hw3

April 29, 2016

```
In [1]: %pylab inline
        %matplotlib inline
```

```
Populating the interactive namespace from numpy and matplotlib
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```
In [165]: import numpy as np
          import pandas as pd
          import scipy.stats as ss
          import matplotlib.pyplot as plt
          from scipy.stats import norm

          import math
          from ctypes import *
          import sys
          import string
```

```
In [166]: review_df = pd.read_csv(’2015 CHR Analytic Data.csv’)
          len(review_df)
```

```
Out[166]: 3191
```

```
In [167]: #Step 1

          df = review_df # Store in dummy variable
          df[’2011 population estimate Value’] = df["2011 population estimate Value"].str.replace(’,’,’
          df[’2011 population estimate Value’] = df[’2011 population estimate Value’].astype(float)
          df = df.drop(df[df[’2011 population estimate Value’] < 30000].index) # Drop all < 30000
          #print len(df)

          #Step 2
          for column_name, column in df.transpose().iterrows():
              if(column_name!=’COUNTYCODE’ and column_name.find("Value",(len(column_name)-5))==-1):
                  df = df.drop(column_name, 1)
          #print len(df)


          #Step3

          df= df.dropna()

          #Delete all total rows

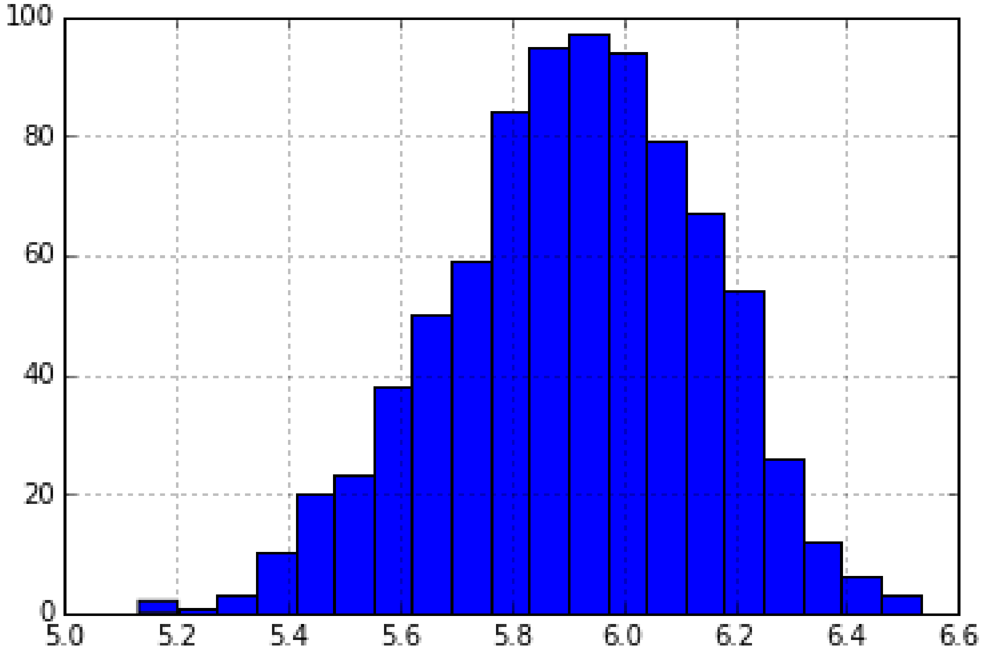
          df.dropna() #Drop all rows having any Nan
          df = df.drop(df[df[’COUNTYCODE’] == 0].index)
          print "1. TOTAL NUMBER OF COUNTIES: ",len(df)
```

```
1. TOTAL NUMBER OF COUNTIES:  823
```

```
In [205]: df['log_paamv'] = df['Premature age-adjusted mortality Value']

          df['log_paamv']=np.log(df['log_paamv'])
          df['log_paamv'].hist(bins=20)
          print "2. log_paamv HISTOGRAM: 2histogram.png"
```

```
2. log_paamv HISTOGRAM: 2histogram.png
```



```
In [182]: from sklearn import datasets, linear_model

          #Shuffle Indexes
          df = df.reindex(np.random.permutation(df.index))
          #print df.head()

          REMOVED_COLUMNS = ['COUNTYCODE', 'log_paamv', 'Premature age-adjusted mortality Value','Prema
          lr_df = df.copy()

          for col_name in REMOVED_COLUMNS:
              #print col_name
              lr_df = lr_df.drop(col_name, 1)
          lr_df.head()

          for c in lr_df.columns:
              if not (lr_df[c].dtype == np.float64 or lr_df[c].dtype == np.int64):
                  lr_df[c] = lr_df[c].apply(lambda val: float(string.replace(str(val),',',''))) ##chang
                  lr_df[c] = lr_df[c].astype('float')
          #Standardize

          regr = linear_model.LinearRegression()

          gMAE = 0.0
          for j in range(0, 10):

              to_be_skipped_from = int( (j*len(lr_df))/10 )
              to_be_skipped = int(len(lr_df)/10)+1

              train_x = lr_df[0:to_be_skipped_from].copy()
              train_y = df[’log_paamv’][0:to_be_skipped_from].copy()

              train_x = train_x.append(lr_df[to_be_skipped_from+to_be_skipped:len(lr_df)+1].copy())
              train_y = train_y.append(df[’log_paamv’][to_be_skipped_from+to_be_skipped:len(lr_df)+1].c

