Importing required libraries

In [1]:
```
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
from sklearn.manifold import TSNE
import warnings
from datetime import datetime
from sklearn.model_selection import GridSearchCV

from sklearn.model_selection import train_test_split
from sklearn import metrics
from sklearn.preprocessing import StandardScaler, LabelEncoder
from sklearn.metrics import accuracy_score
from sklearn.decomposition import PCA

from scipy.stats import randint as sp_randint
from scipy.stats import uniform as sp_uniform
from sklearn.model_selection import RandomizedSearchCV, GridSearchCV

#To create plots
from matplotlib.colors import rgb2hex
from matplotlib.cm import get_cmap

# To get new datatypes and functions
from collections import Counter

# To investigate distributions
from scipy.stats import norm, skew, probplot
from scipy.optimize import curve_fit
```

Loading the training and testing dataset

In [2]:
```
train_df = pd.read_csv('C:\\Users\\Asus\\Desktop\\train.csv')
test_df = pd.read_csv('C:\\Users\\Asus\\Desktop\\test.csv')
# Combine boths dataframes
train_df['Data'] = 'train'
test_df['Data'] = 'test'
both_df = pd.concat([train_df, test_df], axis=0).reset_index(drop=True)
both_df['subject'] = both_df['subject'].astype(str)
train_df["subject"] = pd.read_csv("C:\\Users\\Asus\\Desktop\\UCI HAR Dataset\\train\\subject_train.txt",
                                  header = None, squeeze = True) #squeeze = True will return data in pandas series format
train_df["activity_labels"] = pd.read_csv("C:\\Users\\Asus\\Desktop\\UCI HAR Dataset\\train\\y_train.txt",
                                          header = None, squeeze = True)
activity = pd.read_csv("C:\\Users\\Asus\\Desktop\\UCI HAR Dataset\\train\\y_train.txt", header = None, squeeze = True)
#mapping activity to activity name
label_name = activity.map({1: "WALKING", 2:"WALKING_UPSTAIRS", 3:"WALKING_DOWNSTAIRS", 4:"SITTING", 5:"STANDING", 6:"LYING"
train_df["activity_labels"] = label_name
test_df["subject"] = pd.read_csv("C:\\Users\\Asus\\Desktop\\UCI HAR Dataset\\test\\subject_test.txt",
                                 header = None, squeeze = True) #squeeze = True will return data in pandas series format
test_df["activity_labels"] = pd.read_csv("C:\\Users\\Asus\\Desktop\\UCI HAR Dataset\\test\\y_test.txt",
                                         header = None, squeeze = True)
activity = pd.read_csv("C:\\Users\\Asus\\Desktop\\UCI HAR Dataset\\test\\y_test.txt", header = None, squeeze = True)
#mapping activity to activity name
label_name = activity.map({1: "WALKING", 2:"WALKING_UPSTAIRS", 3:"WALKING_DOWNSTAIRS", 4:"SITTING", 5:"STANDING", 6:"LYING"
test_df["activity_labels"] = label_name
# Create label
label = both_df.pop('Activity')
print('Shape train:\t{}'.format(train_df.shape))
print('Shape test:\t{}\n'.format(test_df.shape))
both_df.head()
```

```
Shape train:    (7352, 565)
Shape test:     (2947, 565)
```

Out[2]:

	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	...	fBodyBodyGyroJerkMag-kurtosis()	an
0	0.288585	-0.020294	-0.132905	-0.995279	-0.983111	-0.913526	-0.995112	-0.983185	-0.923527	-0.934724	...	-0.710304	
1	0.278419	-0.016411	-0.123520	-0.998245	-0.975300	-0.960322	-0.998807	-0.974914	-0.957686	-0.943068	...	-0.861499	
2	0.279653	-0.019467	-0.113462	-0.995380	-0.967187	-0.978944	-0.996520	-0.963668	-0.977469	-0.938692	...	-0.760104	
3	0.279174	-0.026201	-0.123283	-0.996091	-0.983403	-0.990675	-0.997099	-0.982750	-0.989302	-0.938692	...	-0.482845	
4	0.276629	-0.016570	-0.115362	-0.998139	-0.980817	-0.990482	-0.998321	-0.979672	-0.990441	-0.942469	...	-0.699205	

