Untitled

October 11, 2018

```
In [2]: import numpy
        import pandas
```

```
In [3]: train_dataframe = pandas.read_csv("./train.csv")
        test_dataframe = pandas.read_csv("./test.csv")
```

```
In [4]: train_dataframe.head()
```

```
Out[4]:    age  gender     bmi  children smoker     region      charges
        0   19  female  27.900         0    yes  southwest  16884.92400
        1   18    male  33.770         1     no  southeast   1725.55230
        2   28    male  33.000         3     no  southeast   4449.46200
        3   33    male  22.705         0     no  northwest  21984.47061
        4   32    male  28.880         0     no  northwest   3866.85520
```

```
In [5]: test_dataframe.head()
```

```
Out[5]:    age gender    bmi  children smoker     region      charges
        0   30   male  22.99         2    yes  northwest  17361.76610
        1   24   male  32.70         0    yes  southwest  34472.84100
        2   24   male  25.80         0     no  southwest   1972.95000
        3   48   male  29.60         0     no  southwest  21232.18226
        4   47   male  19.19         1     no  northeast   8627.54110
```

```
In [6]: train_dataframe.dtypes
```

```
Out[6]: age            int64
        gender        object
        bmi          float64
        children       int64
        smoker        object
        region        object
        charges      float64
        dtype: object
```

```
In [7]: train_dataframe["gender"].value_counts()
```

```
Out[7]: male      505
        female    495
        Name: gender, dtype: int64
```

```
In [8]: cleanup_nums = {"gender":{"male": 1, "female": 0}}
```

```
In [9]: train_dataframe.replace(cleanup_nums, inplace=True)
        test_dataframe.replace(cleanup_nums, inplace=True)
        train_dataframe.head()
```

```
Out[9]:    age  gender     bmi  children smoker     region      charges
        0   19       0  27.900         0    yes  southwest  16884.92400
        1   18       1  33.770         1     no  southeast   1725.55230
        2   28       1  33.000         3     no  southeast   4449.46200
        3   33       1  22.705         0     no  northwest  21984.47061
        4   32       1  28.880         0     no  northwest   3866.85520
```

```
In [10]: test_dataframe.head()
```

```
Out[10]:    age  gender    bmi  children smoker     region      charges
         0   30       1  22.99         2    yes  northwest  17361.76610
         1   24       1  32.70         0    yes  southwest  34472.84100
         2   24       1  25.80         0     no  southwest   1972.95000
         3   48       1  29.60         0     no  southwest  21232.18226
         4   47       1  19.19         1     no  northeast   8627.54110
```

```
In [11]: train_dataframe["gender"].value_counts()
```

```
Out[11]: 1    505
         0    495
         Name: gender, dtype: int64
```

```
In [12]: cleanup_nums = {"smoker":{"yes": 1, "no": 0}}
```

```
In [13]: train_dataframe.replace(cleanup_nums, inplace=True)
         test_dataframe.replace(cleanup_nums, inplace=True)
         train_dataframe.head()
```

```
Out[13]:    age  gender     bmi  children  smoker     region      charges
         0   19       0  27.900         0       1  southwest  16884.92400
         1   18       1  33.770         1       0  southeast   1725.55230
         2   28       1  33.000         3       0  southeast   4449.46200
         3   33       1  22.705         0       0  northwest  21984.47061
         4   32       1  28.880         0       0  northwest   3866.85520
```

```
In [14]: train_dataframe["region"].value_counts()
```

```
Out[14]: southeast    278
         northeast    247
         southwest    244
         northwest    231
         Name: region, dtype: int64
```

```
In [15]: train_dataframe = pandas.get_dummies(train_dataframe,columns=['region'] )
         test_dataframe = pandas.get_dummies(test_dataframe,columns=['region'] )
```

```
In [16]: test_dataframe.head()
```

```
Out[16]:    age  gender    bmi  children  smoker      charges  region_northeast  \
         0   30       1  22.99         2       1  17361.76610                 0
         1   24       1  32.70         0       1  34472.84100                 0
         2   24       1  25.80         0       0   1972.95000                 0
         3   48       1  29.60         0       0  21232.18226                 0
         4   47       1  19.19         1       0   8627.54110                 1

            region_northwest  region_southeast  region_southwest
         0                 1                 0                 0
         1                 0                 0                 1
         2                 0                 0                 1
         3                 0                 0                 1
         4                 0                 0                 0
```