              test_x = lr_df[to_be_skipped_from:to_be_skipped_from+to_be_skipped].copy()
              test_y = df[’log_paamv’][to_be_skipped_from:to_be_skipped_from+to_be_skipped].copy()

              for c in train_x.columns:
                  train_x[c] = (train_x[c] - np.mean(train_x[c]))/np.std(train_x[c])

              train_y = (train_y - np.mean(train_y))/np.std(train_y)

              for c in test_x.columns:
                  test_x[c] = (test_x[c] - np.mean(test_x[c]))/np.std(test_x[c])

              test_y = (test_y - np.mean(test_y))/np.std(test_y)

              #print ’train_x’,0,to_be_skipped_from
              #print ’train_x append’,to_be_skipped_from+to_be_skipped,len(lr_df)+1
              #print ’test_x’,to_be_skipped_from,to_be_skipped_from+to_be_skipped

              regr.fit(train_x, train_y)

              # The coefficients
              #print("Residual sum of squares:",np.mean((regr.predict(test_x) - test_y) ** 2))
              gMAE += np.mean((regr.predict(test_x) - test_y) ** 2)

          gMAE = gMAE/10

          print "3. Non-regularized Linear Regression MSE: ", gMAE
```

```
3. Non-regularized Linear Regression MSE:  0.124838899866
```

```
In [203]: #Part 4

          from sklearn.decomposition import PCA

          #Standardize dataset
          for c in lr_df.columns:
              lr_df[c] = (lr_df[c] - np.mean(lr_df[c]))/np.std(lr_df[c])

          pca = PCA(n_components=3)
          pca.fit(lr_df)
          print "4. Percentage variance explained of first three components:", pca.explained_variance_ra
```

```
4. Percentage variance explained of first three components: [ 0.28090638  0.13937027  0.0792126 ]
```

```
In [199]: #Part 5 a)
          #PCA
          from sklearn import datasets, linear_model

          #Shuffle Indexes
          df = df.reindex(np.random.permutation(df.index))
          #print df.head()

          lr_df = df.copy()
          #Standardize

          for col_name in REMOVED_COLUMNS:
              #print col_name
              lr_df = lr_df.drop(col_name, 1)
          lr_df.head()

          for c in lr_df.columns:
              if not (lr_df[c].dtype == np.float64 or lr_df[c].dtype == np.int64):
                  lr_df[c] = lr_df[c].apply(lambda val: float(string.replace(str(val),’,’,’’))) ##chang
                  lr_df[c] = lr_df[c].astype(’float’)



          regr = linear_model.LinearRegression()
          gMAE = 0.0


          for j in range(0, 10):

              to_be_skipped_from = int( (j*len(lr_df))/10 )
              to_be_skipped = int(2*len(lr_df)/10)+1

              if j < 9:
                  train_x = lr_df[0:to_be_skipped_from].copy()
                  train_y = df[’log_paamv’][0:to_be_skipped_from].copy()

                  train_x = train_x.append(lr_df[to_be_skipped_from+to_be_skipped:len(lr_df)+1].copy())
                  train_y = train_y.append(df[’log_paamv’][to_be_skipped_from+to_be_skipped:len(lr_df)+

                  test_x = lr_df[to_be_skipped_from:to_be_skipped_from+to_be_skipped/2].copy()
                  test_y = df[’log_paamv’][to_be_skipped_from:to_be_skipped_from+to_be_skipped/2].copy(