5 rows × 563 columns

In [3]:
```
# Group and count main names of columns
pd.DataFrame.from_dict(Counter([col.split('-')[0].split('(')[0] for col in both_df.columns]), orient='index').rename(column
```

Out[3]:

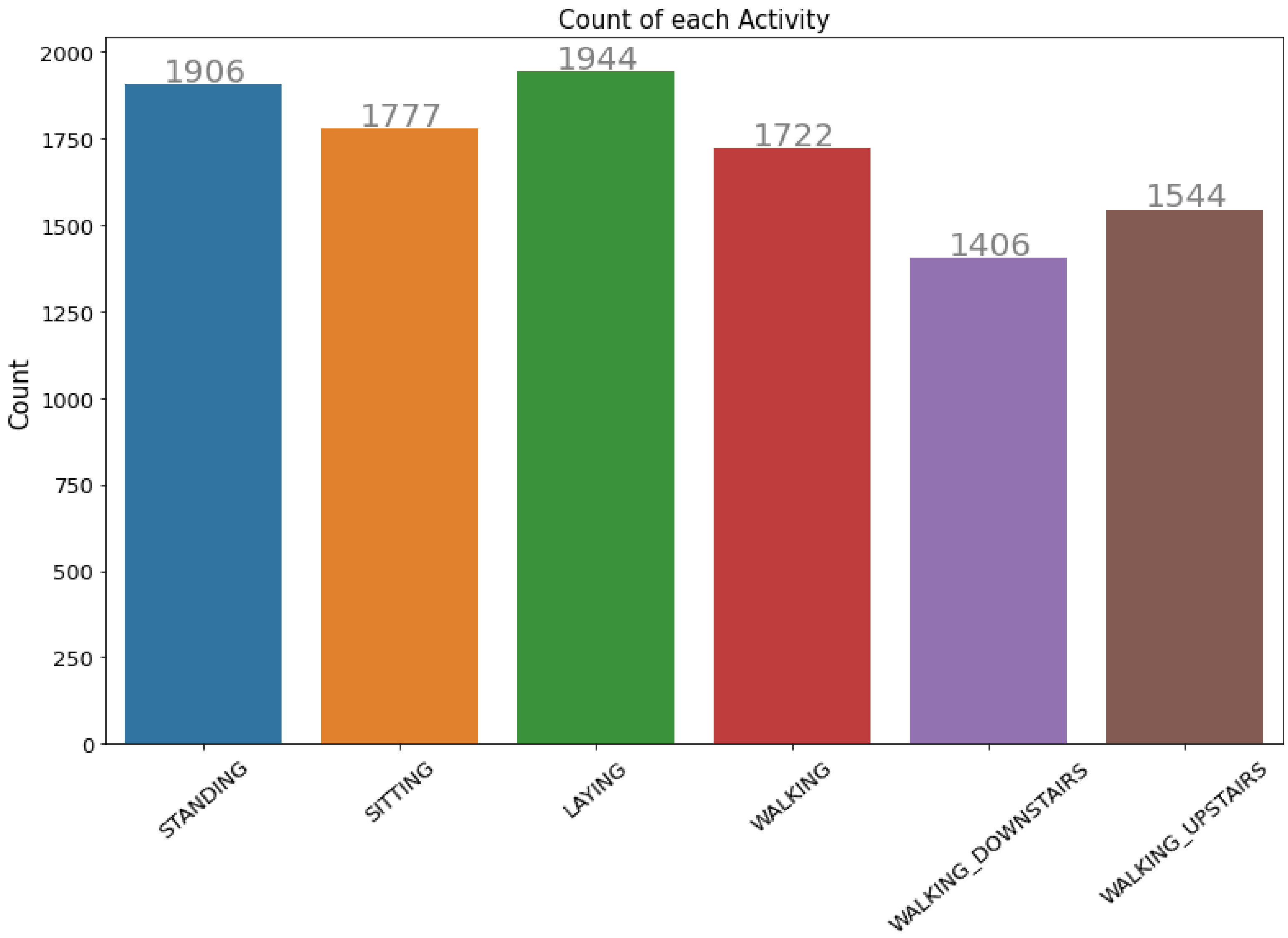
	count
fBodyAcc	79
fBodyGyro	79
fBodyAccJerk	79
tGravityAcc	40
tBodyAcc	40
tBodyGyroJerk	40
tBodyGyro	40
tBodyAccJerk	40
tBodyAccMag	13
tGravityAccMag	13
tBodyAccJerkMag	13
tBodyGyroMag	13
tBodyGyroJerkMag	13
fBodyAccMag	13
fBodyBodyAccJerkMag	13
fBodyBodyGyroMag	13
fBodyBodyGyroJerkMag	13
angle	7
subject	1
Data	1