0.1 regression without regularization

```
In [17]: train_dataframe.describe()
```

```
Out[17]:                age       gender         bmi     children       smoker  \
         count  1000.000000  1000.000000  1000.00000  1000.000000  1000.000000
         mean     39.615000     0.505000    30.86338     1.080000     0.196000
         std      14.153908     0.500225     6.04744     1.198765     0.397167
         min      18.000000     0.000000    15.96000     0.000000     0.000000
         25%      27.000000     0.000000    26.60000     0.000000     0.000000
         50%      40.000000     1.000000    30.59000     1.000000     0.000000
         75%      52.000000     1.000000    35.11250     2.000000     0.000000
         max      64.000000     1.000000    50.38000     5.000000     1.000000

                     charges  region_northeast  region_northwest  region_southeast  \
         count   1000.000000       1000.000000       1000.000000       1000.000000
         mean   13075.755883          0.247000          0.231000          0.278000
         std    11985.924552          0.431483          0.421683          0.448238
         min     1121.873900          0.000000          0.000000          0.000000
         25%     4719.683425          0.000000          0.000000          0.000000
         50%     9283.021300          0.000000          0.000000          0.000000
         75%    15882.795437          0.000000          0.000000          1.000000
         max    63770.428010          1.000000          1.000000          1.000000

                region_southwest
         count       1000.000000
         mean           0.244000
         std            0.429708
         min            0.000000
         25%            0.000000
         50%            0.000000
         75%            0.000000
         max            1.000000
```

```
In [18]: train_dataframe['age'] = train_dataframe['age'].apply(lambda x: x ** 2)
         test_dataframe['age'] = test_dataframe['age'].apply(lambda x: x ** 2)
         train_dataframe.head()

Out[18]:     age  gender     bmi  children  smoker      charges  region_northeast  \
         0   361       0  27.900         0       1  16884.92400                 0
         1   324       1  33.770         1       0   1725.55230                 0
         2   784       1  33.000         3       0   4449.46200                 0
         3  1089       1  22.705         0       0  21984.47061                 0
         4  1024       1  28.880         0       0   3866.85520                 0

            region_northwest  region_southeast  region_southwest
         0                 0                 0                 1
         1                 0                 1                 0
         2                 0                 1                 0
         3                 1                 0                 0
         4                 1                 0                 0

In [19]: X_train = train_dataframe.loc[:, train_dataframe.columns != 'charges'].values
         Y_train = train_dataframe[['charges']].values
         X_test = test_dataframe.loc[:, test_dataframe.columns != 'charges'].values
         Y_test = test_dataframe[['charges']].values

In [20]: def cal_w(X,Y):
             W = numpy.matmul(numpy.matmul(numpy.linalg.inv(numpy.matmul(numpy.transpose(X), X))
             return W

In [21]: W = cal_w(X_train,Y_train)

In [22]: W

Out[22]: array([[ 3.30752409e+00],
                [-2.83185963e+02],
                [ 3.37031996e+02],
                [ 5.53892111e+02],
                [ 2.38823566e+04],
                [-7.52569883e+03],
                [-7.99692026e+03],
                [-8.83897937e+03],
                [-8.81785138e+03]])
```