                  dev_x = lr_df[to_be_skipped_from+to_be_skipped/2:to_be_skipped_from+to_be_skipped].co
                  dev_y = df[’log_paamv’][to_be_skipped_from+to_be_skipped/2:to_be_skipped_from+to_be_s

              else:
                  to_be_skipped = int(len(lr_df)/10)+1
                  train_x = lr_df[to_be_skipped+1:len(lr_df)-to_be_skipped].copy()
                  train_y = df[’log_paamv’][to_be_skipped+1:len(lr_df)-to_be_skipped].copy()

                  test_x = lr_df[len(lr_df)-to_be_skipped+1:len(lr_df)].copy()
```

```
            test_y = df['log_paamv'][len(lr_df)-to_be_skipped+1:len(lr_df)].copy()

            dev_x = lr_df[0:to_be_skipped].copy()
            dev_y = df['log_paamv'][0:to_be_skipped].copy()

        for c in train_x.columns:
            train_x[c] = (train_x[c] - np.mean(train_x[c]))/np.std(train_x[c])

        train_y = (train_y - np.mean(train_y))/np.std(train_y)

        for c in test_x.columns:
            test_x[c] = (test_x[c] - np.mean(test_x[c]))/np.std(test_x[c])

        test_y = (test_y - np.mean(test_y))/np.std(test_y)

        for c in dev_x.columns:
            dev_x[c] = (dev_x[c] - np.mean(dev_x[c]))/np.std(dev_x[c])

        dev_y = (dev_y - np.mean(dev_y))/np.std(dev_y)

        #print 'train_x',0,to_be_skipped_from
        #print 'train_x append',to_be_skipped_from+to_be_skipped,len(lr_df)+1
        #print 'test_x',to_be_skipped_from,to_be_skipped_from+to_be_skipped
        min_error = 10000;
        min_comp = 1
        for k in range(3,44):
            pca = PCA(n_components=k)
            pca.fit(train_x)
            Z = pca.transform(train_x)
            Z =  pd.DataFrame(Z).copy()
            dev_min = pca.transform(dev_x)
            dev_min =  pd.DataFrame(dev_min).copy()
            #print 'Z: ', len(Z),' train_y', len(train_y),' train_x', len(train_x)
            #print 'dev_x', len(dev_x),' dev_y', len(dev_y)
            regr.fit(Z, train_y)
            error = np.mean((regr.predict(dev_min) - dev_y) ** 2)
            if error < min_error:
                min_comp = k
                min_error = error
        #print 'iter ',j
        #print 'min components', min_comp
        pca = PCA(n_components=min_comp)
        pca.fit(train_x)
        Z = pca.transform(train_x)
        Z =  pd.DataFrame(Z).copy()
        test_x = pca.transform(test_x)
        test_x =  pd.DataFrame(test_x).copy()
        regr.fit(Z, train_y)
        gMAE += np.mean((regr.predict(test_x) - test_y) ** 2)

    gMAE = gMAE/10

    print "5. a) principal components regression mse: ", gMAE
```

```
5. a) principal components regression mse:  0.126886957947
```

In [201]:
```
#Part 5 b)
#L2 Regularization

from sklearn.linear_model import Ridge, Lasso

#Shuffle Indexes
df = df.reindex(np.random.permutation(df.index))
#print df.head()

lr_df = df.copy()
#Standardize

for col_name in REMOVED_COLUMNS:
    #print col_name
    lr_df = lr_df.drop(col_name, 1)
lr_df.head()

for c in lr_df.columns:
    if not (lr_df[c].dtype == np.float64 or lr_df[c].dtype == np.int64):