Data Preprocessing

In [4]:
```
# Get null values and dataframe information
print('Null Values In DataFrame: {}\n'.format(both_df.isna().sum().sum()))
both_df.info()
```

```
Null Values In DataFrame: 0

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10299 entries, 0 to 10298
Columns: 563 entries, tBodyAcc-mean()-X to Data
dtypes: float64(561), object(2)
memory usage: 44.2+ MB
```

In [6]:
```
import matplotlib.pyplot as plt
import seaborn as sns
data_df = pd.read_csv('C:\\Users\\Asus\\Desktop\\Data.csv')
fig = plt.figure(figsize = (10, 6))
ax = fig.add_axes([0,0,1,1])
ax.set_title("Count of each Activity", fontsize = 15)
plt.tick_params(labelsize = 10)
sns.countplot(x = "Activity", data = data_df)
for i in ax.patches:
    ax.text(x = i.get_x() + 0.2, y = i.get_height()+10,
            s = str(i.get_height()), fontsize = 20, color = "grey")
plt.xlabel("")
plt.ylabel("Count", fontsize = 15)
plt.tick_params(labelsize = 13)
plt.xticks(rotation = 40)
plt.show()
```

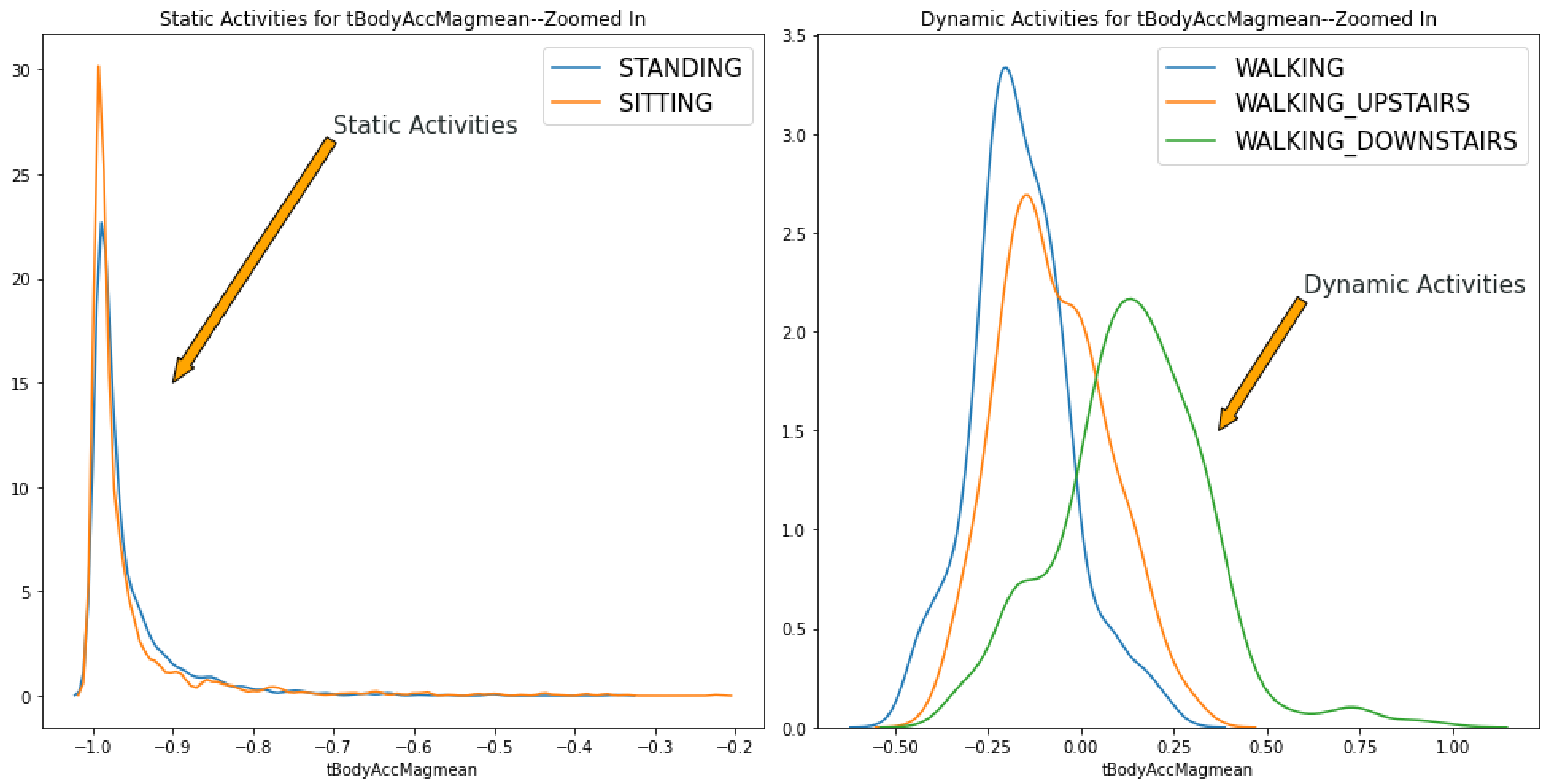


In [7]:
```python
columns = train_df.columns
columns = columns.str.replace("[()]", '')
columns = columns.str.replace("-", '')
columns = columns.str.replace(",", '')
#here, columns is of type pandas index. By writing "columns.str" we have changed its type to
#pandas string. Pandas string has method called replace which we have used here.



train_df.columns = columns
test_df.columns = columns
```

