Human_Activity_Recognition

May 2, 2018

1 Human Activity Recongition Models - UCI Repository

1.1 Importing needed libraries

```
In [1]: import pandas as pd
        import numpy as np
        from sklearn.metrics import accuracy_score
        from sklearn.model_selection import train_test_split
        from sklearn.tree import DecisionTreeClassifier
        import matplotlib.pyplot as plt
        from sklearn.metrics import confusion_matrix
        import seaborn as sn
        from sklearn.utils import shuffle
        from sklearn import linear_model
```

1.2 Loading datasets

```
In [2]: trainX = pd.read_table('./X_train.txt', delim_whitespace=True,header=None)
        trainy = pd.read_table('./y_train.txt',delim_whitespace=True,header=None)
        testX = pd.read_csv("./X_test.txt",delim_whitespace=True,header=None)
        testy = pd.read_csv('./y_test.txt',delim_whitespace=True,header=None)

        dickey = {"1":"WALKING", "2":"WALKING_UPSTAIRS","3":"WALKING_DOWNSTAIRS","4":"SITTING"
```

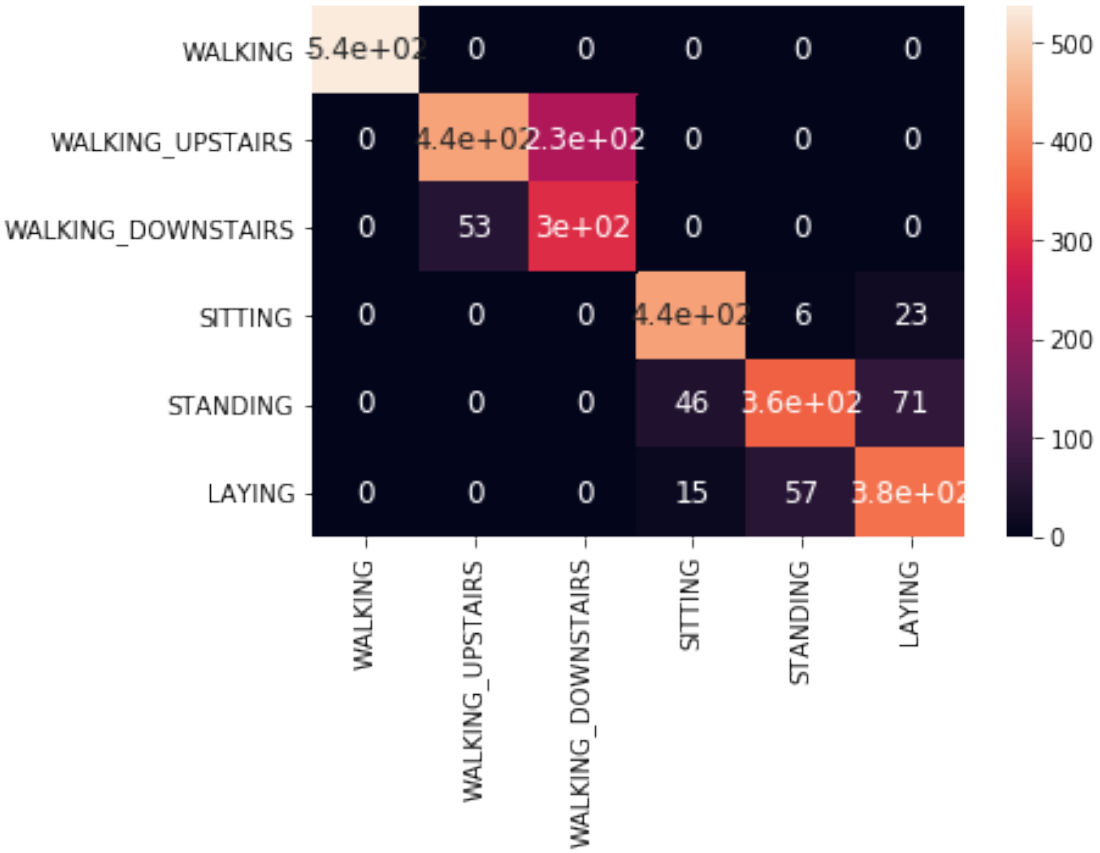
1.3 Normalizing dataset by subtracting with mean and divide by std

```
In [3]: mu = trainX.mean(axis=0)
        mu1 = testX.mean(axis=0)
        stdv = trainX.std(axis = 0)
        stdv1 = testX.std(axis = 0)

        X_train = (trainX - mu)/stdv    #normalized train set
        X_test = (testX - mu1)/stdv1  #normalized test set
        y_train = trainy               #train set of labels
        y_test = testy                #test set of label
        y = np.array(y_train).ravel() #2d to 1 conversion
```

1.4 Decision Tree

```
In [4]: rank_classifier = DecisionTreeClassifier(max_leaf_nodes=20, random_state=0)
        rank_classifier.fit(X_train,y)
        Predictions_test = rank_classifier.predict(X_test)
        Predictions_train = rank_classifier.predict(X_train)
        TrainAccuracy = accuracy_score(y_true = y_train, y_pred = Predictions_train)
        TestAccuracy = accuracy_score(y_true = y_test, y_pred = Predictions_test)

        print("Training Accuracy of Decision Tree: {}".format(TrainAccuracy))
        print("Testing Accuracy of Decision Tree: {}".format(TestAccuracy))

        yy = list(map(str, Predictions_test))
        y_test1 = np.array(y_test.T).ravel()
        yy1 = list(map(str,y_test1))
        pred1 = np.array(pd.Series(yy).map(dickey))
        y_test1 = np.array(pd.Series(yy1).map(dickey))

        array = confusion_matrix(pred1,y_test1)
        df_cm = pd.DataFrame(array, range(6),range(6))
        #sn.set(font_scale=1)#for label size
        sn.heatmap(df_cm, annot=True,annot_kws={"size": 12},yticklabels=("WALKING", "WALKING_U
        plt.show()
```

```
Training Accuracy of Decision Tree: 0.9351196953210011
Testing Accuracy of Decision Tree: 0.828978622327791
```



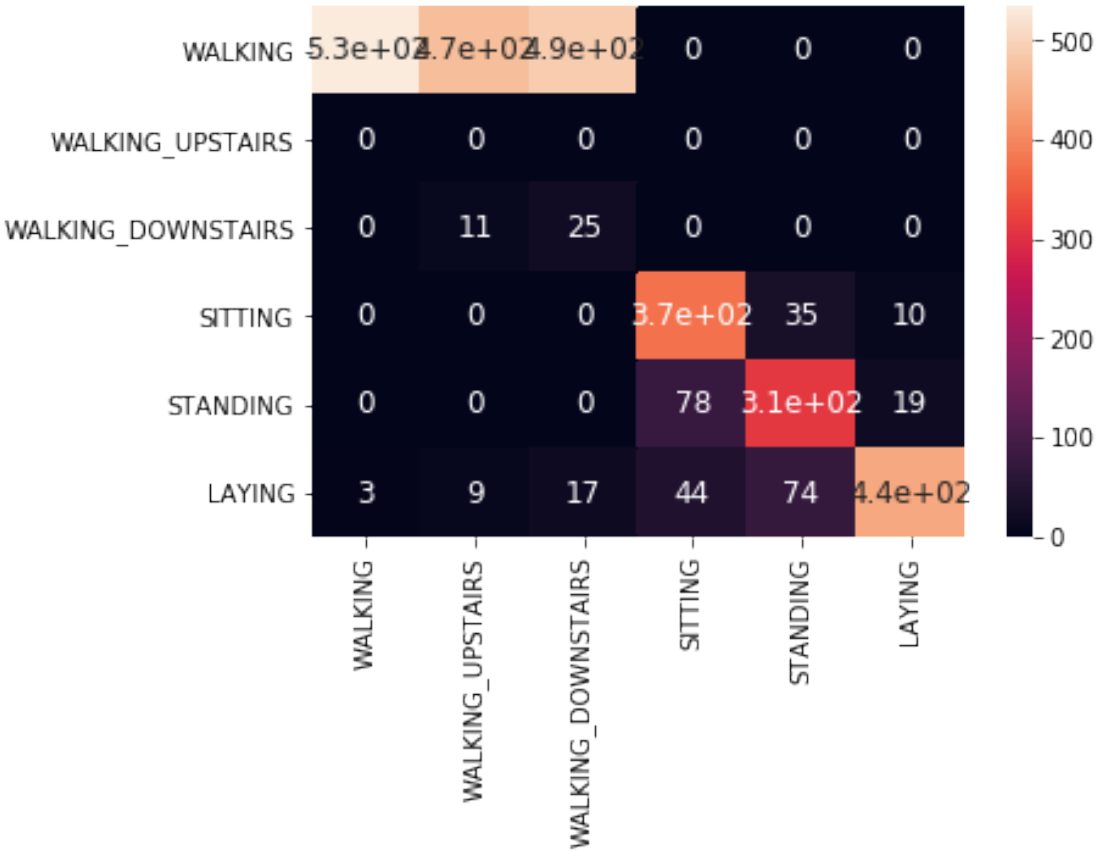
1.5 K Neearest Neighbors

```
In [ ]: from sklearn import neighbors
        Accuracy_KNN = np.array([])
        rangeli = list(range(3,10))
        for i in rangeli:                                    #iterating through different k values
            knn = neighbors.KNeighborsClassifier(n_neighbors=i)
            knn.fit(X_train,y)
            predicted_knn = knn.predict(X_test)
            Accuracy = accuracy_score(y_true = y_test, y_pred = predicted_knn)
            Accuracy_KNN = np.append(Accuracy_KNN, Accuracy)
            print(Accuracy)
            print(Accuracy_KNN)

        plt.plot(rangeli, Accuracy_KNN)
        plt.show()
        print("Optimal K value is {}".format(rangeli[np.argmax(Accuracy_KNN)]))
        print("Accuracy of Optimum K value is {}".format(np.max(Accuracy_KNN)))
```

1.6 Gaussian Naive Bayes

In [7]:
```
from sklearn.naive_bayes import GaussianNB

        mnb = GaussianNB()                #loading model
        mnb.fit(X_train, y)               #fitting the model
        predicted_mnb = mnb.predict(X_test)
        predicted_train = mnb.predict(X_train)
        #Accuracy = accuracy_score(y_true = y_test, y_pred = y_pred)
        Accuracy_test = accuracy_score(y_true = y_test, y_pred = predicted_mnb)
        Accuracy_train = accuracy_score(y_true = y_train, y_pred = predicted_train)
        print("Training Accuracy of Gaussian Naive Bayes:  {}".format(Accuracy_train))
        print("Testing Accuracy of Gaussian Naive Bayes: {}".format(Accuracy_test))

        yy = list(map(str, predicted_mnb))
        y_test1 = np.array(y_test.T).ravel()
        yy1 = list(map(str,y_test1))
        pred1 = np.array(pd.Series(yy).map(dickey))
        y_test1 = np.array(pd.Series(yy1).map(dickey))

        array = confusion_matrix(pred1,y_test1)
        df_cm = pd.DataFrame(array, range(6),range(6))
        df_cm.columns = ["WALKING", "WALKING_UPSTAIRS","WALKING_DOWNSTAIRS","SITTING","STANDIN
        df_cm.index = ["WALKING", "WALKING_UPSTAIRS","WALKING_DOWNSTAIRS","SITTING","STANDING"
        sn.heatmap(df_cm, annot=True,annot_kws={"size": 12},yticklabels=("WALKING", "WALKING_U
        plt.show()
```

```
Training Accuracy of Gaussian Naive Bayes:  0.7461915125136017
Testing Accuracy of Gaussian Naive Bayes: 0.5721072276891754
```



In [8]: df_cm *#confusion matrix dataframe*

Out[8]:

	WALKING	WALKING_UPSTAIRS	WALKING_DOWNSTAIRS	SITTING	STANDING	LAYING
WALKING	534	471	490	0	0	0
WALKING_UPSTAIRS	0	0	0	0	0	0
WALKING_DOWNSTAIRS	0	11	25	0	0	0
SITTING	0	0	0	374	35	10
STANDING	0	0	0	78	311	19
LAYING	3	9	17	44	74	442

