Assignment 1

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Roll Number: 21CS30020

```
# import all the necessary libraries here
import pandas as pd
import numpy as np
from sklearn.model_selection import train_test_split
from numpy.linalg import inv
import matplotlib.pyplot as plt
from sklearn.metrics import r2_score

df = pd.read_csv('../../dataset/linear-regression.csv')
print(df.shape)
```

```
(1599, 12)
```

```
df.head()
```

```
   fixed acidity  volatile acidity  citric acid  residual sugar
chlorides  \
0            7.4              0.70         0.00             1.9
0.076
1            7.8              0.88         0.00             2.6
0.098
2            7.8              0.76         0.04             2.3
0.092
3           11.2              0.28         0.56             1.9
0.075
4            7.4              0.70         0.00             1.9
0.076

   free sulfur dioxide  total sulfur dioxide  density    pH  sulphates
\
0                 11.0                  34.0   0.9978  3.51       0.56

1                 25.0                  67.0   0.9968  3.20       0.68

2                 15.0                  54.0   0.9970  3.26       0.65

3                 17.0                  60.0   0.9980  3.16       0.58

4                 11.0                  34.0   0.9978  3.51       0.56


   alcohol  quality
```

```
0      9.4        5
1      9.8        5
2      9.8        5
3      9.8        6
4      9.4        5
```

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1599 entries, 0 to 1598
Data columns (total 12 columns):
 #   Column                Non-Null Count  Dtype  
---  ------                --------------  -----  
 0   fixed acidity         1599 non-null   float64
 1   volatile acidity      1599 non-null   float64
 2   citric acid           1599 non-null   float64
 3   residual sugar        1599 non-null   float64
 4   chlorides             1599 non-null   float64
 5   free sulfur dioxide   1599 non-null   float64
 6   total sulfur dioxide  1599 non-null   float64
 7   density               1599 non-null   float64
 8   pH                    1599 non-null   float64
 9   sulphates             1599 non-null   float64
 10  alcohol               1599 non-null   float64
 11  quality               1599 non-null   int64  
dtypes: float64(11), int64(1)
memory usage: 150.0 KB
```

```
df.describe()
```

```
       fixed acidity  volatile acidity  citric acid  residual sugar  \
count    1599.000000       1599.000000  1599.000000     1599.000000   
mean        8.319637          0.527821     0.270976        2.538806   
std         1.741096          0.179060     0.194801        1.409928   
min         4.600000          0.120000     0.000000        0.900000   
25%         7.100000          0.390000     0.090000        1.900000   
50%         7.900000          0.520000     0.260000        2.200000   
75%         9.200000          0.640000     0.420000        2.600000   
max        15.900000          1.580000     1.000000       15.500000   

         chlorides  free sulfur dioxide  total sulfur dioxide
density  \
count  1599.000000          1599.000000           1599.000000
1599.000000   
mean      0.087467            15.874922             46.467792
0.996747   
std       0.047065            10.460157             32.895324
0.001887   
min       0.012000             1.000000              6.000000
0.990070   
```

```
25%       0.070000          7.000000             22.000000
0.995600
50%       0.079000         14.000000             38.000000
0.996750
75%       0.090000         21.000000             62.000000
0.997835
max       0.611000         72.000000            289.000000
1.003690

                pH    sulphates      alcohol      quality
count  1599.000000  1599.000000  1599.000000  1599.000000
mean      3.311113     0.658149    10.422983     5.636023
std       0.154386     0.169507     1.065668     0.807569
min       2.740000     0.330000     8.400000     3.000000
25%       3.210000     0.550000     9.500000     5.000000
50%       3.310000     0.620000    10.200000     6.000000
75%       3.400000     0.730000    11.100000     6.000000
max       4.010000     2.000000    14.900000     8.000000
```

```
# Test train Split
X = df.iloc[:,:-1].values
Y = df.iloc[:,-1].values
X_train , X,Y_train,Y =
train_test_split(X,Y,test_size=0.5,random_state=0)
X_val,X_test,Y_val,Y_test = train_test_split(X,Y,test_size =
0.4,random_state = 0)
from sklearn.preprocessing import StandardScaler
st_x= StandardScaler()
X_train= st_x.fit_transform(X_train)
X_test= st_x.transform(X_test)
# from sklearn.preprocessing import normalize
# X_train = normalize(X_train)

print(X_train.shape, Y_train.shape)
print(X_val.shape, Y_val.shape)
print(X_test.shape, Y_test.shape)
```