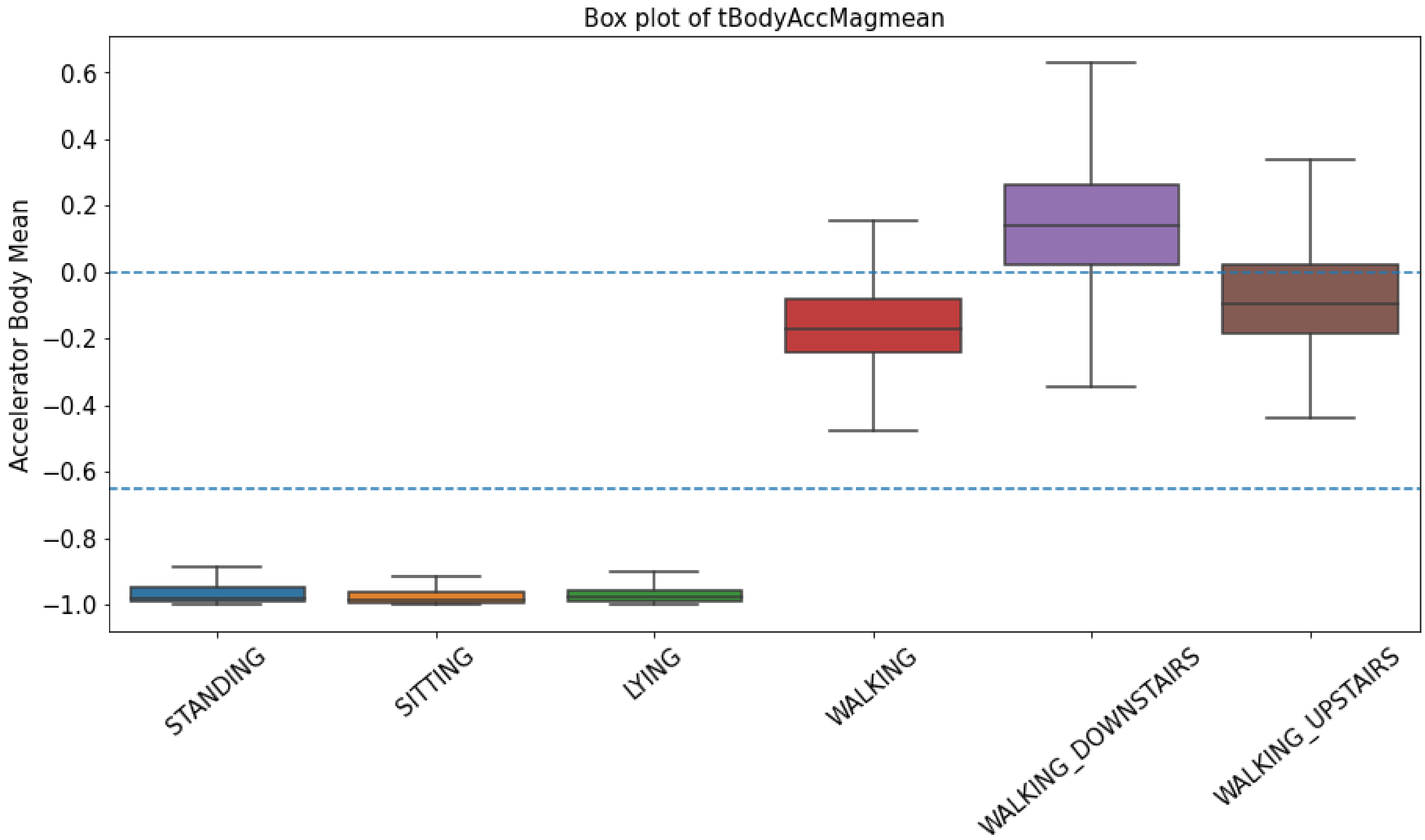
Data Exploratory Analysis

In [8]:
```python
#Let's plot "tBodyAccMagmean" for both static and dynamic activites separately to analysis them in more detail
df_standing = train_df[train_df["Activity"] == "STANDING"]
df_sitting = train_df[train_df["Activity"] == "SITTING"]
df_lying = train_df[train_df["Activity"] == "LYING"]
df_walking = train_df[train_df["Activity"] == "WALKING"]
df_walking_upstairs = train_df[train_df["Activity"] == "WALKING_UPSTAIRS"]
df_walking_downstairs = train_df[train_df["Activity"] == "WALKING_DOWNSTAIRS"]



fig, axes = plt.subplots(nrows = 1, ncols = 2, figsize = (14, 7))



axes[0].set_title("Static Activities for tBodyAccMagmean--Zoomed In")
sns.distplot(df_standing["tBodyAccMagmean"], hist = False, label = "STANDING", ax = axes[0])
sns.distplot(df_sitting["tBodyAccMagmean"], hist = False, label = "SITTING", ax = axes[0])
sns.distplot(df_lying["tBodyAccMagmean"], hist = False, label = "LYING", ax = axes[0])
axes[0].legend(fontsize = 15)
axes[0].annotate('Static Activities', xy=(-0.90, 15), xytext=(-0.7, 27),
arrowprops=dict(facecolor='orange', width = 7, headlength = 15), size = 15, color = "#232b2b")



axes[1].set_title("Dynamic Activities for tBodyAccMagmean--Zoomed In")
sns.distplot(df_walking["tBodyAccMagmean"], hist = False, label = "WALKING", ax = axes[1])
sns.distplot(df_walking_upstairs["tBodyAccMagmean"], hist = False, label = "WALKING_UPSTAIRS", ax = axes[1])
sns.distplot(df_walking_downstairs["tBodyAccMagmean"], hist = False, label = "WALKING_DOWNSTAIRS", ax = axes[1])
axes[1].legend(fontsize = 15)
axes[1].annotate('Dynamic Activities', xy=(0.37, 1.5), xytext=(0.60, 2.2),
arrowprops=dict(facecolor='orange', width = 7, headlength = 13), size = 15, color = "#232b2b")



plt.tight_layout()
plt.show()
```