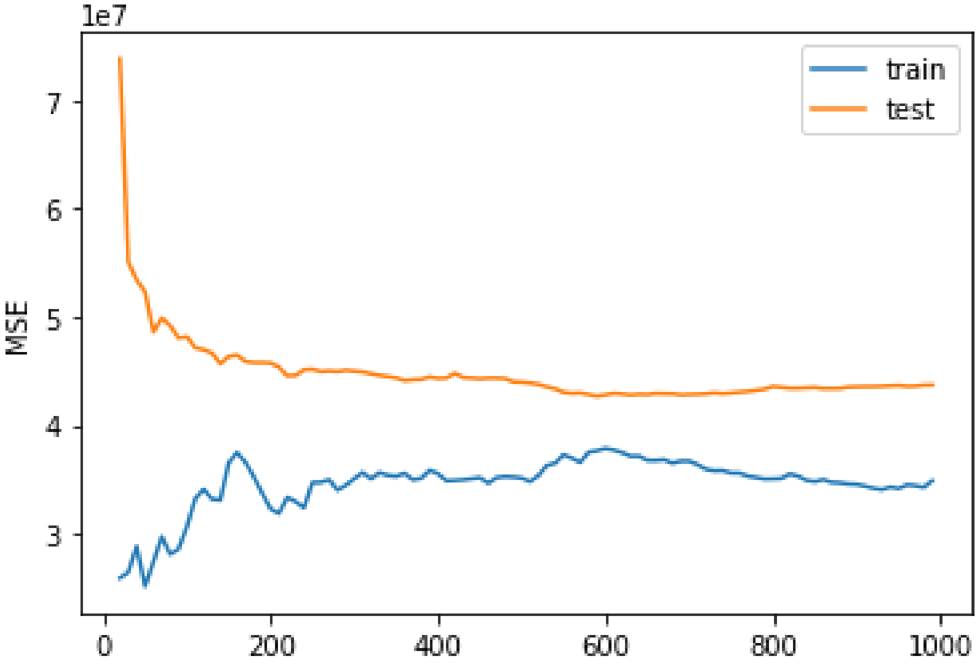
0.2 part B

```
In [23]: def cal_MSE(Y, Yhat):
             return numpy.asscalar(numpy.matmul(numpy.transpose(Y - Yhat), (Y - Yhat)))/Y.shape[

In [24]: sizes = []
         train_errors = []
         test_errors = []
```

```
        for size in range(20, 1000, 10):
            W = cal_w(X_train[:size],Y_train[:size])
            Yhat_train = numpy.matmul(X_train[:size], W)
            Yhat_test = numpy.matmul(X_test, W)
            sizes.append(size)
            train_errors.append(cal_MSE(Y_train[:size], Yhat_train))
            test_errors.append(cal_MSE(Y_test, Yhat_test))
            #print(cal_MSE(Y_train[:size], Yhat_train))
            #print(cal_MSE(Y_test, Yhat_test))
```

```
In [28]: import matplotlib.pyplot as plt
         plt.plot(sizes, train_errors, label='train')
         plt.legend()
         plt.plot(sizes, test_errors, label='test')
         plt.legend()
         plt.ylabel('MSE')
         plt.show()
```



0.3 Batch Gradient Decent

```
In [29]: d = X_train.shape[1]
         W = numpy.zeros((d,1))
         step_size = 0.0000000004
```

```
In [30]: for step_num in range(1, 200000):
             temp = numpy.zeros((d,1))
             for i in range (0, X_train.shape[0]):
                 temp = temp + ((Y_train[i]-numpy.matmul(numpy.transpose(W), X_train[i]))*X_trai
             W_next = W + step_size * temp
             W = W_next
         Yhat = numpy.matmul(X_train, W)
         print("final MSE after "+str(step_num)+" step: "+str(cal_MSE(Y_train, Yhat)))
```

```
final MSE after 199999 step: 122715991.56084847
```

```
In [31]: W
```

```
Out[31]: array([[  3.18683152],
                [ 26.21011364],
                [238.96797125],
                [ 59.74107693],
                [298.53624625],
                [ 18.30637523],
                [ -9.08822966],
                [ 13.94578975],
                [-21.89711975]])
```

```
In [32]: Yhat_test = numpy.matmul(X_test, W)
         print("final MSE of test data after "+str(step_num)+" step: "+str(cal_MSE(Y_test, Yhat_
```

```
final MSE of test data after 199999 step: 151051461.36231995
```

0.4 Stochastic Gradient Decent

```
In [33]: W = numpy.zeros((d,1))
         step_size = 0.0000000004
```

```
In [34]: for step_num in range(1, 20000000):
             temp = numpy.zeros((d,1))
             i = step_num%1000
             temp = temp + ((Y_train[i]-numpy.matmul(numpy.transpose(W), X_train[i]))*X_train[i]
             W_next = W + step_size * temp
             W = W_next
         Yhat = numpy.matmul(X_train, W)
         print("final MSE after "+str(step_num)+" step: "+str(cal_MSE(Y_train, Yhat)))
```

```
final MSE after 19999999 step: 124977095.7821533
```

```
In [35]: W
```

```
Out[35]: array([[ 3.38442291e+00],
                [ 5.82913927e+00],
                [ 2.19888003e+02],
                [ 1.27992666e+01],
                [ 3.12040760e+01],
                [ 3.03571344e+00],
                [ 1.70050571e-01],
                [ 3.60480991e+00],
                [-8.79139469e-01]])
```

```
In [36]: Yhat_test = numpy.matmul(X_test, W)
         print("final MSE of test data after "+str(step_num)+" step: "+str(cal_MSE(Y_test, Yhat_
```

```
final MSE of test data after 19999999 step: 156323270.19909942
```