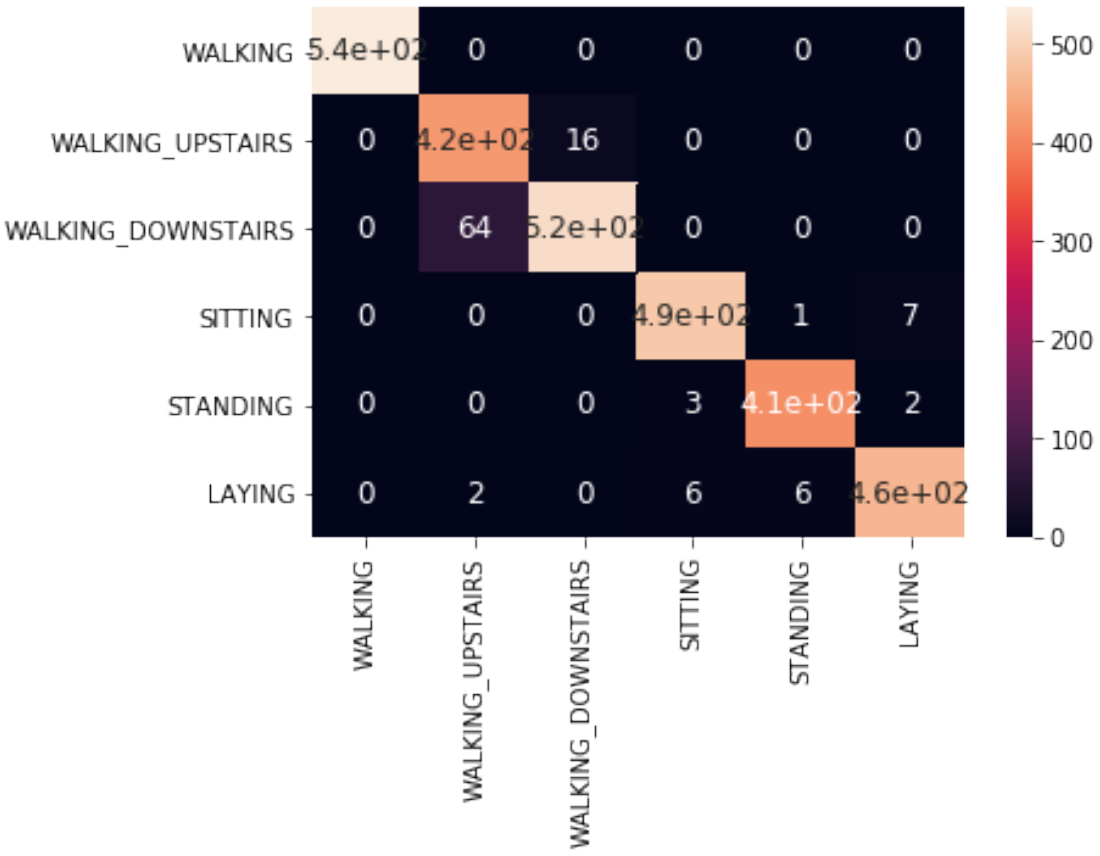
1.7 Logistic Regression

```
In [9]: cli = [1,0.5,0.1,0.01,0.003,0.0003]
        trainacc = np.array([])
        testacc = np.array([])
        for j in cli:          #iterating through different penalty values
            LRmod = linear_model.LogisticRegression(penalty='l1', C=j)
            LRmod.fit(X_train,y)
            pred = LRmod.predict(X_test)
            pred1 = LRmod.predict(X_train)
            testac = accuracy_score(y_true = y_test, y_pred = pred)
            trainac = accuracy_score(y_true = y_train, y_pred = pred1)
            trainacc = np.append(trainacc,trainac)
            testacc = np.append(testacc,testac)
            print("Training Accuracy for penalty {}: {}".format(j,trainac))
            print("Testing Accuracy for penalty {}: {}".format(j,testac))

        print("\n============================================================\n")
        val = np.subtract(trainacc,testacc)    #finding the least difference between training
        print("Optimum Penalty value: {}".format(cli[np.argmin(val)]))
        print("Maximum Testing Accuracy: {}".format(testacc[np.argmin(val)]))
        print("Maximum Training Accuracy: {}".format(trainacc[np.argmin(val)]))
```

```
Training Accuracy for penalty 1: 0.9952393906420022
Testing Accuracy for penalty 1: 0.9640312181879878
Training Accuracy for penalty 0.5: 0.9934711643090316
Testing Accuracy for penalty 0.5: 0.9636918900576857
Training Accuracy for penalty 0.1: 0.9862622415669206
Testing Accuracy for penalty 0.1: 0.9586019681031558
Training Accuracy for penalty 0.01: 0.9458650707290533
Testing Accuracy for penalty 0.01: 0.9317950458092976
Training Accuracy for penalty 0.003: 0.9077801958650707
Testing Accuracy for penalty 0.003: 0.9158466236851035
Training Accuracy for penalty 0.0003: 0.16675734494015235
Testing Accuracy for penalty 0.0003: 0.168306752629793

============================================================

Optimum Penalty value: 0.003
Maximum Testing Accuracy: 0.9158466236851035
Maximum Training Accuracy: 0.9077801958650707
```

```
In [8]: LRmod = linear_model.LogisticRegression(penalty='l1')
        LRmod.fit(X_train,y)
        pred = LRmod.predict(X_test)
        yy = list(map(str, pred))
        y_test1 = np.array(y_test.T).ravel()
        yy1 = list(map(str,y_test1))
```

```
pred1 = np.array(pd.Series(yy).map(dickey))
y_test1 = np.array(pd.Series(yy1).map(dickey))

array = confusion_matrix(pred1,y_test1)
df_cm = pd.DataFrame(array, range(6),range(6))
df_cm.columns = ["WALKING", "WALKING_UPSTAIRS","WALKING_DOWNSTAIRS","SITTING","STANDIN
df_cm.index = ["WALKING", "WALKING_UPSTAIRS","WALKING_DOWNSTAIRS","SITTING","STANDING"

#sn.set(font_scale=1)#for label size
sn.heatmap(df_cm, annot=True,annot_kws={"size": 12},yticklabels=("WALKING", "WALKING_U
plt.show()
```



In [11]: df_cm #confusion matrix plot

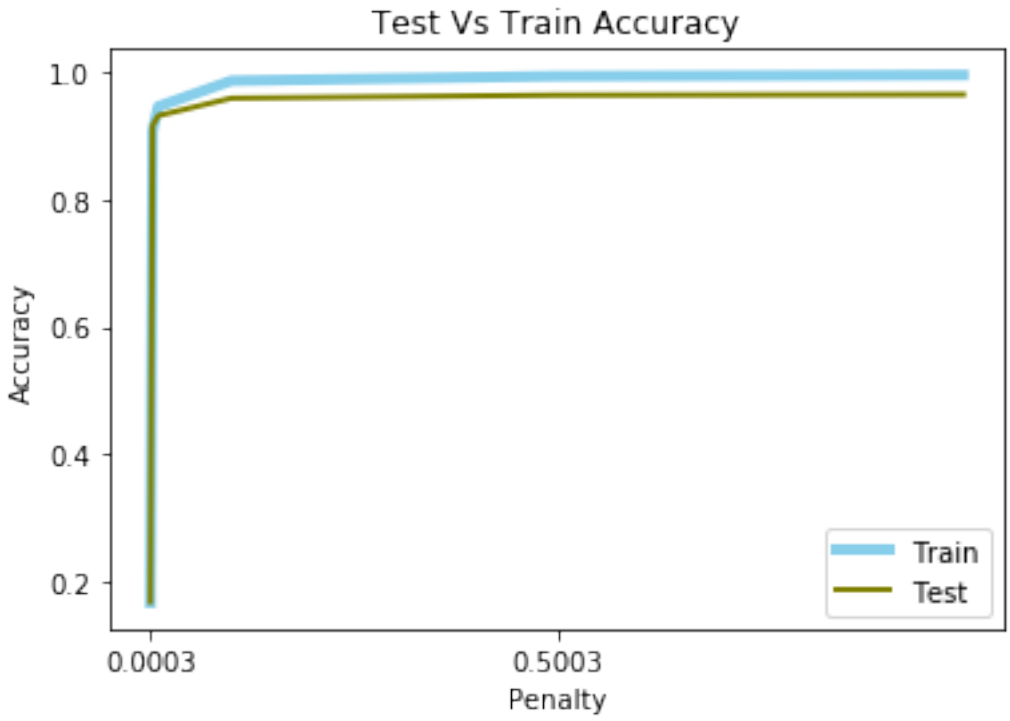
Out[11]:

	WALKING	WALKING_UPSTAIRS	WALKING_DOWNSTAIRS	SITTING	\
WALKING	537	0	0	0	
WALKING_UPSTAIRS	0	426	16	0	
WALKING_DOWNSTAIRS	0	63	516	0	
SITTING	0	0	0	488	
STANDING	0	0	0	3	

```
LAYING                    0                 2                    0        5
```

```
                     STANDING  LAYING
WALKING                     0       0
WALKING_UPSTAIRS            0       0
WALKING_DOWNSTAIRS          0       0
SITTING                     1       6
STANDING                  413       1
LAYING                      6     464
```

In [12]:
```
# multiple line plot
plt.plot( cli,trainacc , marker='', markerfacecolor='blue', markersize=12, color='skyl
plt.plot( cli,testacc ,marker='', color='olive', linewidth=2, label='Test')
plt.xticks(np.arange(min(cli), max(cli), 0.5))
plt.title('Test Vs Train Accuracy')
plt.ylabel('Accuracy')
plt.xlabel('Penalty')
plt.legend()
plt.show()
```



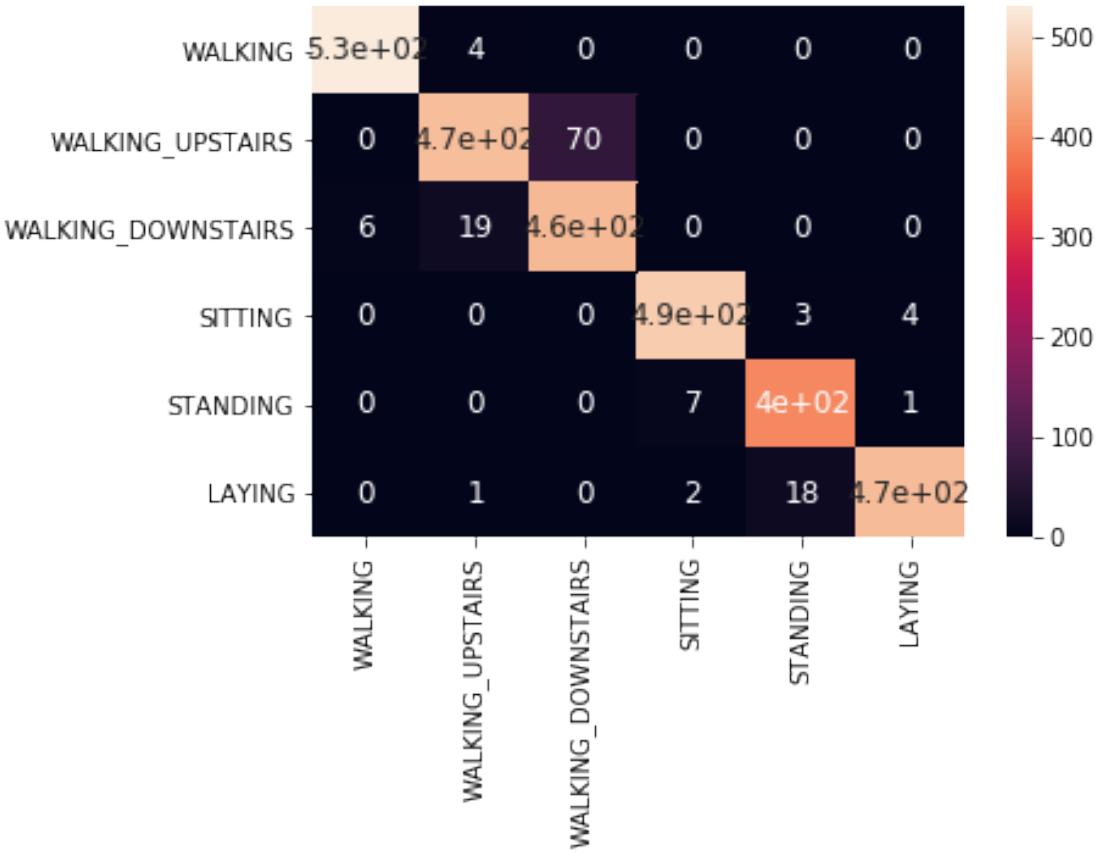
1.8 Support Vector Machine

In [131]:
```
from sklearn.svm import SVC
clf = SVC()
```

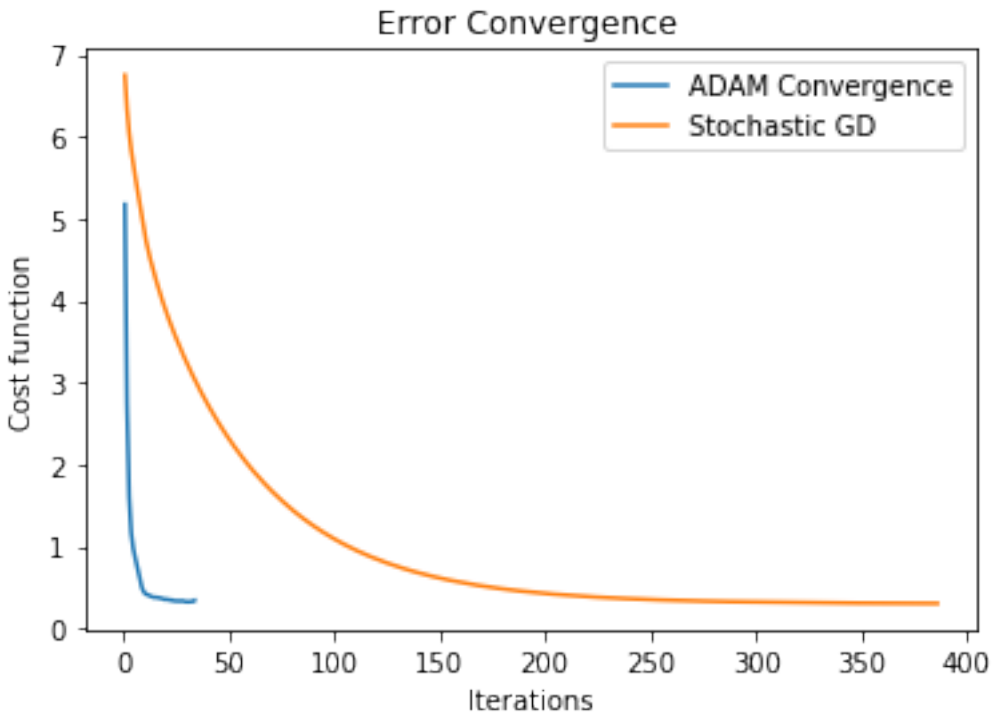
```
clf.fit(X_train, y_train)
predsvm = clf.predict(X_test)
accuracy_score(y_true = y_test, y_pred = predsvm)
predsvm = clf.predict(X_train)
accuracy_score(y_true = y_train, y_pred = predsvm)
```

1.9 Neural Network

```
In [12]: from sklearn.neural_network import MLPClassifier

         clf = MLPClassifier(alpha=5,hidden_layer_sizes=(300, 6), random_state=1,solver='adam'
         sgd = MLPClassifier(alpha=5,hidden_layer_sizes=(300, 6), random_state=1, solver ='sgd
         clf.fit(X_train,y)
         sgd.fit(X_train,y)

Out[12]: MLPClassifier(activation='relu', alpha=5, batch_size='auto', beta_1=0.9,
                beta_2=0.999, early_stopping=False, epsilon=1e-08,
                hidden_layer_sizes=(300, 6), learning_rate='constant',
                learning_rate_init=0.001, max_iter=500, momentum=0.9,
                nesterovs_momentum=True, power_t=0.5, random_state=1, shuffle=True,
                solver='sgd', tol=0.0001, validation_fraction=0.1, verbose=False,
                warm_start=False)

In [91]: pred = clf.predict(X_test)
         predt = clf.predict(X_train)
         TeAccuracy = accuracy_score(y_true = y_test, y_pred = pred)
         TrAccuracy = accuracy_score(y_true = y_train, y_pred = predt)

         print("Training Accuracy in Neural Network: {}".format(TrAccuracy))
         print("Testing Accuracy in Neural Network: {}".format(TeAccuracy))

         yy = list(map(str, pred))
         y_test1 = np.array(y_test.T).ravel()
         yy1 = list(map(str,y_test1))
         pred1 = np.array(pd.Series(yy).map(dickey))
         y_test1 = np.array(pd.Series(yy1).map(dickey))

         array = confusion_matrix(pred1,y_test1)
         df_cm = pd.DataFrame(array, range(6),range(6))
         df_cm.columns = ["WALKING", "WALKING_UPSTAIRS","WALKING_DOWNSTAIRS","SITTING","STANDI
         df_cm.index = ["WALKING", "WALKING_UPSTAIRS","WALKING_DOWNSTAIRS","SITTING","STANDING
         #sn.set(font_scale=1)#for label size
         sn.heatmap(df_cm, annot=True,annot_kws={"size": 12},yticklabels=("WALKING", "WALKING_U
         plt.show()

Training Accuracy in Neural Network: 0.9737486398258978
Testing Accuracy in Neural Network: 0.9541907024092298
```




```
In [13]: X1 = np.linspace(1, clf.n_iter_  , clf.n_iter_ )
         X2 = np.linspace(1, sgd.n_iter_  , sgd.n_iter_ )

         plt.plot(X1 , clf.loss_curve_ , label = 'ADAM Convergence' )
         plt.plot(X2,sgd.loss_curve_,label = "Stochastic GD")
         plt.title('Error Convergence ')
         plt.ylabel('Cost function')
         plt.xlabel('Iterations')
         plt.legend()
         plt.show()
```




```
In [93]: df_cm  #confusion matrix table
```