```
(799, 11) (799,)
(480, 11) (480,)
(320, 11) (320,)
```

```
class l2_regularization():
    def __init__(self,alpha):
        self.alpha = alpha

    def __call__(self,Weight):
        loss = np.dot(Weight.T , Weight)
        return self.alpha * 0.5 * float(loss)
    def grad(self, Weight):
        return self.alpha* Weight

class linear_regression():
    def __init__(self,n_epoch = 500,learning_rate =
0.0001,use_gradient = False):
        self.epoch = n_epoch
        self.learning_rate = learning_rate
        self.use_gradient = use_gradient
        self.init_weight = None
        self.final_weight = None
        self.cost = []
        self.val_cost = []
        self.l2_regularization = l2_regularization(0.01)


    def initialize_weights(self, num_features):
        threshold = np.sqrt(1/num_features)
        w = np.random.uniform(-threshold,threshold,(num_features,1))*
0.01
        b = 0
        self.init_weight = np.insert(w,0,b,axis = 0)


    def train(self,X,Y,X_val,Y_val):
        n_sample,n_feature = X.shape
        n1_sample = X_val.shape[0]
        x = np.insert(X,0,1,axis = 1)
        y = np.reshape(Y,(n_sample, 1))
        X_val = np.insert(X_val,0,1,axis = 1)
        Y_val = np.reshape(Y_val,(n1_sample, 1))
        if self.use_gradient == True:
            self.initialize_weights(n_feature)
            self.fit_gradient_descent(self.init_weight,
x,y,X_val,Y_val)
        else:
            self.fit_analytic(x,y)


    def fit_analytic(self,X,Y):
        x = np.array(X)
        y = np.array(Y)

        XT_X = np.dot(x.T,x)
        XT_X_I_XT= np.dot(inv(XT_X),x.T)
        self.final_weight = np.dot(XT_X_I_XT , y)


    def fit_gradient_descent(self,weight,X,Y,X_val,Y_val):
        _weight = weight.copy()
        self.cost.append(self.MSE_cost(X,Y,_weight))
        self.val_cost.append(self.MSE_cost(X_val,Y_val,_weight))
        for iter in range(self.epoch):
            _weight = _weight - np.multiply(self.learning_rate,
self.gradient_descent(_weight,X,Y))
#             print(self.gradient_descent(_weight,X,Y))
            (self.cost).append(self.MSE_cost(X,Y,_weight))
            (self.val_cost).append(self.MSE_cost(X_val,Y_val,_weight))
            if iter%100 ==0:
                print(f"The training cost for iteration ::{iter} is
________________________________________________{np.squeeze(self.cost[
-1])}")
                print(f"The validation cost for iteration ::{iter} is
______________________________________________{np.squeeze(self.val_cos
t[-1])}","\n")
        self.final_weight = _weight


    def gradient_descent(self,weight,X,Y):
        m = X.shape[0]
        inner = np.dot(X,weight) - Y
        mul = np.dot(X.T , inner) +
(self.l2_regularization).grad(weight)
        return mul/(m)

    def MSE_cost(self,X,Y,weight):
        m = X.shape[0]
        diff = ((np.dot(X,weight)) - Y)
        diff_sq = np.dot(diff.T,diff)
        cost = diff_sq/(2*m) + self.l2_regularization(weight)
        return cost


    def predict(self,X):
        np.insert(X,0,1,axis = 1)
        y_pred = np.dot(X,self.final_weight)
        return y_pred


    def Analytic_RMSE_cost(self,X,Y):
        m = X.shape[0]
        X = np.insert(X,0,1,axis = 1)
        Y = np.reshape(Y,(m, 1))
#         print((np.dot(X,self.final_weight)).astype(int) - Y)
        y_pred = np.dot(X,self.final_weight)
        inner = y_pred - Y
        loss = (np.dot(inner.T,inner))/(2*m)
        loss = np.sqrt(loss)
        loss = np.squeeze(loss)
        return loss
    def Gradient_RMSE_cost(self,X,Y):
        m = X.shape[0]
        X = np.insert(X,0,1,axis = 1)
        Y = np.reshape(Y,(m,1))
        y_pred = np.dot(X,self.final_weight)
        inner = y_pred - Y
        loss = (np.dot(inner.T,inner))/(2*m)
        loss = np.sqrt(loss)
        loss = np.squeeze(loss)
        return loss