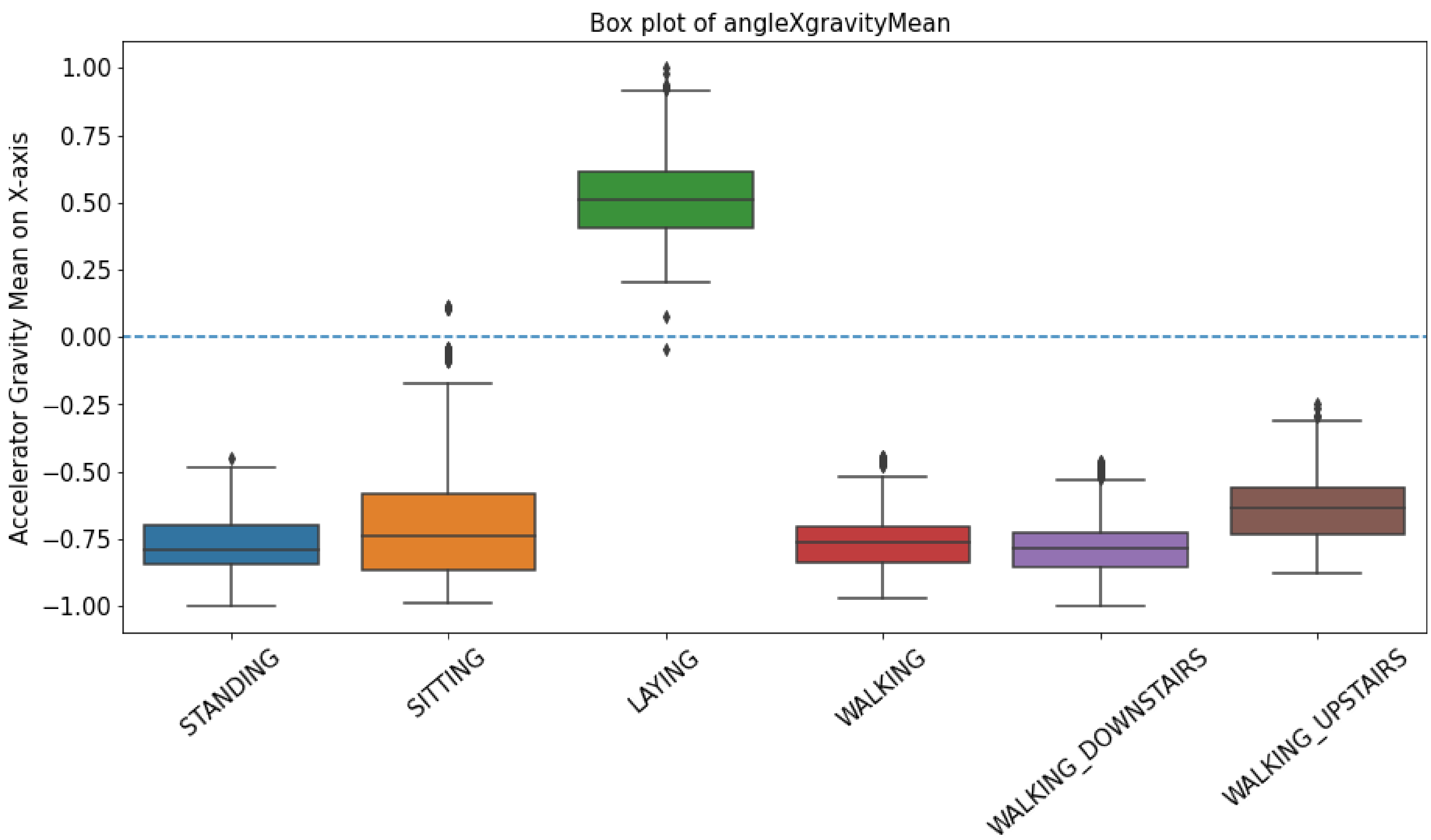
```
C:\Users\Asus\anaconda3\lib\site-packages\seaborn\distributions.py:198: RuntimeWarning: Mean of empty slice.
  line, = ax.plot(a.mean(), 0)
C:\Users\Asus\anaconda3\lib\site-packages\numpy\core\_methods.py:161: RuntimeWarning: invalid value encountered in double_
scalars
  ret = ret.dtype.type(ret / rcount)
```