Out[93]:

	WALKING	WALKING_UPSTAIRS	WALKING_DOWNSTAIRS	SITTING	\
WALKING	531	4	0	0	
WALKING_UPSTAIRS	0	467	70	0	
WALKING_DOWNSTAIRS	6	19	462	0	
SITTING	0	0	0	487	
STANDING	0	0	0	7	
LAYING	0	1	0	2	

	STANDING	LAYING
WALKING	0	0
WALKING_UPSTAIRS	0	0
WALKING_DOWNSTAIRS	0	0
SITTING	3	4
STANDING	399	1
LAYING	18	466

1.10 PCA - Principle Component Analysis

```
In [2]: trainX = pd.read_table('./X_train.txt', delim_whitespace=True,header=None)
        trainy = pd.read_table('./y_train.txt',delim_whitespace=True,header=None)
        testX = pd.read_csv("./X_test.txt",delim_whitespace=True,header=None)
        testy = pd.read_csv('./y_test.txt',delim_whitespace=True,header=None)
```

```
        one = [trainX,testX]
        two = [trainy,testy]
        X_df = pd.concat(one)
        y_df = pd.concat(two)
```

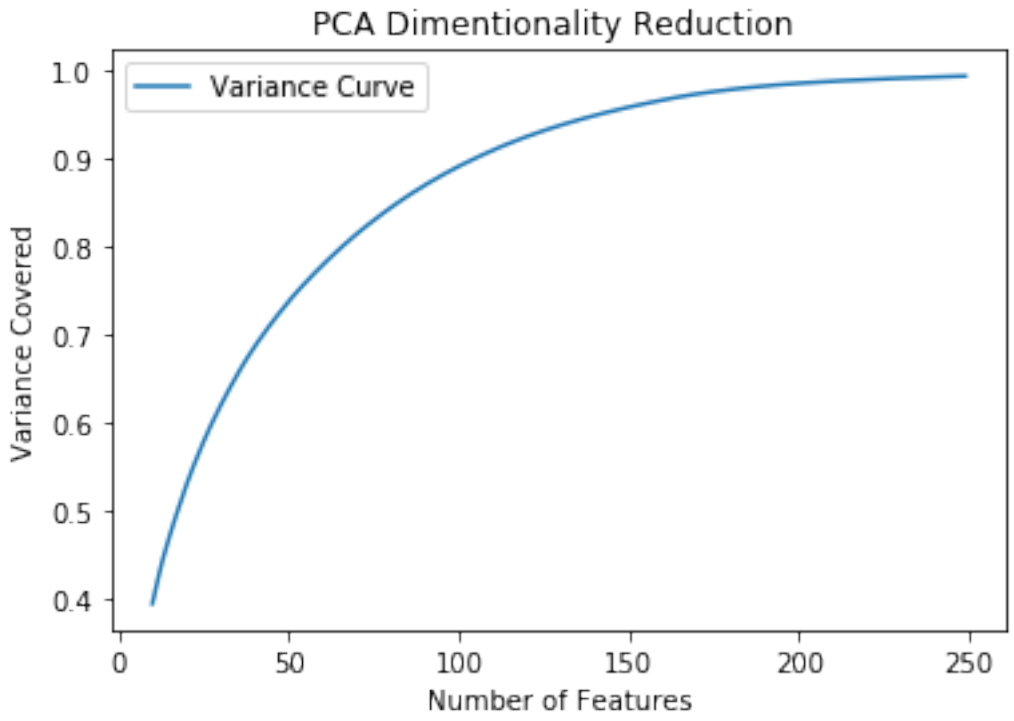
1.10.1 Helper functions for PCA

```
In [3]: def fetaure_norm(X):
            mu = X.mean(axis=0)
            stdv = X.std(axis = 0)

            X_norm = (X - mu)/stdv
            return X_norm

        def pca(X):
            m,n = X.shape

            sigma = (1/m) * X.T * X
            a, b = np.linalg.eig(sigma)

            sort = a.argsort()[::-1]
            eigVal = a[sort]
            eigVec = b[:,sort]

            return eigVal,eigVec

        def reduced_data(X, U, k):
            U_reduce = U[:,:k]
            Z = U_reduce.T * X.T
            return Z

        def recover_data(Z,U,K):
            X_rec = Z.T * U[:,:k].T
            return X_rec

        def variance_cal(S,k,m):
            total1 = 0
            total2 = 0
            for i in range(1,k):
                total1 = total1 + S[i]

            for j in range(1,m):
                total2 = total2 + S[j]

            variance = total1/total2
            return variance

In [14]: X = np.asmatrix(X_df)
```

```
y = np.asmatrix(y_df)

X_norm = fetaure_norm(X)
m,n = X_norm.shape
a,b = pca(X_norm)
tes = np.array([])
li = list(range(10,250))
for k in li:
    Z = reduced_data(X_norm,b,k)
    X_recov = recover_data(Z,b,k)
    test1 = variance_cal(a,k,n)
    tes = np.append(tes,test1)
    #print("Variance covered with {} features: {}%".format(k,test1*100))
```

In [19]:
```
plt.plot(li,tes, label = 'Variance Curve')
plt.title('PCA Dimentionality Reduction ')
plt.ylabel('Variance Covered')
plt.xlabel('Number of Features')
plt.legend()
plt.show()
```

```
C:\Users\gokul\Anaconda3\lib\site-packages\numpy\core\numeric.py:531: ComplexWarning: Casting c
  return array(a, dtype, copy=False, order=order)
```



EDA

May 1, 2018

```
In [1]: # Required Python Machine learning Packages
        #Statistical analysis
        import pandas as pd
        import numpy as np
        # visualization
        import seaborn as sns
        #Plotting graphs
        import matplotlib.pyplot as plt
        %matplotlib inline

In [2]: df1 = pd.read_csv("C:/Users/byabh/Desktop/ALT/project/train.csv")
        df2 = pd.read_csv("C:/Users/byabh/Desktop/ALT/project/test.csv")

In [3]: df1.shape

Out[3]: (7352, 563)

In [4]: df2.shape

Out[4]: (2947, 563)

In [5]: df1.info()

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 7352 entries, 0 to 7351
Columns: 563 entries, tBodyAcc-mean()-X to Activity
dtypes: float64(561), int64(1), object(1)
memory usage: 31.6+ MB


In [21]: df1.describe()

Out[21]:        tBodyAcc-mean()-X  tBodyAcc-mean()-Y  tBodyAcc-mean()-Z  \
         count        7352.000000        7352.000000        7352.000000
         mean            0.274488          -0.017695          -0.109141
         std             0.070261           0.040811           0.056635
         min            -1.000000          -1.000000          -1.000000
         25%             0.262975          -0.024863          -0.120993
         50%             0.277193          -0.017219          -0.108676
```

```
75%            0.288461          -0.010783          -0.097794
max            1.000000           1.000000           1.000000

       tBodyAcc-std()-X  tBodyAcc-std()-Y  tBodyAcc-std()-Z  tBodyAcc-mad()-X  \
count       7352.000000       7352.000000       7352.000000       7352.000000
mean          -0.605438         -0.510938         -0.604754         -0.630512
std            0.448734          0.502645          0.418687          0.424073
min           -1.000000         -0.999873         -1.000000         -1.000000
25%           -0.992754         -0.978129         -0.980233         -0.993591
50%           -0.946196         -0.851897         -0.859365         -0.950709
75%           -0.242813         -0.034231         -0.262415         -0.292680
max            1.000000          0.916238          1.000000          1.000000

       tBodyAcc-mad()-Y  tBodyAcc-mad()-Z  tBodyAcc-max()-X     ...       \
count       7352.000000       7352.000000       7352.000000     ...
mean          -0.526907         -0.606150         -0.468604     ...
std            0.485942          0.414122          0.544547     ...
min           -1.000000         -1.000000         -1.000000     ...
25%           -0.978162         -0.980251         -0.936219     ...
50%           -0.857328         -0.857143         -0.881637     ...
75%           -0.066701         -0.265671         -0.017129     ...
max            0.967664          1.000000          1.000000     ...

       fBodyBodyGyroJerkMag-skewness()  fBodyBodyGyroJerkMag-kurtosis()  \
count                      7352.000000                      7352.000000
mean                         -0.307009                        -0.625294
std                           0.321011                         0.307584
min                          -0.995357                        -0.999765
25%                          -0.542602                        -0.845573
50%                          -0.343685                        -0.711692
75%                          -0.126979                        -0.503878
max                           0.989538                         0.956845

       angle(tBodyAccMean,gravity)  angle(tBodyAccJerkMean),gravityMean)  \
count                 7352.000000                           7352.000000
mean                     0.008684                              0.002186
std                      0.336787                              0.448306
min                     -0.976580                             -1.000000
25%                     -0.121527                             -0.289549
50%                      0.009509                              0.008943
75%                      0.150865                              0.292861
max                      1.000000                              1.000000

       angle(tBodyGyroMean,gravityMean)  angle(tBodyGyroJerkMean,gravityMean)  \
count                      7352.000000                           7352.000000
mean                          0.008726                             -0.005981
std                           0.608303                              0.477975
min                          -1.000000                             -1.000000
```

```
25%                          -0.482273                          -0.376341
50%                           0.008735                          -0.000368
75%                           0.506187                           0.359368
max                           0.998702                           0.996078

       angle(X,gravityMean)  angle(Y,gravityMean)  angle(Z,gravityMean)  \
count           7352.000000           7352.000000           7352.000000
mean              -0.489547              0.058593             -0.056515
std                0.511807              0.297480              0.279122
min               -1.000000             -1.000000             -1.000000
25%               -0.812065             -0.017885             -0.143414
50%               -0.709417              0.182071              0.003181
75%               -0.509079              0.248353              0.107659
max                1.000000              0.478157              1.000000

            subject
count  7352.000000
mean     17.413085
std       8.975143
min       1.000000
25%       8.000000
50%      19.000000
75%      26.000000
max      30.000000

[8 rows x 562 columns]
```

```
In [6]: df1.isnull().sum()
```

```
Out[6]: tBodyAcc-mean()-X                 0
        tBodyAcc-mean()-Y                 0
        tBodyAcc-mean()-Z                 0
        tBodyAcc-std()-X                  0
        tBodyAcc-std()-Y                  0
        tBodyAcc-std()-Z                  0
        tBodyAcc-mad()-X                  0
        tBodyAcc-mad()-Y                  0
        tBodyAcc-mad()-Z                  0
        tBodyAcc-max()-X                  0
        tBodyAcc-max()-Y                  0
        tBodyAcc-max()-Z                  0
        tBodyAcc-min()-X                  0
        tBodyAcc-min()-Y                  0
        tBodyAcc-min()-Z                  0
        tBodyAcc-sma()                    0
        tBodyAcc-energy()-X               0
        tBodyAcc-energy()-Y               0
        tBodyAcc-energy()-Z               0
```

```
tBodyAcc-iqr()-X                        0
tBodyAcc-iqr()-Y                        0
tBodyAcc-iqr()-Z                        0
tBodyAcc-entropy()-X                    0
tBodyAcc-entropy()-Y                    0
tBodyAcc-entropy()-Z                    0
tBodyAcc-arCoeff()-X,1                  0
tBodyAcc-arCoeff()-X,2                  0
tBodyAcc-arCoeff()-X,3                  0
tBodyAcc-arCoeff()-X,4                  0
tBodyAcc-arCoeff()-Y,1                  0
                                       ..
fBodyBodyGyroMag-sma()                  0
fBodyBodyGyroMag-energy()               0
fBodyBodyGyroMag-iqr()                  0
fBodyBodyGyroMag-entropy()              0
fBodyBodyGyroMag-maxInds                0
fBodyBodyGyroMag-meanFreq()             0
fBodyBodyGyroMag-skewness()             0
fBodyBodyGyroMag-kurtosis()             0
fBodyBodyGyroJerkMag-mean()             0
fBodyBodyGyroJerkMag-std()              0
fBodyBodyGyroJerkMag-mad()              0
fBodyBodyGyroJerkMag-max()              0
fBodyBodyGyroJerkMag-min()              0
fBodyBodyGyroJerkMag-sma()              0
fBodyBodyGyroJerkMag-energy()           0
fBodyBodyGyroJerkMag-iqr()              0
fBodyBodyGyroJerkMag-entropy()          0
fBodyBodyGyroJerkMag-maxInds            0
fBodyBodyGyroJerkMag-meanFreq()         0
fBodyBodyGyroJerkMag-skewness()         0
fBodyBodyGyroJerkMag-kurtosis()         0
angle(tBodyAccMean,gravity)             0
angle(tBodyAccJerkMean),gravityMean)    0
angle(tBodyGyroMean,gravityMean)        0
angle(tBodyGyroJerkMean,gravityMean)    0
angle(X,gravityMean)                    0
angle(Y,gravityMean)                    0
angle(Z,gravityMean)                    0
subject                                 0
Activity                                0
Length: 563, dtype: int64
```

```
In [7]: df2.isnull().sum()
```

```
Out[7]: tBodyAcc-mean()-X                 0
        tBodyAcc-mean()-Y                 0
```

```
tBodyAcc-mean()-Z                       0
tBodyAcc-std()-X                        0
tBodyAcc-std()-Y                        0
tBodyAcc-std()-Z                        0
tBodyAcc-mad()-X                        0
tBodyAcc-mad()-Y                        0
tBodyAcc-mad()-Z                        0
tBodyAcc-max()-X                        0
tBodyAcc-max()-Y                        0
tBodyAcc-max()-Z                        0
tBodyAcc-min()-X                        0
tBodyAcc-min()-Y                        0
tBodyAcc-min()-Z                        0
tBodyAcc-sma()                          0
tBodyAcc-energy()-X                     0
tBodyAcc-energy()-Y                     0
tBodyAcc-energy()-Z                     0
tBodyAcc-iqr()-X                        0
tBodyAcc-iqr()-Y                        0
tBodyAcc-iqr()-Z                        0
tBodyAcc-entropy()-X                    0
tBodyAcc-entropy()-Y                    0
tBodyAcc-entropy()-Z                    0
tBodyAcc-arCoeff()-X,1                  0
tBodyAcc-arCoeff()-X,2                  0
tBodyAcc-arCoeff()-X,3                  0
tBodyAcc-arCoeff()-X,4                  0
tBodyAcc-arCoeff()-Y,1                  0
                                       ..
fBodyBodyGyroMag-sma()                  0
fBodyBodyGyroMag-energy()               0
fBodyBodyGyroMag-iqr()                  0
fBodyBodyGyroMag-entropy()              0
fBodyBodyGyroMag-maxInds                0
fBodyBodyGyroMag-meanFreq()             0
fBodyBodyGyroMag-skewness()             0
fBodyBodyGyroMag-kurtosis()             0
fBodyBodyGyroJerkMag-mean()             0
fBodyBodyGyroJerkMag-std()              0
fBodyBodyGyroJerkMag-mad()              0
fBodyBodyGyroJerkMag-max()              0
fBodyBodyGyroJerkMag-min()              0
fBodyBodyGyroJerkMag-sma()              0
fBodyBodyGyroJerkMag-energy()           0
fBodyBodyGyroJerkMag-iqr()              0
fBodyBodyGyroJerkMag-entropy()          0
fBodyBodyGyroJerkMag-maxInds            0
fBodyBodyGyroJerkMag-meanFreq()         0
```

```
fBodyBodyGyroJerkMag-skewness()          0
fBodyBodyGyroJerkMag-kurtosis()          0
angle(tBodyAccMean,gravity)              0
angle(tBodyAccJerkMean),gravityMean)     0
angle(tBodyGyroMean,gravityMean)         0
angle(tBodyGyroJerkMean,gravityMean)     0
angle(X,gravityMean)                     0
angle(Y,gravityMean)                     0
angle(Z,gravityMean)                     0
subject                                  0
Activity                                 0
Length: 563, dtype: int64
```

```
In [8]: df1.head()
```