    def r2_score(self,X,Y):
        m = X.shape[0]
        X = np.insert(X,0,1,axis = 1)
        Y = np.reshape(Y,(m, 1))
        y_pred = np.dot(X,self.final_weight)
        return r2_score(Y,y_pred)

    def viswalize_plot(self):
        figure, (ax1,ax2) = plt.subplots(1,2,figsize=(10,5))

        nums = np.arange(len(self.cost))
        ax1.plot(nums, np.array(self.cost).reshape((len(self.cost,))))
        ax1.set_xlabel('Epoch')
        ax1.set_ylabel('Training cost')
        ax1.set_title('Training_cost')

        ax2.plot(nums,
np.array(self.val_cost).reshape((len(self.val_cost,))))
        ax2.set_xlabel('Epoch')
        ax2.set_ylabel('validation cost')
        ax2.set_title('validation_cost')
        plt.tight_layout()
        plt.show()


regressor_analytic = linear_regression()
regressor_analytic.train(X_train,Y_train,X_val,Y_val)
RMSE_train = regressor_analytic.Analytic_RMSE_cost(X_train,Y_train)
R2_train = regressor_analytic.r2_score(X_train,Y_train)
RMSE_test = regressor_analytic.Analytic_RMSE_cost(X_test,Y_test)
R2_test = regressor_analytic.r2_score(X_test,Y_test)
mapping = {'RMSE':[RMSE_train,RMSE_test], 'R2':[R2_train,R2_test]}
mapit = pd.DataFrame(mapping,index=['Train', 'Test'])

mapit
```

```
                      RMSE        R2
Train  0.45565725096906634  0.397593
Test    0.4712886518848852  0.290613
```

```
regressor_grad = linear_regression(5000,0.01,True)
regressor_grad.train(X_train,Y_train,X_val,Y_val)
test_RMSE_cost = regressor_grad.Gradient_RMSE_cost(X_test,Y_test)
test_R2_cost = regressor_grad.r2_score(X_test,Y_test)
regressor_grad.viswalize_plot()
mapit = pd.DataFrame([[test_RMSE_cost, test_R2_cost]],
columns=['RMSE','R2_Score'], index=['Test(alpha = 0.01)'])
```

```
The training cost for iteration ::0 is
________________________________________________16.05082010830841
The validation cost for iteration ::0 is
______________________________________________16.55309408567745

The training cost for iteration ::100 is
________________________________________________2.386146446704379
The validation cost for iteration ::100 is
______________________________________________8.130424447120063

The training cost for iteration ::200 is
________________________________________________0.6127291134798358
The validation cost for iteration ::200 is
______________________________________________5.6031575057262994

The training cost for iteration ::300 is
________________________________________________0.3920418005406632
The validation cost for iteration ::300 is
______________________________________________5.411012768561847

The training cost for iteration ::400 is
________________________________________________0.3685293611043925
The validation cost for iteration ::400 is
______________________________________________5.679285483777327

The training cost for iteration ::500 is
________________________________________________0.36757816685241174
The validation cost for iteration ::500 is
______________________________________________5.9824849639272415

The training cost for iteration ::600 is
________________________________________________0.36824930654969734
The validation cost for iteration ::600 is
______________________________________________6.230094220557529

The training cost for iteration ::700 is
________________________________________________0.36862864883123514
The validation cost for iteration ::700 is
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                                              6.413483887952604

The training cost for iteration ::800 is
                                                0.3687839776167393
The validation cost for iteration ::800 is
                                              6.543689893191299

The training cost for iteration ::900 is
                                                0.3688422282463087
The validation cost for iteration ::900 is
                                              6.634175147340628

The training cost for iteration ::1000 is
                                                0.36886318775164983
The validation cost for iteration ::1000 is
                                              6.696364600670088

The training cost for iteration ::1100 is
                                                0.36887037605174233
The validation cost for iteration ::1100 is
                                              6.738953183003692

The training cost for iteration ::1200 is
                                                0.3688725631918711
The validation cost for iteration ::1200 is
                                              6.768245504078961

The training cost for iteration ::1300 is
                                                0.36887296072449205
The validation cost for iteration ::1300 is
                                              6.788689661798574