        lr_df[c] = lr_df[c].apply(lambda val: float(string.replace(str(val),’,’,’’))) ##chang
        lr_df[c] = lr_df[c].astype(’float’)

gMAE = 0.0


for j in range(0, 10):

    to_be_skipped_from = int( (j*len(lr_df))/10 )
    to_be_skipped = int(2*len(lr_df)/10)+1

    if j < 9:
        train_x = lr_df[0:to_be_skipped_from].copy()
        train_y = df[’log_paamv’][0:to_be_skipped_from].copy()

        train_x = train_x.append(lr_df[to_be_skipped_from+to_be_skipped:len(lr_df)+1].copy())
        train_y = train_y.append(df[’log_paamv’][to_be_skipped_from+to_be_skipped:len(lr_df)+

        test_x = lr_df[to_be_skipped_from:to_be_skipped_from+to_be_skipped/2].copy()
        test_y = df[’log_paamv’][to_be_skipped_from:to_be_skipped_from+to_be_skipped/2].copy(

        dev_x = lr_df[to_be_skipped_from+to_be_skipped/2:to_be_skipped_from+to_be_skipped].co
        dev_y = df[’log_paamv’][to_be_skipped_from+to_be_skipped/2:to_be_skipped_from+to_be_s

    else:
        to_be_skipped = int(len(lr_df)/10)+1
        train_x = lr_df[to_be_skipped+1:len(lr_df)-to_be_skipped].copy()
        train_y = df[’log_paamv’][to_be_skipped+1:len(lr_df)-to_be_skipped].copy()

        test_x = lr_df[len(lr_df)-to_be_skipped+1:len(lr_df)].copy()
        test_y = df[’log_paamv’][len(lr_df)-to_be_skipped+1:len(lr_df)].copy()

        dev_x = lr_df[0:to_be_skipped].copy()
        dev_y = df['log_paamv'][0:to_be_skipped].copy()

    for c in train_x.columns:
        train_x[c] = (train_x[c] - np.mean(train_x[c]))/np.std(train_x[c])

    train_y = (train_y - np.mean(train_y))/np.std(train_y)

    for c in test_x.columns:
        test_x[c] = (test_x[c] - np.mean(test_x[c]))/np.std(test_x[c])

    test_y = (test_y - np.mean(test_y))/np.std(test_y)

    for c in dev_x.columns:
        dev_x[c] = (dev_x[c] - np.mean(dev_x[c]))/np.std(dev_x[c])

    dev_y = (dev_y - np.mean(dev_y))/np.std(dev_y)

    #print 'train_x',0,to_be_skipped_from
    #print 'train_x append',to_be_skipped_from+to_be_skipped,len(lr_df)+1
    #print 'test_x',to_be_skipped_from,to_be_skipped_from+to_be_skipped
    min_error = 10000;
    min_alpha = 1
    alphas = [pow(10,-5),pow(10,-4),pow(10,-3),pow(10,-2),pow(10,-1),1,10,100,1000,10000,10000
    for alpha in alphas:
        regr = Ridge(alpha=alpha)
        regr.fit(train_x, train_y)
        error = np.mean((regr.predict(dev_x) - dev_y) ** 2)
        if error < min_error:
            min_alpha = alpha
            min_error = error
    #print 'iter ',j
    #print 'min alpha', min_alpha
    #print 'min error', min_error
    regr = Ridge(alpha=min_alpha)
    regr.fit(train_x, train_y)
    gMAE += np.mean((regr.predict(test_x) - test_y) ** 2)

gMAE = gMAE/10

print "5. b) L2 regularized mse: ", gMAE
```

```
5. b) L2 regularized mse:  0.12111448232
```

```
In [202]: #Part 5 c)
          #L1 Regularization

          from sklearn.linear_model import Ridge, Lasso

          #Shuffle Indexes
          df = df.reindex(np.random.permutation(df.index))
          #print df.head()

          lr_df = df.copy()
          #Standardize
```

```
for col_name in REMOVED_COLUMNS:
    #print col_name
    lr_df = lr_df.drop(col_name, 1)
lr_df.head()