Out[8]:

	tBodyAcc-mean()-X	tBodyAcc-mean()-Y	tBodyAcc-mean()-Z	tBodyAcc-std()-X	\
0	0.288585	-0.020294	-0.132905	-0.995279	
1	0.278419	-0.016411	-0.123520	-0.998245	
2	0.279653	-0.019467	-0.113462	-0.995380	
3	0.279174	-0.026201	-0.123283	-0.996091	
4	0.276629	-0.016570	-0.115362	-0.998139	

	tBodyAcc-std()-Y	tBodyAcc-std()-Z	tBodyAcc-mad()-X	tBodyAcc-mad()-Y	\
0	-0.983111	-0.913526	-0.995112	-0.983185	
1	-0.975300	-0.960322	-0.998807	-0.974914	
2	-0.967187	-0.978944	-0.996520	-0.963668	
3	-0.983403	-0.990675	-0.997099	-0.982750	
4	-0.980817	-0.990482	-0.998321	-0.979672	

	tBodyAcc-mad()-Z	tBodyAcc-max()-X	...	\
0	-0.923527	-0.934724	...	
1	-0.957686	-0.943068	...	
2	-0.977469	-0.938692	...	
3	-0.989302	-0.938692	...	
4	-0.990441	-0.942469	...	

	fBodyBodyGyroJerkMag-kurtosis()	angle(tBodyAccMean,gravity)	\
0	-0.710304	-0.112754	
1	-0.861499	0.053477	
2	-0.760104	-0.118559	
3	-0.482845	-0.036788	
4	-0.699205	0.123320	

	angle(tBodyAccJerkMean),gravityMean)	angle(tBodyGyroMean,gravityMean)	\
0	0.030400	-0.464761	
1	-0.007435	-0.732626	
2	0.177899	0.100699	
3	-0.012892	0.640011	

```
4                                0.122542                          0.693578

   angle(tBodyGyroJerkMean,gravityMean)  angle(X,gravityMean)  \
0                             -0.018446             -0.841247
1                              0.703511             -0.844788
2                              0.808529             -0.848933
3                             -0.485366             -0.848649
4                             -0.615971             -0.847865

   angle(Y,gravityMean)  angle(Z,gravityMean)  subject  Activity
0              0.179941             -0.058627        1  STANDING
1              0.180289             -0.054317        1  STANDING
2              0.180637             -0.049118        1  STANDING
3              0.181935             -0.047663        1  STANDING
4              0.185151             -0.043892        1  STANDING

[5 rows x 563 columns]
```

In [9]:
```
corr = df1[df1.columns].corr()
corr
```

Out[9]:

	tBodyAcc-mean()-X	tBodyAcc-mean()-Y	\
tBodyAcc-mean()-X	1.000000	0.148061	
tBodyAcc-mean()-Y	0.148061	1.000000	
tBodyAcc-mean()-Z	-0.256952	-0.078769	
tBodyAcc-std()-X	0.000619	-0.045160	
tBodyAcc-std()-Y	-0.021903	-0.044920	
tBodyAcc-std()-Z	-0.044617	-0.049746	
tBodyAcc-mad()-X	0.006290	-0.044180	
tBodyAcc-mad()-Y	-0.022754	-0.045049	
tBodyAcc-mad()-Z	-0.047558	-0.050402	
tBodyAcc-max()-X	0.044062	-0.038108	
tBodyAcc-max()-Y	-0.007875	0.090189	
tBodyAcc-max()-Z	-0.075881	-0.057029	
tBodyAcc-min()-X	0.078354	0.058568	
tBodyAcc-min()-Y	0.021214	0.132042	
tBodyAcc-min()-Z	-0.003283	0.037539	
tBodyAcc-sma()	-0.029204	-0.046390	
tBodyAcc-energy()-X	0.016582	-0.030475	
tBodyAcc-energy()-Y	-0.040811	-0.061759	
tBodyAcc-energy()-Z	-0.085116	-0.061180	
tBodyAcc-iqr()-X	0.020762	-0.043231	
tBodyAcc-iqr()-Y	-0.024179	-0.046717	
tBodyAcc-iqr()-Z	-0.054570	-0.054820	
tBodyAcc-entropy()-X	0.148508	-0.003331	
tBodyAcc-entropy()-Y	0.006747	0.195152	
tBodyAcc-entropy()-Z	-0.084416	-0.023682	
tBodyAcc-arCoeff()-X,1	0.019447	0.033899	

tBodyAcc-arCoeff()-X,2	0.012241	-0.043617
tBodyAcc-arCoeff()-X,3	-0.041704	0.041133
tBodyAcc-arCoeff()-X,4	0.049486	-0.039958
tBodyAcc-arCoeff()-Y,1	0.023920	0.021360
...	...	...
fBodyBodyGyroMag-min()	0.002004	-0.015493
fBodyBodyGyroMag-sma()	-0.005990	-0.047916
fBodyBodyGyroMag-energy()	-0.012038	-0.046806
fBodyBodyGyroMag-iqr()	-0.003913	-0.052700
fBodyBodyGyroMag-entropy()	-0.017451	-0.042685
fBodyBodyGyroMag-maxInds	0.034239	0.002729
fBodyBodyGyroMag-meanFreq()	0.050053	0.004438
fBodyBodyGyroMag-skewness()	-0.017158	0.001864
fBodyBodyGyroMag-kurtosis()	-0.012325	0.000621
fBodyBodyGyroJerkMag-mean()	0.008362	-0.034307
fBodyBodyGyroJerkMag-std()	0.006094	-0.032599
fBodyBodyGyroJerkMag-mad()	0.006916	-0.033867
fBodyBodyGyroJerkMag-max()	0.006751	-0.030778
fBodyBodyGyroJerkMag-min()	0.007878	-0.030126
fBodyBodyGyroJerkMag-sma()	0.008362	-0.034307
fBodyBodyGyroJerkMag-energy()	0.017109	-0.018531
fBodyBodyGyroJerkMag-iqr()	0.011356	-0.037269
fBodyBodyGyroJerkMag-entropy()	-0.015953	-0.040870
fBodyBodyGyroJerkMag-maxInds	0.008751	-0.008536
fBodyBodyGyroJerkMag-meanFreq()	0.030681	-0.022395
fBodyBodyGyroJerkMag-skewness()	-0.017557	-0.001587
fBodyBodyGyroJerkMag-kurtosis()	-0.015613	-0.004459
angle(tBodyAccMean,gravity)	-0.544320	0.070559
angle(tBodyAccJerkMean),gravityMean)	0.012173	-0.013541
angle(tBodyGyroMean,gravityMean)	0.037444	0.017967
angle(tBodyGyroJerkMean,gravityMean)	0.028844	0.075679
angle(X,gravityMean)	-0.035257	-0.005309
angle(Y,gravityMean)	0.034371	0.001053
angle(Z,gravityMean)	0.028242	-0.013903
subject	0.024181	-0.003144

	tBodyAcc-mean()-Z	tBodyAcc-std()-X	\
tBodyAcc-mean()-X	-0.256952	0.000619	
tBodyAcc-mean()-Y	-0.078769	-0.045160	
tBodyAcc-mean()-Z	1.000000	-0.020217	
tBodyAcc-std()-X	-0.020217	1.000000	
tBodyAcc-std()-Y	-0.016641	0.927461	
tBodyAcc-std()-Z	-0.008410	0.851668	
tBodyAcc-mad()-X	-0.018747	0.998632	
tBodyAcc-mad()-Y	-0.015203	0.920888	
tBodyAcc-mad()-Z	-0.001988	0.846392	
tBodyAcc-max()-X	-0.037197	0.980844	
tBodyAcc-max()-Y	-0.027803	0.895217	

tBodyAcc-max()-Z	0.110455	0.844993
tBodyAcc-min()-X	0.006544	-0.966500
tBodyAcc-min()-Y	0.013678	-0.904539
tBodyAcc-min()-Z	0.119078	-0.828170
tBodyAcc-sma()	-0.008180	0.973155
tBodyAcc-energy()-X	-0.012748	0.948324
tBodyAcc-energy()-Y	-0.000758	0.828584
tBodyAcc-energy()-Z	0.024404	0.685223
tBodyAcc-iqr()-X	-0.016711	0.981220
tBodyAcc-iqr()-Y	-0.014024	0.892791
tBodyAcc-iqr()-Z	0.011974	0.824057
tBodyAcc-entropy()-X	-0.088150	0.789943
tBodyAcc-entropy()-Y	-0.006791	0.824226
tBodyAcc-entropy()-Z	0.293465	0.771745
tBodyAcc-arCoeff()-X,1	0.007290	-0.691916
tBodyAcc-arCoeff()-X,2	-0.005728	0.539342
tBodyAcc-arCoeff()-X,3	-0.002225	-0.351496
tBodyAcc-arCoeff()-X,4	-0.004501	0.326309
tBodyAcc-arCoeff()-Y,1	0.008761	-0.526660
...	...	...
fBodyBodyGyroMag-min()	-0.019347	0.583319
fBodyBodyGyroMag-sma()	-0.037371	0.880551
fBodyBodyGyroMag-energy()	-0.055971	0.715234
fBodyBodyGyroMag-iqr()	-0.034111	0.857843
fBodyBodyGyroMag-entropy()	-0.022350	0.889188
fBodyBodyGyroMag-maxInds	0.017991	0.326934
fBodyBodyGyroMag-meanFreq()	0.005830	0.208269
fBodyBodyGyroMag-skewness()	-0.019986	-0.246488
fBodyBodyGyroMag-kurtosis()	-0.022204	-0.244528
fBodyBodyGyroJerkMag-mean()	-0.028841	0.832774
fBodyBodyGyroJerkMag-std()	-0.024438	0.788650
fBodyBodyGyroJerkMag-mad()	-0.026039	0.806262
fBodyBodyGyroJerkMag-max()	-0.021565	0.760560
fBodyBodyGyroJerkMag-min()	-0.013753	0.692226
fBodyBodyGyroJerkMag-sma()	-0.028841	0.832774
fBodyBodyGyroJerkMag-energy()	-0.022744	0.556664
fBodyBodyGyroJerkMag-iqr()	-0.027220	0.819759
fBodyBodyGyroJerkMag-entropy()	-0.024494	0.907663
fBodyBodyGyroJerkMag-maxInds	-0.005461	0.110503
fBodyBodyGyroJerkMag-meanFreq()	-0.020481	-0.065987
fBodyBodyGyroJerkMag-skewness()	0.020091	0.148034
fBodyBodyGyroJerkMag-kurtosis()	0.019127	0.115565
angle(tBodyAccMean,gravity)	0.052841	-0.035011
angle(tBodyAccJerkMean),gravityMean)	-0.039836	-0.021633
angle(tBodyGyroMean,gravityMean)	-0.063609	0.018985
angle(tBodyGyroJerkMean,gravityMean)	-0.034037	-0.024810
angle(X,gravityMean)	0.008587	-0.371653
angle(Y,gravityMean)	-0.015288	0.471065

angle(Z,gravityMean)	-0.022643	0.394825
subject	-0.000637	-0.064345

	tBodyAcc-std()-Y	tBodyAcc-std()-Z	\
tBodyAcc-mean()-X	-0.021903	-0.044617	
tBodyAcc-mean()-Y	-0.044920	-0.049746	
tBodyAcc-mean()-Z	-0.016641	-0.008410	
tBodyAcc-std()-X	0.927461	0.851668	
tBodyAcc-std()-Y	1.000000	0.895510	
tBodyAcc-std()-Z	0.895510	1.000000	
tBodyAcc-mad()-X	0.922803	0.844469	
tBodyAcc-mad()-Y	0.997347	0.891441	
tBodyAcc-mad()-Z	0.894509	0.997418	
tBodyAcc-max()-X	0.917366	0.853884	
tBodyAcc-max()-Y	0.953573	0.866820	
tBodyAcc-max()-Z	0.884490	0.937802	
tBodyAcc-min()-X	-0.937918	-0.860691	
tBodyAcc-min()-Y	-0.957736	-0.853346	
tBodyAcc-min()-Z	-0.838818	-0.939072	
tBodyAcc-sma()	0.971500	0.928042	
tBodyAcc-energy()-X	0.806380	0.712938	
tBodyAcc-energy()-Y	0.922659	0.792105	
tBodyAcc-energy()-Z	0.737765	0.926496	
tBodyAcc-iqr()-X	0.905882	0.820715	
tBodyAcc-iqr()-Y	0.973206	0.870539	
tBodyAcc-iqr()-Z	0.880695	0.969033	
tBodyAcc-entropy()-X	0.845322	0.798024	
tBodyAcc-entropy()-Y	0.878742	0.808811	
tBodyAcc-entropy()-Z	0.803019	0.812531	
tBodyAcc-arCoeff()-X,1	-0.725729	-0.692578	
tBodyAcc-arCoeff()-X,2	0.586190	0.549356	
tBodyAcc-arCoeff()-X,3	-0.351732	-0.311226	
tBodyAcc-arCoeff()-X,4	0.262917	0.225030	
tBodyAcc-arCoeff()-Y,1	-0.604030	-0.558662	
...	...	...	
fBodyBodyGyroMag-min()	0.591406	0.608322	
fBodyBodyGyroMag-sma()	0.913172	0.904425	
fBodyBodyGyroMag-energy()	0.753055	0.788041	
fBodyBodyGyroMag-iqr()	0.900684	0.876575	
fBodyBodyGyroMag-entropy()	0.930074	0.892139	
fBodyBodyGyroMag-maxInds	0.349507	0.306643	
fBodyBodyGyroMag-meanFreq()	0.173938	0.153879	
fBodyBodyGyroMag-skewness()	-0.222345	-0.170854	
fBodyBodyGyroMag-kurtosis()	-0.223777	-0.173792	
fBodyBodyGyroJerkMag-mean()	0.848042	0.845062	
fBodyBodyGyroJerkMag-std()	0.810266	0.807140	
fBodyBodyGyroJerkMag-mad()	0.824312	0.826947	
fBodyBodyGyroJerkMag-max()	0.789438	0.776082	