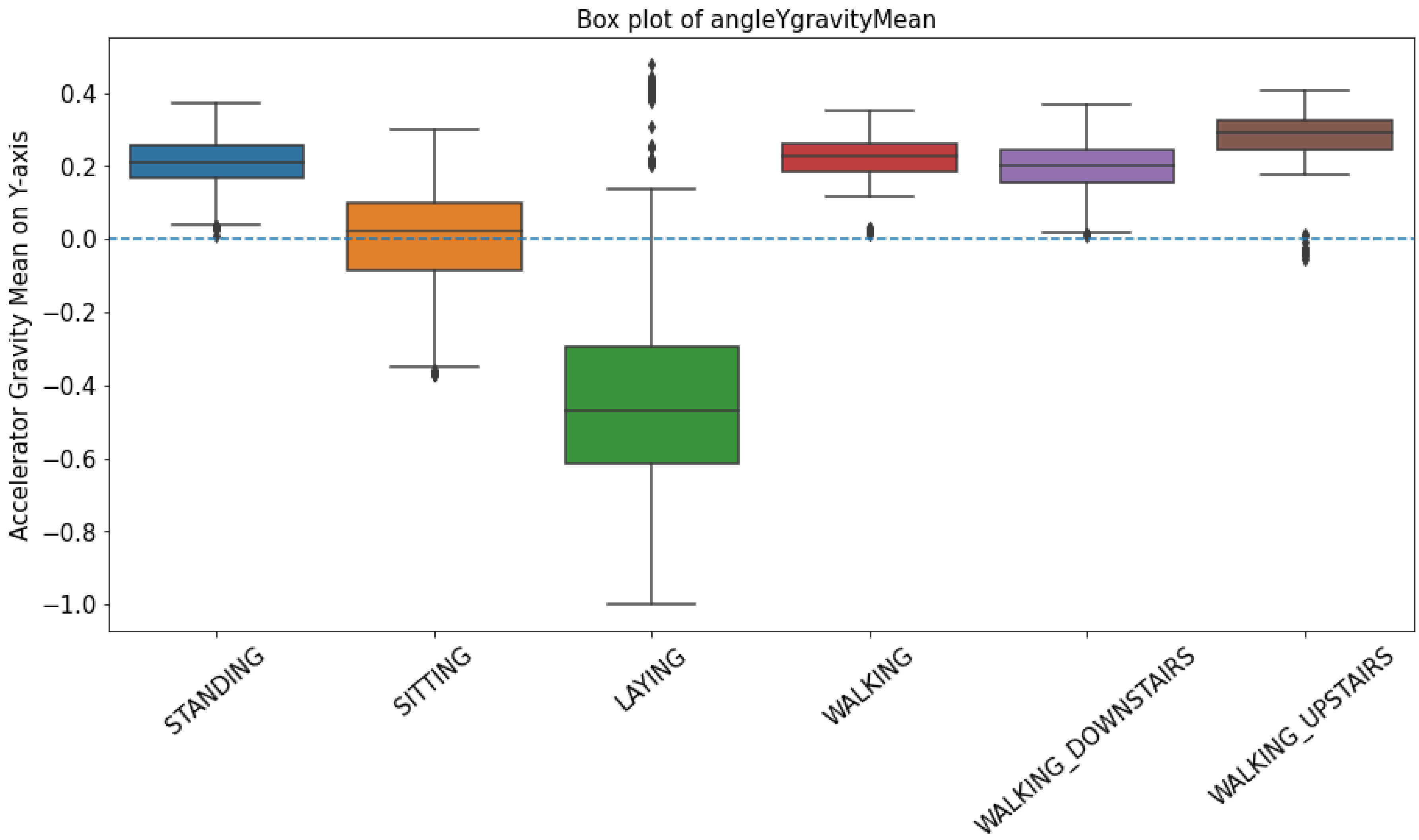
In [9]:
```
plt.figure(figsize = (15, 7))
sns.boxplot(x = "activity_labels", y = "tBodyAccMagmean", showfliers = False, data = train_df)
plt.axhline(y = -0.65, linestyle = "--")
plt.axhline(y = 0, linestyle = "--")
plt.title("Box plot of tBodyAccMagmean", fontsize = 15)
plt.ylabel("Accelerator Body Mean", fontsize = 15)
plt.xlabel("Activity Name", fontsize = 15)
plt.xlabel("")
plt.tick_params(labelsize = 15)
plt.xticks(rotation = 40)
plt.show()
```