The training cost for iteration ::1400 is
                                                0.3688727389056786
The validation cost for iteration ::1400 is
                                              6.803364156264823

The training cost for iteration ::1500 is
                                                0.36887232468900166
The validation cost for iteration ::1500 is
                                              6.814364567193813

The training cost for iteration ::1600 is
                                                0.3688718743569755
The validation cost for iteration ::1600 is
                                              6.8230934726638655

The training cost for iteration ::1700 is
                                                0.3688714448709841
The validation cost for iteration ::1700 is
```

```
______________________________________________6.830471475496082

The training cost for iteration ::1800 is
________________________________________________0.36887105609684356
The validation cost for iteration ::1800 is
______________________________________________6.8370880837595935

The training cost for iteration ::1900 is
________________________________________________0.3688707136163434
The validation cost for iteration ::1900 is
______________________________________________6.843308252377915

The training cost for iteration ::2000 is
________________________________________________0.36887041727922704
The validation cost for iteration ::2000 is
______________________________________________6.849346867431097

The training cost for iteration ::2100 is
________________________________________________0.3688701645492565
The validation cost for iteration ::2100 is
______________________________________________6.8553203441166914

The training cost for iteration ::2200 is
________________________________________________0.36886995190586397
The validation cost for iteration ::2200 is
______________________________________________6.861282035595588

The training cost for iteration ::2300 is
________________________________________________0.3688697754853456
The validation cost for iteration ::2300 is
______________________________________________6.867246275986829

The training cost for iteration ::2400 is
________________________________________________0.3688696314006058
The validation cost for iteration ::2400 is
______________________________________________6.873204498403224

The training cost for iteration ::2500 is
________________________________________________0.3688695159098123
The validation cost for iteration ::2500 is
______________________________________________6.879135865459986

The training cost for iteration ::2600 is
________________________________________________0.3688694255056114
The validation cost for iteration ::2600 is
______________________________________________6.885014128907599

The training cost for iteration ::2700 is
________________________________________________0.36886935695867096
The validation cost for iteration ::2700 is
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______________________________________________6.890811921110152

The training cost for iteration ::2800 is
________________________________________________0.3688693073336011
The validation cost for iteration ::2800 is
______________________________________________6.896503316673446

The training cost for iteration ::2900 is
________________________________________________0.36886927398791014
The validation cost for iteration ::2900 is
______________________________________________6.902065245291686

The training cost for iteration ::3000 is
________________________________________________0.3688692545607287
The validation cost for iteration ::3000 is
______________________________________________6.907478156026502

The training cost for iteration ::3100 is
________________________________________________0.3688692469556766
The validation cost for iteration ::3100 is
______________________________________________6.912726206571962

The training cost for iteration ::3200 is
________________________________________________0.3688692493207332
The validation cost for iteration ::3200 is
______________________________________________6.917797162715324

The training cost for iteration ::3300 is
________________________________________________0.3688692600269695
The validation cost for iteration ::3300 is
______________________________________________6.922682131864543

The training cost for iteration ::3400 is
________________________________________________0.36886927764733307
The validation cost for iteration ::3400 is
______________________________________________6.927375212155209

The training cost for iteration ::3500 is
________________________________________________0.36886930093619374
The validation cost for iteration ::3500 is
______________________________________________6.93187310958779

The training cost for iteration ::3600 is
________________________________________________0.3688693288100892
The validation cost for iteration ::3600 is
______________________________________________6.936174755871838

The training cost for iteration ::3700 is
________________________________________________0.3688693603298807
The validation cost for iteration ::3700 is
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```
                                                      6.940280946339083

The training cost for iteration ::3800 is
                                                        0.36886939468440605
The validation cost for iteration ::3800 is
                                                      6.944194008446088

The training cost for iteration ::3900 is
                                                        0.3688694311756323
The validation cost for iteration ::3900 is
                                                      6.947917505626311

The training cost for iteration ::4000 is
                                                        0.36886946920525826
The validation cost for iteration ::4000 is
                                                      6.951455977595896

The training cost for iteration ::4100 is
                                                        0.368869508262688
The validation cost for iteration ::4100 is
                                                      6.954814715988684

The training cost for iteration ::4200 is
                                                        0.36886954791427573
The validation cost for iteration ::4200 is
                                                      6.957999572922185

The training cost for iteration ::4300 is
                                                        0.36886958779374335
The validation cost for iteration ::4300 is
                                                      6.961016799450716