fBodyBodyGyroJerkMag-min()	0.695171	0.688876
fBodyBodyGyroJerkMag-sma()	0.848042	0.845062
fBodyBodyGyroJerkMag-energy()	0.561602	0.607198
fBodyBodyGyroJerkMag-iqr()	0.839970	0.841904
fBodyBodyGyroJerkMag-entropy()	0.941676	0.907742
fBodyBodyGyroJerkMag-maxInds	0.085848	0.084596
fBodyBodyGyroJerkMag-meanFreq()	-0.105621	-0.097978
fBodyBodyGyroJerkMag-skewness()	0.206227	0.157792
fBodyBodyGyroJerkMag-kurtosis()	0.176946	0.126701
angle(tBodyAccMean,gravity)	-0.020379	-0.006769
angle(tBodyAccJerkMean),gravityMean)	-0.012505	-0.020036
angle(tBodyGyroMean,gravityMean)	-0.008507	-0.018429
angle(tBodyGyroJerkMean,gravityMean)	-0.014592	-0.006471
angle(X,gravityMean)	-0.380531	-0.345011
angle(Y,gravityMean)	0.523600	0.476006
angle(Z,gravityMean)	0.433169	0.482828
subject	-0.115524	-0.050123

	tBodyAcc-mad()-X	tBodyAcc-mad()-Y	\
tBodyAcc-mean()-X	0.006290	-0.022754	
tBodyAcc-mean()-Y	-0.044180	-0.045049	
tBodyAcc-mean()-Z	-0.018747	-0.015203	
tBodyAcc-std()-X	0.998632	0.920888	
tBodyAcc-std()-Y	0.922803	0.997347	
tBodyAcc-std()-Z	0.844469	0.891441	
tBodyAcc-mad()-X	1.000000	0.916106	
tBodyAcc-mad()-Y	0.916106	1.000000	
tBodyAcc-mad()-Z	0.839267	0.891178	
tBodyAcc-max()-X	0.973216	0.910411	
tBodyAcc-max()-Y	0.889934	0.949550	
tBodyAcc-max()-Z	0.838920	0.879898	
tBodyAcc-min()-X	-0.962235	-0.933135	
tBodyAcc-min()-Y	-0.900336	-0.941377	
tBodyAcc-min()-Z	-0.821987	-0.830013	
tBodyAcc-sma()	0.970683	0.968444	
tBodyAcc-energy()-X	0.952774	0.797458	
tBodyAcc-energy()-Y	0.826500	0.920711	
tBodyAcc-energy()-Z	0.677877	0.732843	
tBodyAcc-iqr()-X	0.988774	0.899840	
tBodyAcc-iqr()-Y	0.887641	0.985779	
tBodyAcc-iqr()-Z	0.817624	0.879191	
tBodyAcc-entropy()-X	0.786504	0.845644	
tBodyAcc-entropy()-Y	0.819094	0.875782	
tBodyAcc-entropy()-Z	0.767210	0.799785	
tBodyAcc-arCoeff()-X,1	-0.686394	-0.726102	
tBodyAcc-arCoeff()-X,2	0.533584	0.585651	
tBodyAcc-arCoeff()-X,3	-0.351745	-0.350046	
tBodyAcc-arCoeff()-X,4	0.330057	0.259325	

tBodyAcc-arCoeff()-Y,1	-0.520063	-0.608932
...	...	...
fBodyBodyGyroMag-min()	0.578915	0.581332
fBodyBodyGyroMag-sma()	0.872924	0.903835
fBodyBodyGyroMag-energy()	0.707377	0.744645
fBodyBodyGyroMag-iqr()	0.850380	0.890635
fBodyBodyGyroMag-entropy()	0.882374	0.924919
fBodyBodyGyroMag-maxInds	0.327483	0.351200
fBodyBodyGyroMag-meanFreq()	0.211800	0.164406
fBodyBodyGyroMag-skewness()	-0.246336	-0.216630
fBodyBodyGyroMag-kurtosis()	-0.244121	-0.219116
fBodyBodyGyroJerkMag-mean()	0.827020	0.834307
fBodyBodyGyroJerkMag-std()	0.783964	0.794102
fBodyBodyGyroJerkMag-mad()	0.800696	0.808738
fBodyBodyGyroJerkMag-max()	0.757086	0.773988
fBodyBodyGyroJerkMag-min()	0.688261	0.684543
fBodyBodyGyroJerkMag-sma()	0.827020	0.834307
fBodyBodyGyroJerkMag-energy()	0.553443	0.543024
fBodyBodyGyroJerkMag-iqr()	0.813578	0.826472
fBodyBodyGyroJerkMag-entropy()	0.900842	0.935176
fBodyBodyGyroJerkMag-maxInds	0.110421	0.086578
fBodyBodyGyroJerkMag-meanFreq()	-0.059972	-0.102908
fBodyBodyGyroJerkMag-skewness()	0.149257	0.200890
fBodyBodyGyroJerkMag-kurtosis()	0.117804	0.172809
angle(tBodyAccMean,gravity)	-0.042713	-0.023722
angle(tBodyAccJerkMean),gravityMean)	-0.021537	-0.012310
angle(tBodyGyroMean,gravityMean)	0.019389	-0.012546
angle(tBodyGyroJerkMean,gravityMean)	-0.024951	-0.012341
angle(X,gravityMean)	-0.368191	-0.377025
angle(Y,gravityMean)	0.466424	0.525081
angle(Z,gravityMean)	0.390922	0.431459
subject	-0.063440	-0.114753

	tBodyAcc-mad()-Z	tBodyAcc-max()-X	\
tBodyAcc-mean()-X	-0.047558	0.044062	
tBodyAcc-mean()-Y	-0.050402	-0.038108	
tBodyAcc-mean()-Z	-0.001988	-0.037197	
tBodyAcc-std()-X	0.846392	0.980844	
tBodyAcc-std()-Y	0.894509	0.917366	
tBodyAcc-std()-Z	0.997418	0.853884	
tBodyAcc-mad()-X	0.839267	0.973216	
tBodyAcc-mad()-Y	0.891178	0.910411	
tBodyAcc-mad()-Z	1.000000	0.847870	
tBodyAcc-max()-X	0.847870	1.000000	
tBodyAcc-max()-Y	0.865312	0.885533	
tBodyAcc-max()-Z	0.931937	0.839990	
tBodyAcc-min()-X	-0.856964	-0.941451	
tBodyAcc-min()-Y	-0.848485	-0.898652	

tBodyAcc-min()-Z	-0.921870	-0.837620
tBodyAcc-sma()	0.926489	0.956887
tBodyAcc-energy()-X	0.702695	0.911337
tBodyAcc-energy()-Y	0.789715	0.808401
tBodyAcc-energy()-Z	0.919672	0.688850
tBodyAcc-iqr()-X	0.816073	0.940769
tBodyAcc-iqr()-Y	0.871101	0.882976
tBodyAcc-iqr()-Z	0.982451	0.823211
tBodyAcc-entropy()-X	0.802152	0.782189
tBodyAcc-entropy()-Y	0.811557	0.822608
tBodyAcc-entropy()-Z	0.813208	0.769402
tBodyAcc-arCoeff()-X,1	-0.700562	-0.686009
tBodyAcc-arCoeff()-X,2	0.556128	0.544331
tBodyAcc-arCoeff()-X,3	-0.314395	-0.347732
tBodyAcc-arCoeff()-X,4	0.221019	0.312502
tBodyAcc-arCoeff()-Y,1	-0.566710	-0.523589
...	...	...
fBodyBodyGyroMag-min()	0.600431	0.587362
fBodyBodyGyroMag-sma()	0.896598	0.886391
fBodyBodyGyroMag-energy()	0.779122	0.724494
fBodyBodyGyroMag-iqr()	0.869030	0.862943
fBodyBodyGyroMag-entropy()	0.891104	0.890202
fBodyBodyGyroMag-maxInds	0.305967	0.330693
fBodyBodyGyroMag-meanFreq()	0.141606	0.209024
fBodyBodyGyroMag-skewness()	-0.163409	-0.242664
fBodyBodyGyroMag-kurtosis()	-0.167514	-0.240810
fBodyBodyGyroJerkMag-mean()	0.832605	0.839037
fBodyBodyGyroJerkMag-std()	0.795280	0.797571
fBodyBodyGyroJerkMag-mad()	0.814749	0.814786
fBodyBodyGyroJerkMag-max()	0.765128	0.769854
fBodyBodyGyroJerkMag-min()	0.677777	0.694370
fBodyBodyGyroJerkMag-sma()	0.832605	0.839037
fBodyBodyGyroJerkMag-energy()	0.590332	0.564026
fBodyBodyGyroJerkMag-iqr()	0.830244	0.826750
fBodyBodyGyroJerkMag-entropy()	0.904920	0.909701
fBodyBodyGyroJerkMag-maxInds	0.084881	0.107148
fBodyBodyGyroJerkMag-meanFreq()	-0.101864	-0.076599
fBodyBodyGyroJerkMag-skewness()	0.157937	0.154220
fBodyBodyGyroJerkMag-kurtosis()	0.127359	0.120023
angle(tBodyAccMean,gravity)	-0.008768	-0.033048
angle(tBodyAccJerkMean),gravityMean)	-0.020508	-0.021895
angle(tBodyGyroMean,gravityMean)	-0.023525	0.025066
angle(tBodyGyroJerkMean,gravityMean)	-0.007231	-0.028871
angle(X,gravityMean)	-0.347389	-0.384192
angle(Y,gravityMean)	0.477607	0.480229
angle(Z,gravityMean)	0.479751	0.405023
subject	-0.055457	-0.055633

```
                                        ...     \
tBodyAcc-mean()-X                       ...
tBodyAcc-mean()-Y                       ...
tBodyAcc-mean()-Z                       ...
tBodyAcc-std()-X                        ...
tBodyAcc-std()-Y                        ...
tBodyAcc-std()-Z                        ...
tBodyAcc-mad()-X                        ...
tBodyAcc-mad()-Y                        ...
tBodyAcc-mad()-Z                        ...
tBodyAcc-max()-X                        ...
tBodyAcc-max()-Y                        ...
tBodyAcc-max()-Z                        ...
tBodyAcc-min()-X                        ...
tBodyAcc-min()-Y                        ...
tBodyAcc-min()-Z                        ...
tBodyAcc-sma()                          ...
tBodyAcc-energy()-X                     ...
tBodyAcc-energy()-Y                     ...
tBodyAcc-energy()-Z                     ...
tBodyAcc-iqr()-X                        ...
tBodyAcc-iqr()-Y                        ...
tBodyAcc-iqr()-Z                        ...
tBodyAcc-entropy()-X                    ...
tBodyAcc-entropy()-Y                    ...
tBodyAcc-entropy()-Z                    ...
tBodyAcc-arCoeff()-X,1                  ...
tBodyAcc-arCoeff()-X,2                  ...
tBodyAcc-arCoeff()-X,3                  ...
tBodyAcc-arCoeff()-X,4                  ...
tBodyAcc-arCoeff()-Y,1                  ...
...                                     ...
fBodyBodyGyroMag-min()                  ...
fBodyBodyGyroMag-sma()                  ...
fBodyBodyGyroMag-energy()               ...
fBodyBodyGyroMag-iqr()                  ...
fBodyBodyGyroMag-entropy()              ...
fBodyBodyGyroMag-maxInds                ...
fBodyBodyGyroMag-meanFreq()             ...
fBodyBodyGyroMag-skewness()             ...
fBodyBodyGyroMag-kurtosis()             ...
fBodyBodyGyroJerkMag-mean()             ...
fBodyBodyGyroJerkMag-std()              ...
fBodyBodyGyroJerkMag-mad()              ...
fBodyBodyGyroJerkMag-max()              ...
fBodyBodyGyroJerkMag-min()              ...
fBodyBodyGyroJerkMag-sma()              ...
fBodyBodyGyroJerkMag-energy()           ...
```

```
fBodyBodyGyroJerkMag-iqr()              ...
fBodyBodyGyroJerkMag-entropy()          ...
fBodyBodyGyroJerkMag-maxInds            ...
fBodyBodyGyroJerkMag-meanFreq()         ...
fBodyBodyGyroJerkMag-skewness()         ...
fBodyBodyGyroJerkMag-kurtosis()         ...
angle(tBodyAccMean,gravity)             ...
angle(tBodyAccJerkMean),gravityMean)    ...
angle(tBodyGyroMean,gravityMean)        ...
angle(tBodyGyroJerkMean,gravityMean)    ...
angle(X,gravityMean)                    ...
angle(Y,gravityMean)                    ...
angle(Z,gravityMean)                    ...
subject                                 ...

                                      fBodyBodyGyroJerkMag-skewness()  \
tBodyAcc-mean()-X                                           -0.017557
tBodyAcc-mean()-Y                                           -0.001587
tBodyAcc-mean()-Z                                            0.020091
tBodyAcc-std()-X                                             0.148034
tBodyAcc-std()-Y                                             0.206227
tBodyAcc-std()-Z                                             0.157792
tBodyAcc-mad()-X                                             0.149257
tBodyAcc-mad()-Y                                             0.200890
tBodyAcc-mad()-Z                                             0.157937
tBodyAcc-max()-X                                             0.154220
tBodyAcc-max()-Y                                             0.194701
tBodyAcc-max()-Z                                             0.161063
tBodyAcc-min()-X                                            -0.166157
tBodyAcc-min()-Y                                            -0.207130
tBodyAcc-min()-Z                                            -0.160016
tBodyAcc-sma()                                               0.169745
tBodyAcc-energy()-X                                          0.084176
tBodyAcc-energy()-Y                                          0.142539
tBodyAcc-energy()-Z                                          0.066382
tBodyAcc-iqr()-X                                             0.151624
tBodyAcc-iqr()-Y                                             0.182534
tBodyAcc-iqr()-Z                                             0.160759
tBodyAcc-entropy()-X                                         0.277360
tBodyAcc-entropy()-Y                                         0.285445
tBodyAcc-entropy()-Z                                         0.259551
tBodyAcc-arCoeff()-X,1                                      -0.246099
tBodyAcc-arCoeff()-X,2                                       0.241974
tBodyAcc-arCoeff()-X,3                                      -0.094182
tBodyAcc-arCoeff()-X,4                                      -0.056280
tBodyAcc-arCoeff()-Y,1                                      -0.274384
...                                                               ...
fBodyBodyGyroMag-min()                                       0.153756
```