0.5 Regression With Regularization

```
In [37]: lambdaI = 4*numpy.identity(X_train.shape[1])
         lambdaI.shape
```

```
Out[37]: (9, 9)
```

```
In [38]: def cal_w(X,Y, lam):
             lambdaI = lam*numpy.identity(X.shape[1])
             W = numpy.matmul(numpy.matmul(numpy.linalg.inv(numpy.matmul(numpy.transpose(X), X)+
             return W
```

```
In [39]: X_train[100:200].shape
```

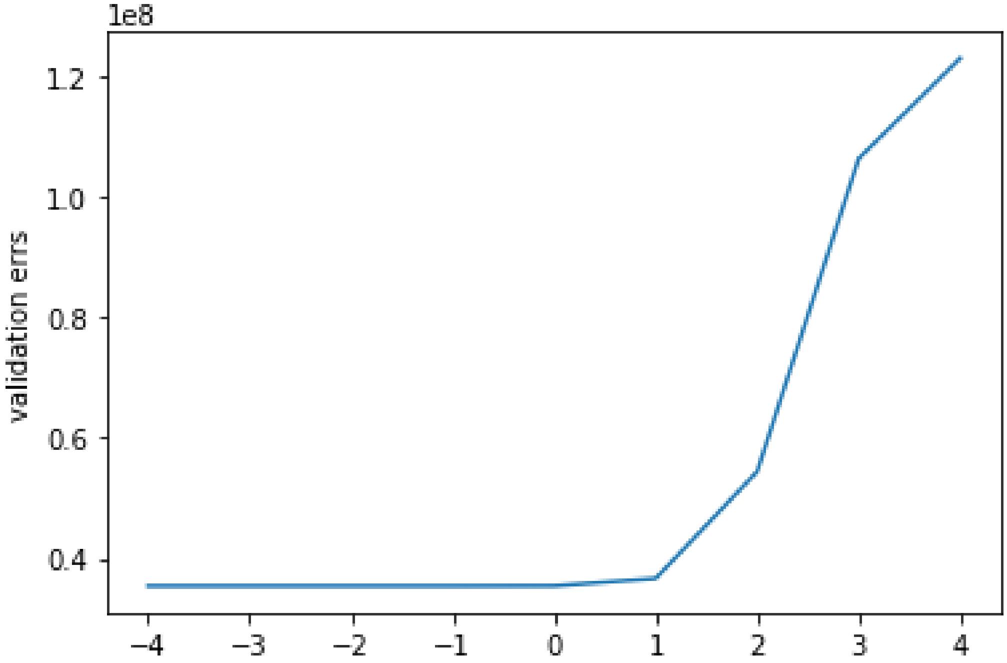
```
Out[39]: (100, 9)
```

```
In [40]: validation_err = []
         for p in range(-4,5,1):
             lam = 10**p
             temp = 0
             for i in range(0, 1000, 200):
                 X_train_train = numpy.delete(X_train, range(i,i+200), 0)
                 X_train_valid = X_train[i:i+200]
                 Y_train_train = numpy.delete(Y_train, range(i,i+200), 0)
                 Y_train_valid = Y_train[i:i+200]
                 W = cal_w(X_train_train,Y_train_train, lam)
                 Yhat_train_valid = numpy.matmul(X_train_valid, W)
                 temp = temp + cal_MSE(Y_train_valid, Yhat_train_valid)
             validation_err.append(temp/5)
             W = cal_w(X_train,Y_train, lam)
             Yhat_train = numpy.matmul(X_train, W)
             print(cal_MSE(Y_train, Yhat_train))
```

```
34673667.87071548
34673667.911172494
```

```
34673671.948340915
34674067.28818611
34706568.7767418
35711282.26299803
49759909.07841898
102087142.97740214
122195557.87957357
```

```
In [41]: import matplotlib.pyplot as plt
         plt.plot(range(-4,5,1), validation_err)
         plt.ylabel('validation errs')
         plt.show()
```



```
In [42]: lam = 1e-4
         W = cal_w(X_train,Y_train, lam)
         Yhat_train = numpy.matmul(X_train, W)
         print(cal_MSE(Y_train, Yhat_train))
         Yhat_test = numpy.matmul(X_test, W)
         print(cal_MSE(Y_test, Yhat_test))
```

```
34673667.87071548
43731022.13001466
```