The training cost for iteration ::4400 is
                                                        0.36886962759366115
The validation cost for iteration ::4400 is
                                                      6.963872910623591

The training cost for iteration ::4500 is
                                                        0.36886966705789626
The validation cost for iteration ::4500 is
                                                      6.966574573878555

The training cost for iteration ::4600 is
                                                        0.36886970597492896
The validation cost for iteration ::4600 is
                                                      6.969128517665889

The training cost for iteration ::4700 is
                                                        0.36886974417194973
The validation cost for iteration ::4700 is
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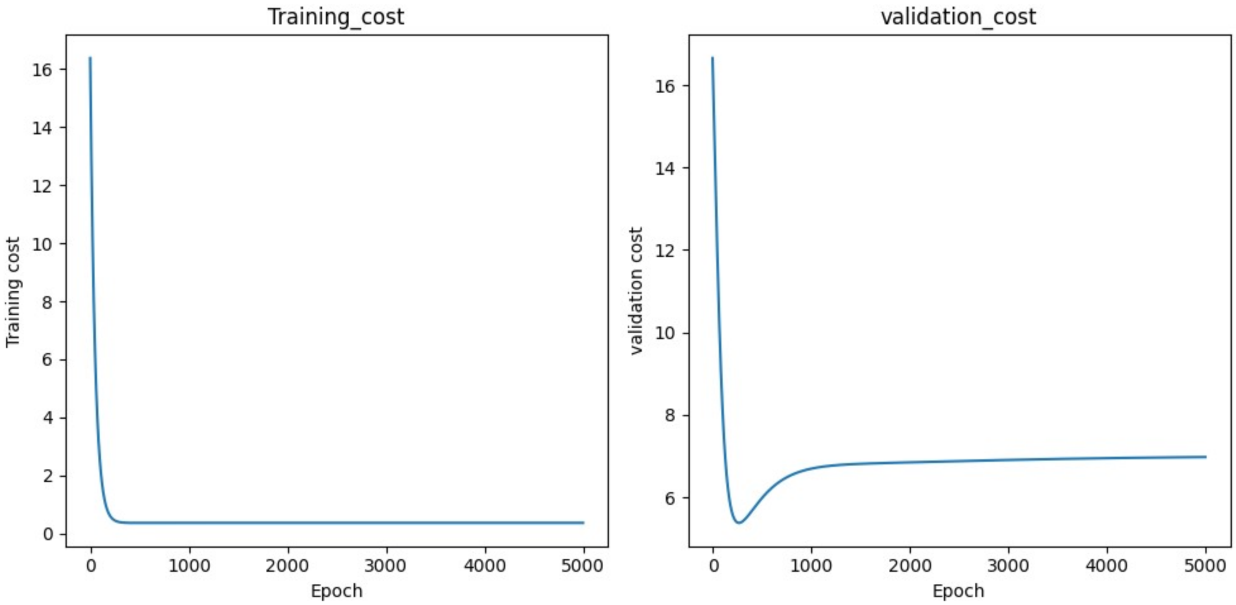
______________________________________________6.971541457443392

The training cost for iteration ::4800 is
________________________________________________0.36886978150965394
The validation cost for iteration ::4800 is
______________________________________________6.973820036466639

The training cost for iteration ::4900 is
________________________________________________0.36886981787765794
The validation cost for iteration ::4900 is
______________________________________________6.97597077909096
```



```
mapit

                                    RMSE  R2_Score
Test(alpha = 0.01)  0.4712902553429182  0.290608
```

```
regressor_grad = linear_regression(5000,0.001,True)
regressor_grad.train(X_train,Y_train,X_val,Y_val)
test_RMSE_cost = regressor_grad.Gradient_RMSE_cost(X_test,Y_test)
test_R2_cost = regressor_grad.r2_score(X_test,Y_test)
regressor_grad.viswalize_plot()
mapit = pd.DataFrame([[test_RMSE_cost, test_R2_cost]],
columns=['RMSE','R2_Score'], index=['Test(alpha = 0.001)'])
```

```
The training cost for iteration ::0 is
________________________________________________16.34188003596894
The validation cost for iteration ::0 is
______________________________________________15.94181320001244
```

```
The training cost for iteration ::100 is
________________________________________________13.402859263237286
The validation cost for iteration ::100 is
______________________________________________15.024053973947321