fBodyBodyGyroMag-sma()	0.177364
fBodyBodyGyroMag-energy()	0.067323
fBodyBodyGyroMag-iqr()	0.166997
fBodyBodyGyroMag-entropy()	0.303512
fBodyBodyGyroMag-maxInds	0.076718
fBodyBodyGyroMag-meanFreq()	0.040586
fBodyBodyGyroMag-skewness()	0.062280
fBodyBodyGyroMag-kurtosis()	0.056261
fBodyBodyGyroJerkMag-mean()	0.198254
fBodyBodyGyroJerkMag-std()	0.282325
fBodyBodyGyroJerkMag-mad()	0.213850
fBodyBodyGyroJerkMag-max()	0.370449
fBodyBodyGyroJerkMag-min()	0.170983
fBodyBodyGyroJerkMag-sma()	0.198254
fBodyBodyGyroJerkMag-energy()	0.155783
fBodyBodyGyroJerkMag-iqr()	0.158900
fBodyBodyGyroJerkMag-entropy()	0.281598
fBodyBodyGyroJerkMag-maxInds	-0.285968
fBodyBodyGyroJerkMag-meanFreq()	-0.403967
fBodyBodyGyroJerkMag-skewness()	1.000000
fBodyBodyGyroJerkMag-kurtosis()	0.967322
angle(tBodyAccMean,gravity)	0.008940
angle(tBodyAccJerkMean),gravityMean)	-0.007344
angle(tBodyGyroMean,gravityMean)	0.034514
angle(tBodyGyroJerkMean,gravityMean)	-0.017937
angle(X,gravityMean)	-0.086006
angle(Y,gravityMean)	0.086993
angle(Z,gravityMean)	0.057831
subject	-0.049072

	fBodyBodyGyroJerkMag-kurtosis() \
tBodyAcc-mean()-X	-0.015613
tBodyAcc-mean()-Y	-0.004459
tBodyAcc-mean()-Z	0.019127
tBodyAcc-std()-X	0.115565
tBodyAcc-std()-Y	0.176946
tBodyAcc-std()-Z	0.126701
tBodyAcc-mad()-X	0.117804
tBodyAcc-mad()-Y	0.172809
tBodyAcc-mad()-Z	0.127359
tBodyAcc-max()-X	0.120023
tBodyAcc-max()-Y	0.163373
tBodyAcc-max()-Z	0.126735
tBodyAcc-min()-X	-0.133136
tBodyAcc-min()-Y	-0.176075
tBodyAcc-min()-Z	-0.128191
tBodyAcc-sma()	0.138071
tBodyAcc-energy()-X	0.056073

```
tBodyAcc-energy()-Y                                  0.122090
tBodyAcc-energy()-Z                                  0.042874
tBodyAcc-iqr()-X                                     0.123228
tBodyAcc-iqr()-Y                                     0.156302
tBodyAcc-iqr()-Z                                     0.131903
tBodyAcc-entropy()-X                                 0.238104
tBodyAcc-entropy()-Y                                 0.243020
tBodyAcc-entropy()-Z                                 0.218408
tBodyAcc-arCoeff()-X,1                              -0.204883
tBodyAcc-arCoeff()-X,2                               0.207402
tBodyAcc-arCoeff()-X,3                              -0.074900
tBodyAcc-arCoeff()-X,4                              -0.058820
tBodyAcc-arCoeff()-Y,1                              -0.230109
...                                                       ...
fBodyBodyGyroMag-min()                               0.120787
fBodyBodyGyroMag-sma()                               0.137778
fBodyBodyGyroMag-energy()                            0.036723
fBodyBodyGyroMag-iqr()                               0.130970
fBodyBodyGyroMag-entropy()                           0.249709
fBodyBodyGyroMag-maxInds                             0.084938
fBodyBodyGyroMag-meanFreq()                          0.054012
fBodyBodyGyroMag-skewness()                          0.065545
fBodyBodyGyroMag-kurtosis()                          0.064070
fBodyBodyGyroJerkMag-mean()                          0.156522
fBodyBodyGyroJerkMag-std()                           0.237163
fBodyBodyGyroJerkMag-mad()                           0.165215
fBodyBodyGyroJerkMag-max()                           0.340411
fBodyBodyGyroJerkMag-min()                           0.136574
fBodyBodyGyroJerkMag-sma()                           0.156522
fBodyBodyGyroJerkMag-energy()                        0.117151
fBodyBodyGyroJerkMag-iqr()                           0.121840
fBodyBodyGyroJerkMag-entropy()                       0.229115
fBodyBodyGyroJerkMag-maxInds                        -0.225041
fBodyBodyGyroJerkMag-meanFreq()                     -0.269189
fBodyBodyGyroJerkMag-skewness()                      0.967322
fBodyBodyGyroJerkMag-kurtosis()                      1.000000
angle(tBodyAccMean,gravity)                          0.009738
angle(tBodyAccJerkMean),gravityMean)                -0.011499
angle(tBodyGyroMean,gravityMean)                     0.024553
angle(tBodyGyroJerkMean,gravityMean)                -0.014865
angle(X,gravityMean)                                -0.079751
angle(Y,gravityMean)                                 0.078079
angle(Z,gravityMean)                                 0.052548
subject                                             -0.043902

                                     angle(tBodyAccMean,gravity)  \
tBodyAcc-mean()-X                                      -0.544320
tBodyAcc-mean()-Y                                       0.070559
```

tBodyAcc-mean()-Z	0.052841
tBodyAcc-std()-X	-0.035011
tBodyAcc-std()-Y	-0.020379
tBodyAcc-std()-Z	-0.006769
tBodyAcc-mad()-X	-0.042713
tBodyAcc-mad()-Y	-0.023722
tBodyAcc-mad()-Z	-0.008768
tBodyAcc-max()-X	-0.033048
tBodyAcc-max()-Y	-0.014925
tBodyAcc-max()-Z	0.006758
tBodyAcc-min()-X	0.011599
tBodyAcc-min()-Y	0.014729
tBodyAcc-min()-Z	0.012315
tBodyAcc-sma()	-0.022561
tBodyAcc-energy()-X	-0.055305
tBodyAcc-energy()-Y	-0.025741
tBodyAcc-energy()-Z	-0.006042
tBodyAcc-iqr()-X	-0.064654
tBodyAcc-iqr()-Y	-0.030962
tBodyAcc-iqr()-Z	-0.010121
tBodyAcc-entropy()-X	-0.074203
tBodyAcc-entropy()-Y	0.011542
tBodyAcc-entropy()-Z	-0.003438
tBodyAcc-arCoeff()-X,1	0.010001
tBodyAcc-arCoeff()-X,2	-0.026900
tBodyAcc-arCoeff()-X,3	0.046956
tBodyAcc-arCoeff()-X,4	-0.037966
tBodyAcc-arCoeff()-Y,1	0.006353
...	...
fBodyBodyGyroMag-min()	-0.008090
fBodyBodyGyroMag-sma()	-0.017941
fBodyBodyGyroMag-energy()	-0.009465
fBodyBodyGyroMag-iqr()	-0.019889
fBodyBodyGyroMag-entropy()	-0.011314
fBodyBodyGyroMag-maxInds	-0.021877
fBodyBodyGyroMag-meanFreq()	-0.038451
fBodyBodyGyroMag-skewness()	0.037233
fBodyBodyGyroMag-kurtosis()	0.034768
fBodyBodyGyroJerkMag-mean()	-0.027926
fBodyBodyGyroJerkMag-std()	-0.028105
fBodyBodyGyroJerkMag-mad()	-0.028560
fBodyBodyGyroJerkMag-max()	-0.027401
fBodyBodyGyroJerkMag-min()	-0.024983
fBodyBodyGyroJerkMag-sma()	-0.027926
fBodyBodyGyroJerkMag-energy()	-0.034346
fBodyBodyGyroJerkMag-iqr()	-0.031830
fBodyBodyGyroJerkMag-entropy()	-0.011659
fBodyBodyGyroJerkMag-maxInds	-0.001029

fBodyBodyGyroJerkMag-meanFreq()	-0.012811
fBodyBodyGyroJerkMag-skewness()	0.008940
fBodyBodyGyroJerkMag-kurtosis()	0.009738
angle(tBodyAccMean,gravity)	1.000000
angle(tBodyAccJerkMean),gravityMean)	-0.077318
angle(tBodyGyroMean,gravityMean)	-0.006269
angle(tBodyGyroJerkMean,gravityMean)	-0.020823
angle(X,gravityMean)	0.011880
angle(Y,gravityMean)	0.001540
angle(Z,gravityMean)	-0.003069
subject	-0.005087

	angle(tBodyAccJerkMean),gravityMean) \
tBodyAcc-mean()-X	0.012173
tBodyAcc-mean()-Y	-0.013541
tBodyAcc-mean()-Z	-0.039836
tBodyAcc-std()-X	-0.021633
tBodyAcc-std()-Y	-0.012505
tBodyAcc-std()-Z	-0.020036
tBodyAcc-mad()-X	-0.021537
tBodyAcc-mad()-Y	-0.012310
tBodyAcc-mad()-Z	-0.020508
tBodyAcc-max()-X	-0.021895
tBodyAcc-max()-Y	-0.007158
tBodyAcc-max()-Z	-0.022020
tBodyAcc-min()-X	0.023030
tBodyAcc-min()-Y	0.014424
tBodyAcc-min()-Z	0.020518
tBodyAcc-sma()	-0.014693
tBodyAcc-energy()-X	-0.019629
tBodyAcc-energy()-Y	0.007120
tBodyAcc-energy()-Z	-0.014376
tBodyAcc-iqr()-X	-0.022188
tBodyAcc-iqr()-Y	-0.010626
tBodyAcc-iqr()-Z	-0.023888
tBodyAcc-entropy()-X	-0.011340
tBodyAcc-entropy()-Y	-0.016408
tBodyAcc-entropy()-Z	-0.024112
tBodyAcc-arCoeff()-X,1	0.001261
tBodyAcc-arCoeff()-X,2	0.001448
tBodyAcc-arCoeff()-X,3	-0.008412
tBodyAcc-arCoeff()-X,4	0.003179
tBodyAcc-arCoeff()-Y,1	0.004074
...	...
fBodyBodyGyroMag-min()	-0.013200
fBodyBodyGyroMag-sma()	-0.020580
fBodyBodyGyroMag-energy()	-0.017899
fBodyBodyGyroMag-iqr()	-0.018232

fBodyBodyGyroMag-entropy()	-0.015277
fBodyBodyGyroMag-maxInds	-0.009348
fBodyBodyGyroMag-meanFreq()	-0.021716
fBodyBodyGyroMag-skewness()	0.021007
fBodyBodyGyroMag-kurtosis()	0.020924
fBodyBodyGyroJerkMag-mean()	-0.024792
fBodyBodyGyroJerkMag-std()	-0.025102
fBodyBodyGyroJerkMag-mad()	-0.024116
fBodyBodyGyroJerkMag-max()	-0.027143
fBodyBodyGyroJerkMag-min()	-0.000510
fBodyBodyGyroJerkMag-sma()	-0.024792
fBodyBodyGyroJerkMag-energy()	-0.024952
fBodyBodyGyroJerkMag-iqr()	-0.024097
fBodyBodyGyroJerkMag-entropy()	-0.020435
fBodyBodyGyroJerkMag-maxInds	-0.020643
fBodyBodyGyroJerkMag-meanFreq()	-0.012493
fBodyBodyGyroJerkMag-skewness()	-0.007344
fBodyBodyGyroJerkMag-kurtosis()	-0.011499
angle(tBodyAccMean,gravity)	-0.077318
angle(tBodyAccJerkMean),gravityMean)	1.000000
angle(tBodyGyroMean,gravityMean)	0.009141
angle(tBodyGyroJerkMean,gravityMean)	0.035263
angle(X,gravityMean)	0.023246
angle(Y,gravityMean)	-0.012990
angle(Z,gravityMean)	-0.017520
subject	0.012510

	angle(tBodyGyroMean,gravityMean) \
tBodyAcc-mean()-X	0.037444
tBodyAcc-mean()-Y	0.017967
tBodyAcc-mean()-Z	-0.063609
tBodyAcc-std()-X	0.018985
tBodyAcc-std()-Y	-0.008507
tBodyAcc-std()-Z	-0.018429
tBodyAcc-mad()-X	0.019389
tBodyAcc-mad()-Y	-0.012546
tBodyAcc-mad()-Z	-0.023525
tBodyAcc-max()-X	0.025066
tBodyAcc-max()-Y	-0.007806
tBodyAcc-max()-Z	-0.028210
tBodyAcc-min()-X	-0.002334
tBodyAcc-min()-Y	-0.010098
tBodyAcc-min()-Z	-0.022894
tBodyAcc-sma()	-0.001252
tBodyAcc-energy()-X	0.038898
tBodyAcc-energy()-Y	-0.010330
tBodyAcc-energy()-Z	-0.023726
tBodyAcc-iqr()-X	0.015409

```
tBodyAcc-iqr()-Y                                  -0.019400
tBodyAcc-iqr()-Z                                  -0.028276
tBodyAcc-entropy()-X                              -0.020965
tBodyAcc-entropy()-Y                               0.006699
tBodyAcc-entropy()-Z                              -0.020580
tBodyAcc-arCoeff()-X,1                             0.013850
tBodyAcc-arCoeff()-X,2                            -0.017072
tBodyAcc-arCoeff()-X,3                             0.010346
tBodyAcc-arCoeff()-X,4                             0.000182
tBodyAcc-arCoeff()-Y,1                             0.023494
...                                                     ...
fBodyBodyGyroMag-min()                             0.033373
fBodyBodyGyroMag-sma()                             0.014801
fBodyBodyGyroMag-energy()                          0.014147
fBodyBodyGyroMag-iqr()                             0.006455
fBodyBodyGyroMag-entropy()                         0.002584
fBodyBodyGyroMag-maxInds                          -0.029205
fBodyBodyGyroMag-meanFreq()                        0.029915
fBodyBodyGyroMag-skewness()                        0.020762
fBodyBodyGyroMag-kurtosis()                        0.027187
fBodyBodyGyroJerkMag-mean()                        0.032075
fBodyBodyGyroJerkMag-std()                         0.039071
fBodyBodyGyroJerkMag-mad()                         0.035937
fBodyBodyGyroJerkMag-max()                         0.039419
fBodyBodyGyroJerkMag-min()                         0.019790
fBodyBodyGyroJerkMag-sma()                         0.032075
fBodyBodyGyroJerkMag-energy()                      0.051252
fBodyBodyGyroJerkMag-iqr()                         0.024179
fBodyBodyGyroJerkMag-entropy()                     0.006060
fBodyBodyGyroJerkMag-maxInds                      -0.010464
fBodyBodyGyroJerkMag-meanFreq()                   -0.026615
fBodyBodyGyroJerkMag-skewness()                    0.034514
fBodyBodyGyroJerkMag-kurtosis()                    0.024553
angle(tBodyAccMean,gravity)                       -0.006269
angle(tBodyAccJerkMean),gravityMean)               0.009141
angle(tBodyGyroMean,gravityMean)                   1.000000
angle(tBodyGyroJerkMean,gravityMean)              -0.116001
angle(X,gravityMean)                              -0.005853
angle(Y,gravityMean)                              -0.012313
angle(Z,gravityMean)                              -0.019903
subject                                           -0.005314

                                  angle(tBodyGyroJerkMean,gravityMean)  \
tBodyAcc-mean()-X                                             0.028844
tBodyAcc-mean()-Y                                             0.075679
tBodyAcc-mean()-Z                                            -0.034037
tBodyAcc-std()-X                                             -0.024810
tBodyAcc-std()-Y                                             -0.014592
```