for c in lr_df.columns:
    if not (lr_df[c].dtype == np.float64 or lr_df[c].dtype == np.int64):
        lr_df[c] = lr_df[c].apply(lambda val: float(string.replace(str(val),’,’,’’))) ##chang
        lr_df[c] = lr_df[c].astype(’float’)


gMAE = 0.0


for j in range(0, 10):

    to_be_skipped_from = int( (j*len(lr_df))/10 )
    to_be_skipped = int(2*len(lr_df)/10)+1

    if j < 9:
        train_x = lr_df[0:to_be_skipped_from].copy()
        train_y = df[’log_paamv’][0:to_be_skipped_from].copy()

        train_x = train_x.append(lr_df[to_be_skipped_from+to_be_skipped:len(lr_df)+1].copy())
        train_y = train_y.append(df[’log_paamv’][to_be_skipped_from+to_be_skipped:len(lr_df)+

        test_x = lr_df[to_be_skipped_from:to_be_skipped_from+to_be_skipped/2].copy()
        test_y = df[’log_paamv’][to_be_skipped_from:to_be_skipped_from+to_be_skipped/2].copy(

        dev_x = lr_df[to_be_skipped_from+to_be_skipped/2:to_be_skipped_from+to_be_skipped].co
        dev_y = df[’log_paamv’][to_be_skipped_from+to_be_skipped/2:to_be_skipped_from+to_be_s

    else:
        to_be_skipped = int(len(lr_df)/10)+1
        train_x = lr_df[to_be_skipped+1:len(lr_df)-to_be_skipped].copy()
        train_y = df[’log_paamv’][to_be_skipped+1:len(lr_df)-to_be_skipped].copy()

        test_x = lr_df[len(lr_df)-to_be_skipped+1:len(lr_df)].copy()
        test_y = df[’log_paamv’][len(lr_df)-to_be_skipped+1:len(lr_df)].copy()

        dev_x = lr_df[0:to_be_skipped].copy()
        dev_y = df[’log_paamv’][0:to_be_skipped].copy()

    for c in train_x.columns:
        train_x[c] = (train_x[c] - np.mean(train_x[c]))/np.std(train_x[c])

    train_y = (train_y - np.mean(train_y))/np.std(train_y)

    for c in test_x.columns:
        test_x[c] = (test_x[c] - np.mean(test_x[c]))/np.std(test_x[c])

    test_y = (test_y - np.mean(test_y))/np.std(test_y)

    for c in dev_x.columns:
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```
                dev_x[c] = (dev_x[c] - np.mean(dev_x[c]))/np.std(dev_x[c])

            dev_y = (dev_y - np.mean(dev_y))/np.std(dev_y)

            #print 'train_x',0,to_be_skipped_from
            #print 'train_x append',to_be_skipped_from+to_be_skipped,len(lr_df)+1
            #print 'test_x',to_be_skipped_from,to_be_skipped_from+to_be_skipped
            min_error = 10000;
            min_alpha = 1
            alphas = [pow(10,-5),pow(10,-4),pow(10,-3),pow(10,-2),pow(10,-1),1,10,100,1000,10000,10000
            for alpha in alphas:
                regr = Lasso(alpha=alpha)
                regr.fit(train_x, train_y)
                error = np.mean((regr.predict(dev_x) - dev_y) ** 2)
                if error < min_error:
                    min_alpha = alpha
                    min_error = error
            #print 'iter ',j
            #print 'min alpha', min_alpha
            #print 'min error', min_error
            regr = Lasso(alpha=min_alpha)
            regr.fit(train_x, train_y)
            gMAE += np.mean((regr.predict(test_x) - test_y) ** 2)

        gMAE = gMAE/10

        print "5. c) L1 regularized mse: ", gMAE
```

```
5. b) L1 regularized mse:  0.122738420223
```

```
In [ ]:
```