The training cost for iteration ::200 is
________________________________________________11.004477552855622
The validation cost for iteration ::200 is
______________________________________________14.118016738996088

The training cost for iteration ::300 is
________________________________________________9.046724947622769
The validation cost for iteration ::300 is
______________________________________________13.215899100380138

The training cost for iteration ::400 is
________________________________________________7.448352213584501
The validation cost for iteration ::400 is
______________________________________________12.330047524566051

The training cost for iteration ::500 is
________________________________________________6.143249794814306
The validation cost for iteration ::500 is
______________________________________________11.478150771037562

The training cost for iteration ::600 is
________________________________________________5.07756436962846
The validation cost for iteration ::600 is
______________________________________________10.676240392267353

The training cost for iteration ::700 is
________________________________________________4.207388143564033
The validation cost for iteration ::700 is
______________________________________________9.935994615438727

The training cost for iteration ::800 is
________________________________________________3.49689826104566
The validation cost for iteration ::800 is
______________________________________________9.264266803516737

The training cost for iteration ::900 is
________________________________________________2.9168532566908043
The validation cost for iteration ::900 is
______________________________________________8.663644209714178

The training cost for iteration ::1000 is
________________________________________________2.4433747175270932
The validation cost for iteration ::1000 is
______________________________________________8.133380637133024
```

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The training cost for iteration ::1100 is
                                                2.0569580017478923
The validation cost for iteration ::1100 is
                                              7.670365617764958

The training cost for iteration ::1200 is
                                                1.7416676678936789
The validation cost for iteration ::1200 is
                                              7.269975881240378

The training cost for iteration ::1300 is
                                                1.4844823194750387
The validation cost for iteration ::1300 is
                                              6.926755431984917

The training cost for iteration ::1400 is
                                                1.274760604819952
The validation cost for iteration ::1400 is
                                              6.634922103779276

The training cost for iteration ::1500 is
                                                1.1038056398192688
The validation cost for iteration ::1500 is
                                              6.388721871085394

The training cost for iteration ::1600 is
                                                0.9645095024860344
The validation cost for iteration ::1600 is
                                              6.182660154308997

The training cost for iteration ::1700 is
                                                0.8510629439956593
The validation cost for iteration ::1700 is
                                              6.0116393914657555

The training cost for iteration ::1800 is
                                                0.7587182646763918
The validation cost for iteration ::1800 is
                                              5.87102859036449

The training cost for iteration ::1900 is
                                                0.6835955614052758
The validation cost for iteration ::1900 is
                                              5.756685803951377

The training cost for iteration ::2000 is
                                                0.6225243770951118
The validation cost for iteration ::2000 is
                                              5.66494970991178
```

```
The training cost for iteration ::2100 is
________________________________________________0.5729142604606515
The validation cost for iteration ::2100 is
______________________________________________5.592612280573202

The training cost for iteration ::2200 is
________________________________________________0.5326489433097173
The validation cost for iteration ::2200 is
______________________________________________5.536881089801445

The training cost for iteration ::2300 is
________________________________________________0.49999981723220444
The validation cost for iteration ::2300 is
______________________________________________5.4953371196984975

The training cost for iteration ::2400 is