tBodyAcc-std()-Z	-0.006471
tBodyAcc-mad()-X	-0.024951
tBodyAcc-mad()-Y	-0.012341
tBodyAcc-mad()-Z	-0.007231
tBodyAcc-max()-X	-0.028871
tBodyAcc-max()-Y	-0.000297
tBodyAcc-max()-Z	-0.001207
tBodyAcc-min()-X	0.017876
tBodyAcc-min()-Y	0.030691
tBodyAcc-min()-Z	0.023655
tBodyAcc-sma()	-0.017063
tBodyAcc-energy()-X	-0.035055
tBodyAcc-energy()-Y	-0.018273
tBodyAcc-energy()-Z	-0.004978
tBodyAcc-iqr()-X	-0.023794
tBodyAcc-iqr()-Y	-0.007427
tBodyAcc-iqr()-Z	-0.014460
tBodyAcc-entropy()-X	0.008744
tBodyAcc-entropy()-Y	-0.002266
tBodyAcc-entropy()-Z	-0.017999
tBodyAcc-arCoeff()-X,1	-0.005259
tBodyAcc-arCoeff()-X,2	-0.000868
tBodyAcc-arCoeff()-X,3	0.004592
tBodyAcc-arCoeff()-X,4	-0.006466
tBodyAcc-arCoeff()-Y,1	-0.008647
...	...
fBodyBodyGyroMag-min()	-0.017281
fBodyBodyGyroMag-sma()	-0.020783
fBodyBodyGyroMag-energy()	-0.014116
fBodyBodyGyroMag-iqr()	-0.018858
fBodyBodyGyroMag-entropy()	-0.010280
fBodyBodyGyroMag-maxInds	-0.013065
fBodyBodyGyroMag-meanFreq()	-0.030216
fBodyBodyGyroMag-skewness()	0.009041
fBodyBodyGyroMag-kurtosis()	0.006010
fBodyBodyGyroJerkMag-mean()	-0.032498
fBodyBodyGyroJerkMag-std()	-0.037467
fBodyBodyGyroJerkMag-mad()	-0.035165
fBodyBodyGyroJerkMag-max()	-0.037756
fBodyBodyGyroJerkMag-min()	-0.027902
fBodyBodyGyroJerkMag-sma()	-0.032498
fBodyBodyGyroJerkMag-energy()	-0.040234
fBodyBodyGyroJerkMag-iqr()	-0.032039
fBodyBodyGyroJerkMag-entropy()	-0.013140
fBodyBodyGyroJerkMag-maxInds	-0.001908
fBodyBodyGyroJerkMag-meanFreq()	0.000102
fBodyBodyGyroJerkMag-skewness()	-0.017937
fBodyBodyGyroJerkMag-kurtosis()	-0.014865

```
angle(tBodyAccMean,gravity)                                -0.020823
angle(tBodyAccJerkMean),gravityMean)                        0.035263
angle(tBodyGyroMean,gravityMean)                           -0.116001
angle(tBodyGyroJerkMean,gravityMean)                        1.000000
angle(X,gravityMean)                                        0.023995
angle(Y,gravityMean)                                       -0.005869
angle(Z,gravityMean)                                       -0.005656
subject                                                     0.009340
```

	angle(X,gravityMean) \
tBodyAcc-mean()-X	-0.035257
tBodyAcc-mean()-Y	-0.005309
tBodyAcc-mean()-Z	0.008587
tBodyAcc-std()-X	-0.371653
tBodyAcc-std()-Y	-0.380531
tBodyAcc-std()-Z	-0.345011
tBodyAcc-mad()-X	-0.368191
tBodyAcc-mad()-Y	-0.377025
tBodyAcc-mad()-Z	-0.347389
tBodyAcc-max()-X	-0.384192
tBodyAcc-max()-Y	-0.372172
tBodyAcc-max()-Z	-0.346824
tBodyAcc-min()-X	0.362847
tBodyAcc-min()-Y	0.367873
tBodyAcc-min()-Z	0.322009
tBodyAcc-sma()	-0.369237
tBodyAcc-energy()-X	-0.328143
tBodyAcc-energy()-Y	-0.278821
tBodyAcc-energy()-Z	-0.231070
tBodyAcc-iqr()-X	-0.356899
tBodyAcc-iqr()-Y	-0.362021
tBodyAcc-iqr()-Z	-0.348926
tBodyAcc-entropy()-X	-0.219338
tBodyAcc-entropy()-Y	-0.412082
tBodyAcc-entropy()-Z	-0.363931
tBodyAcc-arCoeff()-X,1	0.127210
tBodyAcc-arCoeff()-X,2	-0.198142
tBodyAcc-arCoeff()-X,3	0.054136
tBodyAcc-arCoeff()-X,4	-0.133529
tBodyAcc-arCoeff()-Y,1	0.365153
...	...
fBodyBodyGyroMag-min()	-0.219413
fBodyBodyGyroMag-sma()	-0.355797
fBodyBodyGyroMag-energy()	-0.271573
fBodyBodyGyroMag-iqr()	-0.349244
fBodyBodyGyroMag-entropy()	-0.382903
fBodyBodyGyroMag-maxInds	-0.163026
fBodyBodyGyroMag-meanFreq()	-0.003285

```
fBodyBodyGyroMag-skewness()                          0.149721
fBodyBodyGyroMag-kurtosis()                          0.169906
fBodyBodyGyroJerkMag-mean()                         -0.337874
fBodyBodyGyroJerkMag-std()                          -0.333759
fBodyBodyGyroJerkMag-mad()                          -0.334863
fBodyBodyGyroJerkMag-max()                          -0.329147
fBodyBodyGyroJerkMag-min()                          -0.275944
fBodyBodyGyroJerkMag-sma()                          -0.337874
fBodyBodyGyroJerkMag-energy()                       -0.221466
fBodyBodyGyroJerkMag-iqr()                          -0.333914
fBodyBodyGyroJerkMag-entropy()                      -0.381654
fBodyBodyGyroJerkMag-maxInds                        -0.022140
fBodyBodyGyroJerkMag-meanFreq()                      0.087332
fBodyBodyGyroJerkMag-skewness()                     -0.086006
fBodyBodyGyroJerkMag-kurtosis()                     -0.079751
angle(tBodyAccMean,gravity)                          0.011880
angle(tBodyAccJerkMean),gravityMean)                 0.023246
angle(tBodyGyroMean,gravityMean)                    -0.005853
angle(tBodyGyroJerkMean,gravityMean)                 0.023995
angle(X,gravityMean)                                 1.000000
angle(Y,gravityMean)                                -0.783848
angle(Z,gravityMean)                                -0.643655
subject                                              0.026137

                                     angle(Y,gravityMean)  \
tBodyAcc-mean()-X                                0.034371
tBodyAcc-mean()-Y                                0.001053
tBodyAcc-mean()-Z                               -0.015288
tBodyAcc-std()-X                                 0.471065
tBodyAcc-std()-Y                                 0.523600
tBodyAcc-std()-Z                                 0.476006
tBodyAcc-mad()-X                                 0.466424
tBodyAcc-mad()-Y                                 0.525081
tBodyAcc-mad()-Z                                 0.477607
tBodyAcc-max()-X                                 0.480229
tBodyAcc-max()-Y                                 0.490324
tBodyAcc-max()-Z                                 0.463763
tBodyAcc-min()-X                                -0.470812
tBodyAcc-min()-Y                                -0.495516
tBodyAcc-min()-Z                                -0.435264
tBodyAcc-sma()                                   0.497465
tBodyAcc-energy()-X                              0.387451
tBodyAcc-energy()-Y                              0.441348
tBodyAcc-energy()-Z                              0.354304
tBodyAcc-iqr()-X                                 0.453287
tBodyAcc-iqr()-Y                                 0.517324
tBodyAcc-iqr()-Z                                 0.475045
tBodyAcc-entropy()-X                             0.399623
```

tBodyAcc-entropy()-Y	0.536131
tBodyAcc-entropy()-Z	0.459355
tBodyAcc-arCoeff()-X,1	-0.291999
tBodyAcc-arCoeff()-X,2	0.290587
tBodyAcc-arCoeff()-X,3	-0.120631
tBodyAcc-arCoeff()-X,4	0.143715
tBodyAcc-arCoeff()-Y,1	-0.475463
...	...
fBodyBodyGyroMag-min()	0.282196
fBodyBodyGyroMag-sma()	0.470841
fBodyBodyGyroMag-energy()	0.376770
fBodyBodyGyroMag-iqr()	0.466535
fBodyBodyGyroMag-entropy()	0.511678
fBodyBodyGyroMag-maxInds	0.179644
fBodyBodyGyroMag-meanFreq()	-0.036850
fBodyBodyGyroMag-skewness()	-0.142488
fBodyBodyGyroMag-kurtosis()	-0.172624
fBodyBodyGyroJerkMag-mean()	0.424918
fBodyBodyGyroJerkMag-std()	0.405123
fBodyBodyGyroJerkMag-mad()	0.412795
fBodyBodyGyroJerkMag-max()	0.395197
fBodyBodyGyroJerkMag-min()	0.348492
fBodyBodyGyroJerkMag-sma()	0.424918
fBodyBodyGyroJerkMag-energy()	0.256398
fBodyBodyGyroJerkMag-iqr()	0.423054
fBodyBodyGyroJerkMag-entropy()	0.501864
fBodyBodyGyroJerkMag-maxInds	0.031612
fBodyBodyGyroJerkMag-meanFreq()	-0.100125
fBodyBodyGyroJerkMag-skewness()	0.086993
fBodyBodyGyroJerkMag-kurtosis()	0.078079
angle(tBodyAccMean,gravity)	0.001540
angle(tBodyAccJerkMean),gravityMean)	-0.012990
angle(tBodyGyroMean,gravityMean)	-0.012313
angle(tBodyGyroJerkMean,gravityMean)	-0.005869
angle(X,gravityMean)	-0.783848
angle(Y,gravityMean)	1.000000
angle(Z,gravityMean)	0.594885
subject	-0.009829

	angle(Z,gravityMean)	subject
tBodyAcc-mean()-X	0.028242	0.024181
tBodyAcc-mean()-Y	-0.013903	-0.003144
tBodyAcc-mean()-Z	-0.022643	-0.000637
tBodyAcc-std()-X	0.394825	-0.064345
tBodyAcc-std()-Y	0.433169	-0.115524
tBodyAcc-std()-Z	0.482828	-0.050123
tBodyAcc-mad()-X	0.390922	-0.063440
tBodyAcc-mad()-Y	0.431459	-0.114753

tBodyAcc-mad()-Z	0.479751	-0.055457
tBodyAcc-max()-X	0.405023	-0.055633
tBodyAcc-max()-Y	0.427291	-0.095483
tBodyAcc-max()-Z	0.419728	-0.027330
tBodyAcc-min()-X	-0.393206	0.085809
tBodyAcc-min()-Y	-0.412024	0.111776
tBodyAcc-min()-Z	-0.477637	0.038566
tBodyAcc-sma()	0.431265	-0.075566
tBodyAcc-energy()-X	0.323065	-0.053050
tBodyAcc-energy()-Y	0.344350	-0.128176
tBodyAcc-energy()-Z	0.429705	-0.034002
tBodyAcc-iqr()-X	0.380316	-0.065194
tBodyAcc-iqr()-Y	0.421035	-0.097494
tBodyAcc-iqr()-Z	0.462577	-0.069121
tBodyAcc-entropy()-X	0.288006	-0.057343
tBodyAcc-entropy()-Y	0.416276	-0.117959
tBodyAcc-entropy()-Z	0.428746	-0.055065
tBodyAcc-arCoeff()-X,1	-0.198829	0.071491
tBodyAcc-arCoeff()-X,2	0.224827	-0.099240
tBodyAcc-arCoeff()-X,3	-0.082230	0.033032
tBodyAcc-arCoeff()-X,4	0.141427	0.056491
tBodyAcc-arCoeff()-Y,1	-0.331567	0.066864
...	...	...
fBodyBodyGyroMag-min()	0.276441	-0.104049
fBodyBodyGyroMag-sma()	0.424220	-0.108550
fBodyBodyGyroMag-energy()	0.347327	-0.068409
fBodyBodyGyroMag-iqr()	0.415610	-0.118459
fBodyBodyGyroMag-entropy()	0.437761	-0.103263
fBodyBodyGyroMag-maxInds	0.169496	-0.006372
fBodyBodyGyroMag-meanFreq()	0.051765	-0.113745
fBodyBodyGyroMag-skewness()	-0.183925	0.036477
fBodyBodyGyroMag-kurtosis()	-0.199710	0.018023
fBodyBodyGyroJerkMag-mean()	0.404965	-0.133020
fBodyBodyGyroJerkMag-std()	0.381481	-0.127135
fBodyBodyGyroJerkMag-mad()	0.391401	-0.128849
fBodyBodyGyroJerkMag-max()	0.367856	-0.127612
fBodyBodyGyroJerkMag-min()	0.330625	-0.100183
fBodyBodyGyroJerkMag-sma()	0.404965	-0.133020
fBodyBodyGyroJerkMag-energy()	0.265572	-0.102816
fBodyBodyGyroJerkMag-iqr()	0.400885	-0.132640
fBodyBodyGyroJerkMag-entropy()	0.449402	-0.113674
fBodyBodyGyroJerkMag-maxInds	0.021004	0.016231
fBodyBodyGyroJerkMag-meanFreq()	-0.057468	0.009755
fBodyBodyGyroJerkMag-skewness()	0.057831	-0.049072
fBodyBodyGyroJerkMag-kurtosis()	0.052548	-0.043902
angle(tBodyAccMean,gravity)	-0.003069	-0.005087
angle(tBodyAccJerkMean),gravityMean)	-0.017520	0.012510
angle(tBodyGyroMean,gravityMean)	-0.019903	-0.005314

```
angle(tBodyGyroJerkMean,gravityMean)              -0.005656  0.009340
angle(X,gravityMean)                              -0.643655  0.026137
angle(Y,gravityMean)                               0.594885 -0.009829
angle(Z,gravityMean)                               1.000000 -0.098712
subject                                           -0.098712  1.000000

[562 rows x 562 columns]
```

The data has 7352 observations with 563 variables with the first few columns representing the mean and standard deviations of body accelerations in 3 spatial dimensions (X, Y, Z). The last two columns are "subject" and "Acitivity" which represent the subject that the observation is taken from and the corresponding activity respectively. Let's see what activities have been recorded in this data

```
In [10]: print('Train labels', df1['Activity'].unique(), '\nTest Labels', df2['Activity'].uniq

Train labels ['STANDING' 'SITTING' 'LAYING' 'WALKING' 'WALKING_DOWNSTAIRS'
 'WALKING_UPSTAIRS']
Test Labels ['STANDING' 'SITTING' 'LAYING' 'WALKING' 'WALKING_DOWNSTAIRS'
 'WALKING_UPSTAIRS']
```

We have 6 activities, 3 passive (laying, standing and sitting) and 3 active (walking, walking_downstairs, walking_upstairs) which involve walking. So, each observation in the dataset represent one of the six activities whose features are recorded in the 561 variables. Our goal would be trian a machine to predict one of the six activities given a feature set of these 561 variables.

