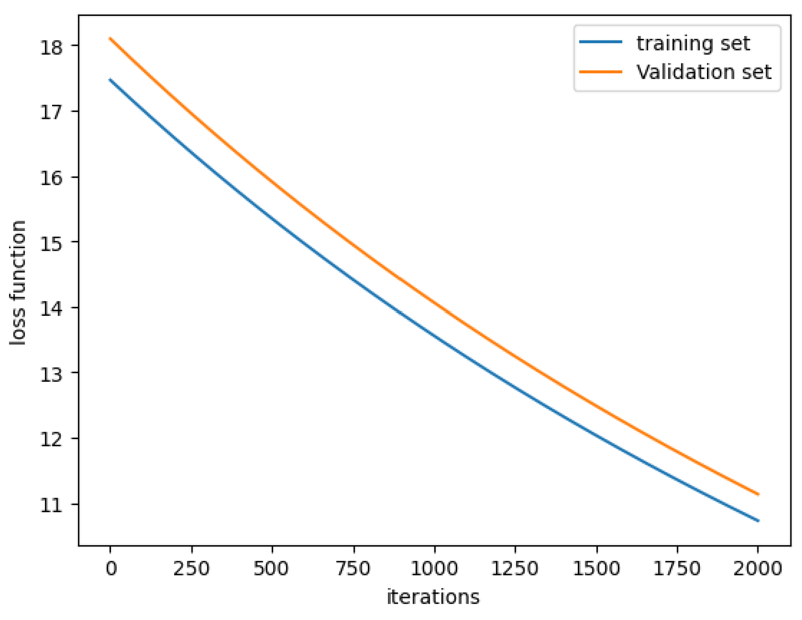
```
alpha =  0.01
theta =  [ 5.61261762  0.1417225  -0.22366163 -0.08319497  0.04207518 -0.08708917
  0.02194309 -0.05544636 -0.10541968 -0.03672069  0.1546629   0.25687256]
```




```
RMSE =  0.6047663583977808
R square =  0.3791008395236878




alpha =  0.001
theta =  [ 4.9563254   0.48079048  0.13233627  0.24701805 -0.02528752  0.07128736
  0.09960763  0.06190617 -0.06677567  0.57783945  0.18407771  0.47854503]
```




```
RMSE =  1.0877350069616392
R square =  -1.0085934184232417




alpha =  0.0001
theta =  [1.82118515 0.78530184 0.89813109 0.74040662 0.68410411 0.72360544
 0.73218664 0.70239543 0.65274364 1.0920734  0.73759658 0.99069068]
```




```
RMSE =  4.75662329864475
R square =  -37.409914571088954
```