________________________________________________0.4735551847671079
The validation cost for iteration ::2400 is
______________________________________________5.465891914474383

The training cost for iteration ::2500 is
________________________________________________0.4521624063416597
The validation cost for iteration ::2500 is
______________________________________________5.4467464648257025

The training cost for iteration ::2600 is
________________________________________________0.4348805911702247
The validation cost for iteration ::2600 is
______________________________________________5.436353175847375

The training cost for iteration ::2700 is
________________________________________________0.4209419101916149
The validation cost for iteration ::2700 is
______________________________________________5.433381570248893

The training cost for iteration ::2800 is
________________________________________________0.40971996006016975
The validation cost for iteration ::2800 is
______________________________________________5.436687919573352

The training cost for iteration ::2900 is
________________________________________________0.40070389381582494
The validation cost for iteration ::2900 is
______________________________________________5.4452887104155

The training cost for iteration ::3000 is
________________________________________________0.39347726801655136
The validation cost for iteration ::3000 is
______________________________________________5.458337687666643
```

```
The training cost for iteration ::3100 is
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The validation cost for iteration ::3100 is
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The training cost for iteration ::3200 is
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The validation cost for iteration ::3200 is
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The training cost for iteration ::3300 is
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The validation cost for iteration ::3300 is
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The training cost for iteration ::3400 is
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The validation cost for iteration ::3400 is
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The training cost for iteration ::3500 is
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The validation cost for iteration ::3500 is
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The training cost for iteration ::3600 is
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The validation cost for iteration ::3800 is
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The training cost for iteration ::3900 is
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The validation cost for iteration ::3900 is
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The training cost for iteration ::4000 is
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The validation cost for iteration ::4000 is
______________________________________________5.713377996054516
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The training cost for iteration ::4100 is
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The validation cost for iteration ::4100 is
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The validation cost for iteration ::4200 is
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The training cost for iteration ::4400 is
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The validation cost for iteration ::4400 is
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The training cost for iteration ::4500 is
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The validation cost for iteration ::4700 is
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The validation cost for iteration ::4800 is
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The training cost for iteration ::4900 is
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The validation cost for iteration ::4900 is
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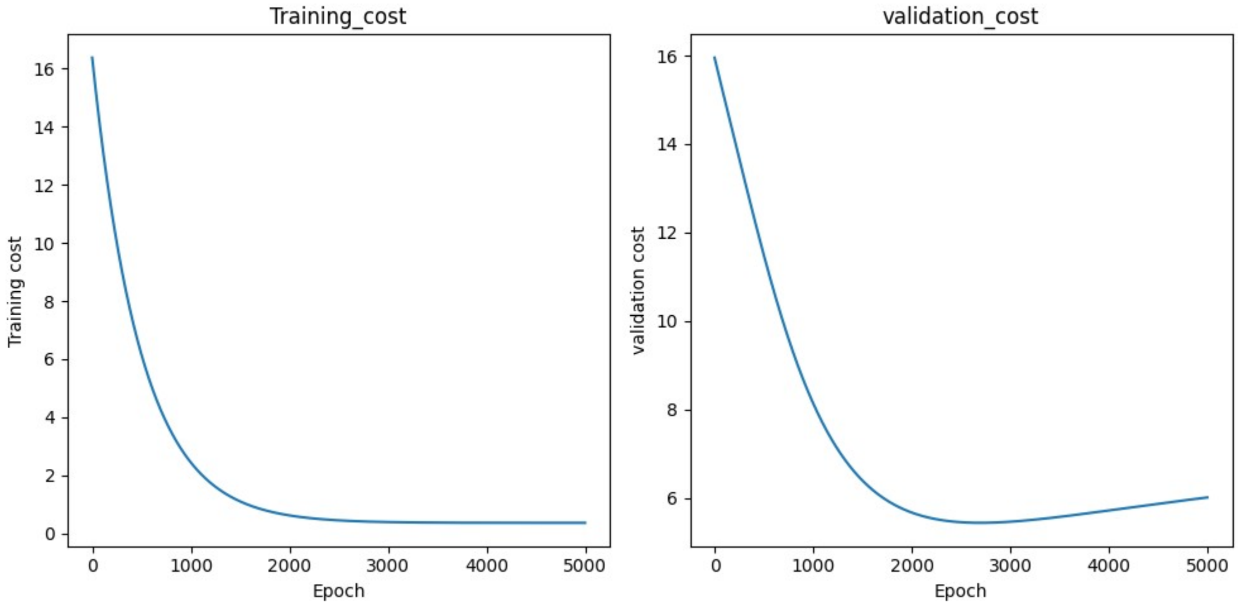

```
mapit

                                   RMSE  R2_Score
Test(alpha = 0.001)  0.4705017378139649   0.29298

regressor_grad = linear_regression(5000,0.0001,True)
regressor_grad.train(X_train,Y_train,X_val,Y_val)
test_RMSE_cost = regressor_grad.Gradient_RMSE_cost(X_test,Y_test)
test_R2_cost = regressor_grad.r2_score(X_test,Y_test)
regressor_grad.viswalize_plot()
mapit = pd.DataFrame([[test_RMSE_cost, test_R2_cost]],
columns=['RMSE','R2_Score'], index=['Test(alpha = 0.0001)'])

The training cost for iteration ::0 is
________________________________________________16.37111134934246
The validation cost for iteration ::0 is
______________________________________________16.40481988639171