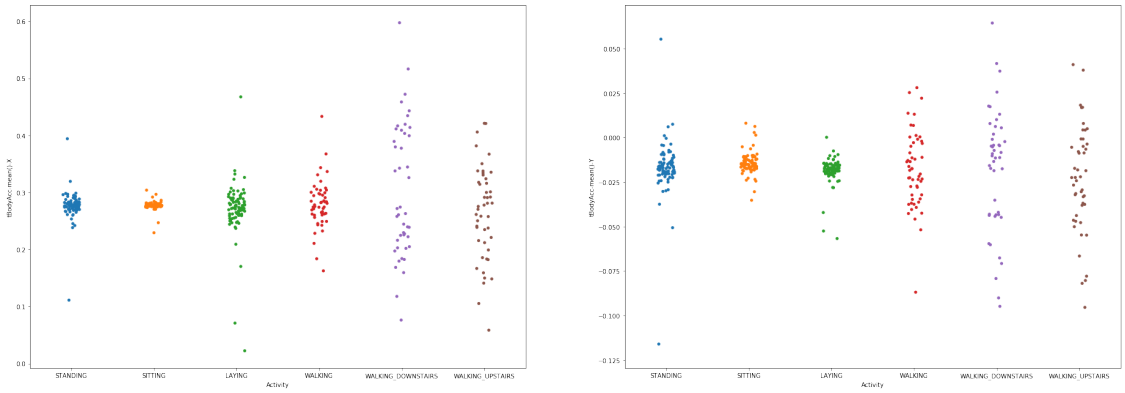
Let's check how many observations are recorded by each subject.

```
In [12]: pd.crosstab(df1.subject, df1.Activity)

Out[12]: Activity  LAYING  SITTING  STANDING  WALKING  WALKING_DOWNSTAIRS  \
         subject
         1             50       47        53       95                  49
         3             62       52        61       58                  49
         5             52       44        56       56                  47
         6             57       55        57       57                  48
         7             52       48        53       57                  47
         8             54       46        54       48                  38
         11            57       53        47       59                  46
         14            51       54        60       59                  45
         15            72       59        53       54                  42
         16            70       69        78       51                  47
         17            71       64        78       61                  46
         19            83       73        73       52                  39
         21            90       85        89       52                  45
         22            72       62        63       46                  36
         23            72       68        68       59                  54
         25            73       65        74       74                  58
         26            76       78        74       59                  50
```

```
27          74          70          80          57          44
28          80          72          79          54          46
29          69          60          65          53          48
30          70          62          59          65          62

Activity  WALKING_UPSTAIRS
subject
1                       53
3                       59
5                       47
6                       51
7                       51
8                       41
11                      54
14                      54
15                      48
16                      51
17                      48
19                      40
21                      47
22                      42
23                      51
25                      65
26                      55
27                      51
28                      51
29                      49
30                      65
```

since the data is almost evenly distributed for all the activities among all the subjects, we have picked subject 21 to compare the activities with the first three variables - mean body acceleration in 3 spatial dimensions.

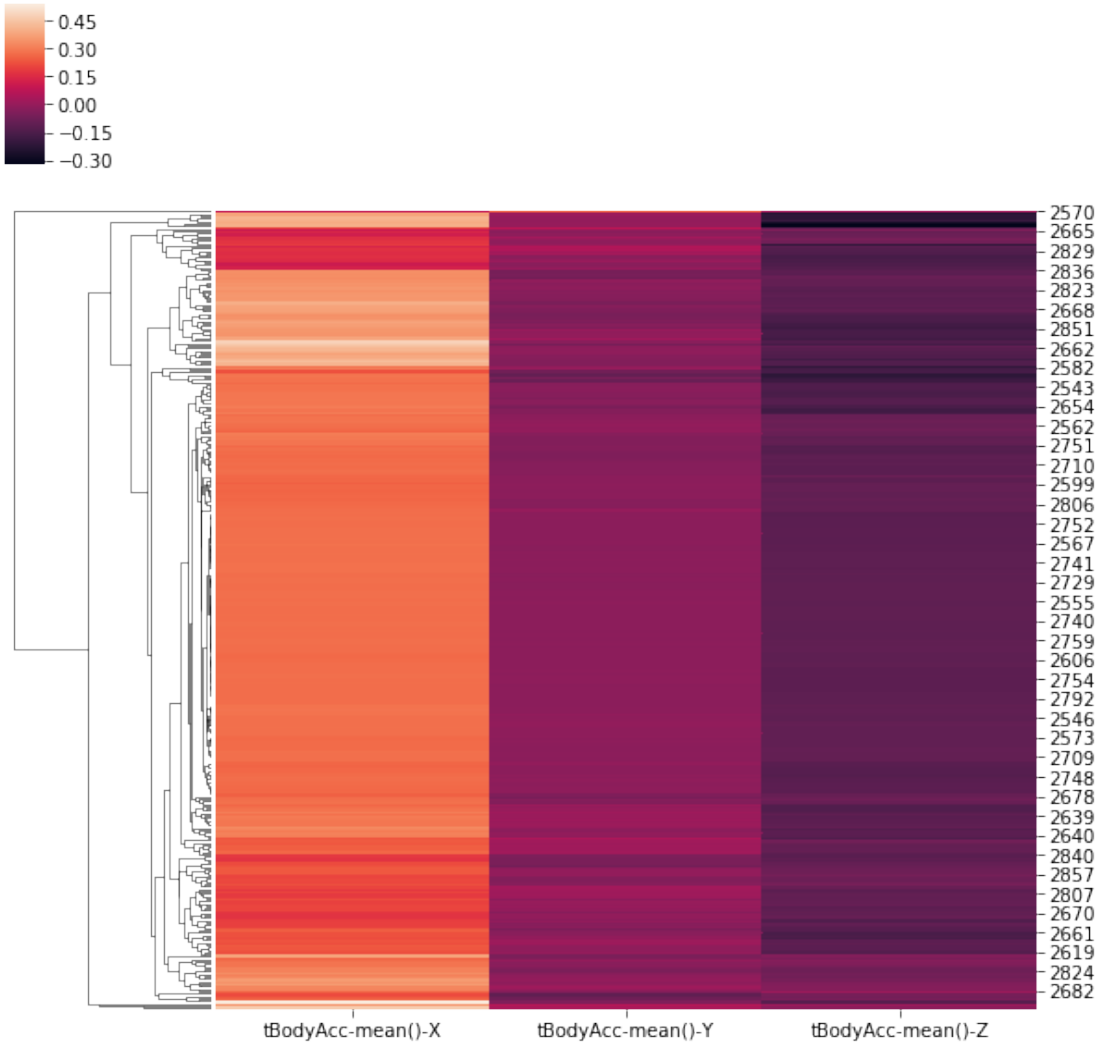
```
In [26]: sub21 = df1.loc[df1['subject']==21]

In [30]: fig = plt.figure(figsize=(32,24))
         ax1 = fig.add_subplot(221)
         ax1 = sns.stripplot(x='Activity', y=sub21.iloc[:,0], data=sub21, jitter=True)
         ax2 = fig.add_subplot(222)
         ax2 = sns.stripplot(x='Activity', y=sub21.iloc[:,1], data=sub21, jitter=True)
         plt.show()
```



So, the mean body acceleration is more variable for walking activities than for passive ones especially in the X direction.

```
In [28]: sns.clustermap(sub15.iloc[:,[0,1,2]], col_cluster=False)
```

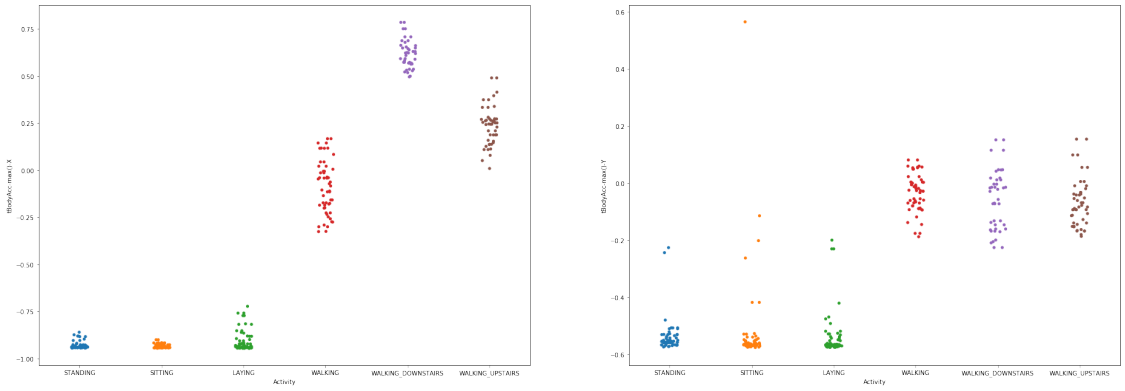
```
Out[28]: <seaborn.matrix.ClusterGrid at 0x1f205489550>
```



Even though we see some dark spots in the X and Z directions (possibly from the walking activities), the bulk of the map is pretty homogenous and does not help much. Perhaps other attributes like maximum or minimum acceleration might give us a better insight than the average.

Plotting maximum acceleration with activity.

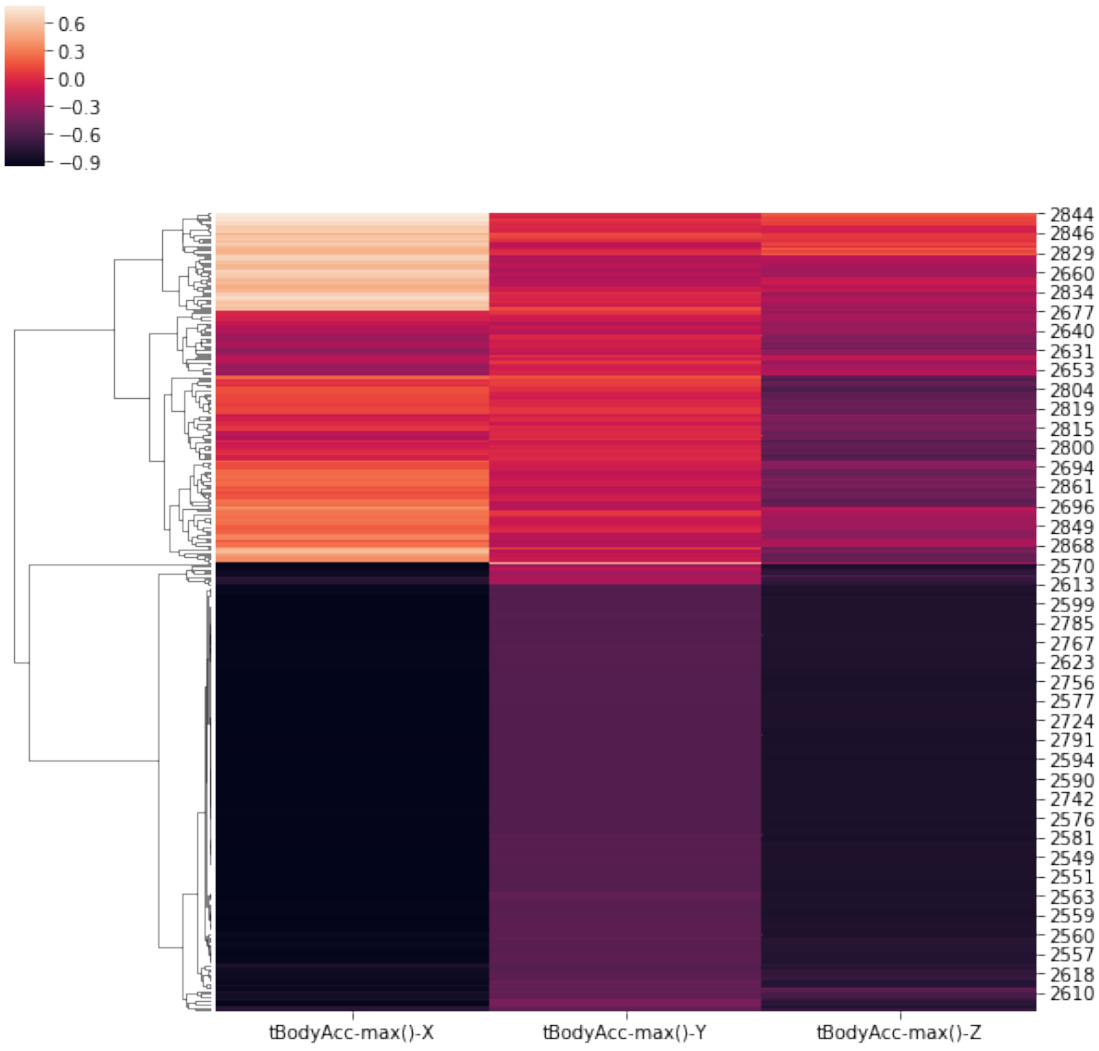
```
In [19]: fig = plt.figure(figsize=(32,24))
         ax1 = fig.add_subplot(221)
         ax1 = sns.stripplot(x='Activity', y='tBodyAcc-max()-X', data=sub15, jitter=True)
         ax2 = fig.add_subplot(222)
         ax2 = sns.stripplot(x='Activity', y='tBodyAcc-max()-Y', data=sub15, jitter=True)
         plt.show()
```



Passive activities fall mostly below the active ones. It actually makes sense that maximum acceleration is higher during the walking activities.

```
In [20]: sns.clustermap(sub15[['tBodyAcc-max()-X', 'tBodyAcc-max()-Y', 'tBodyAcc-max()-Z']], c
```

```
Out[20]: <seaborn.matrix.ClusterGrid at 0x1f2046643c8>
```



We can now see the difference in the distribution between the active and passive activities with the walkdown activity (values between 0.5 and 0.8) clearly distinct from all others especially in the X-direction. The passive activities are indistinguishable and present no clear pattern in any direction (X, Y, Z).