The training cost for iteration ::100 is
________________________________________________16.049142233190732
The validation cost for iteration ::100 is
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The training cost for iteration ::200 is
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The validation cost for iteration ::200 is
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The training cost for iteration ::300 is
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The validation cost for iteration ::300 is
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The training cost for iteration ::600 is
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The validation cost for iteration ::600 is
______________________________________________15.80387623857902

The training cost for iteration ::700 is
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The validation cost for iteration ::1000 is
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The validation cost for iteration ::1100 is
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The validation cost for iteration ::1600 is
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The training cost for iteration ::1700 is
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The validation cost for iteration ::1700 is
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The training cost for iteration ::1800 is
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The validation cost for iteration ::1800 is
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The validation cost for iteration ::1900 is
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The validation cost for iteration ::2000 is
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The validation cost for iteration ::2100 is
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The training cost for iteration ::2200 is
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The validation cost for iteration ::2200 is
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The training cost for iteration ::2300 is
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The validation cost for iteration ::2300 is
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The training cost for iteration ::2400 is
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The training cost for iteration ::2600 is
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The validation cost for iteration ::2600 is
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The training cost for iteration ::3100 is
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The training cost for iteration ::3200 is
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The training cost for iteration ::3400 is
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The training cost for iteration ::4100 is
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The training cost for iteration ::4200 is
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The validation cost for iteration ::4200 is
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The training cost for iteration ::4300 is
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The validation cost for iteration ::4300 is
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The training cost for iteration ::4400 is
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The validation cost for iteration ::4400 is
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The training cost for iteration ::4500 is
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The validation cost for iteration ::4500 is
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The training cost for iteration ::4600 is
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The training cost for iteration ::4700 is
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The training cost for iteration ::4800 is
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The validation cost for iteration ::4800 is
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The training cost for iteration ::4900 is
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The validation cost for iteration ::4900 is
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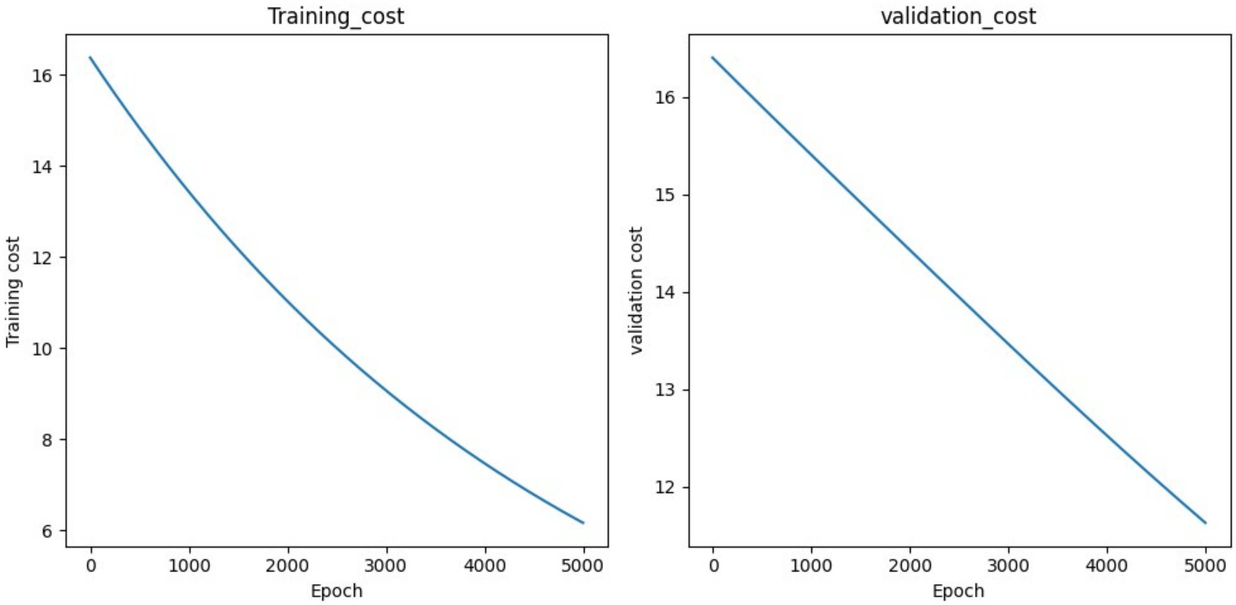

```
mapit

                                          RMSE   R2_Score
Test(alpha = 0.0001)  2.4362325077704643 -17.956005
```