In [10]:
```
plt.figure(figsize = (15, 7))
sns.boxplot(x = "Activity", y = "angleXgravityMean", showfliers = True, data = train_df)
plt.axhline(y = 0, linestyle = "--")
plt.title("Box plot of angleXgravityMean ", fontsize = 15)
plt.ylabel("Accelerator Gravity Mean on X-axis", fontsize = 15)
plt.xlabel("")
plt.tick_params(labelsize = 15)
plt.xticks(rotation = 40)
plt.show()
```

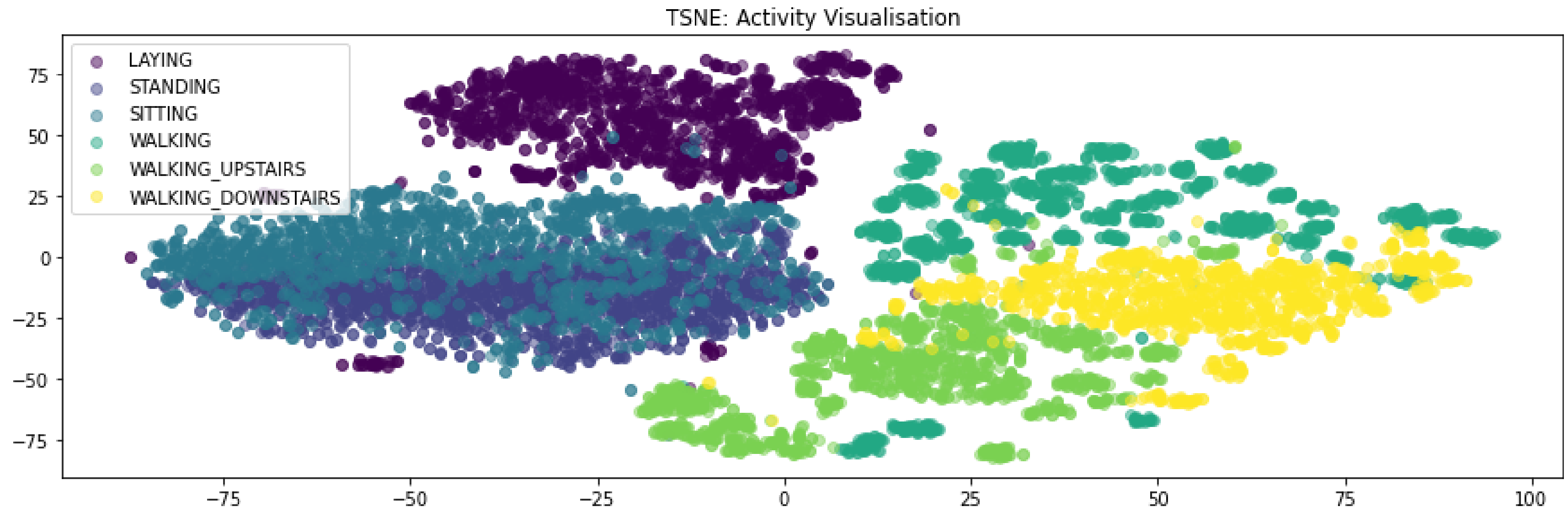


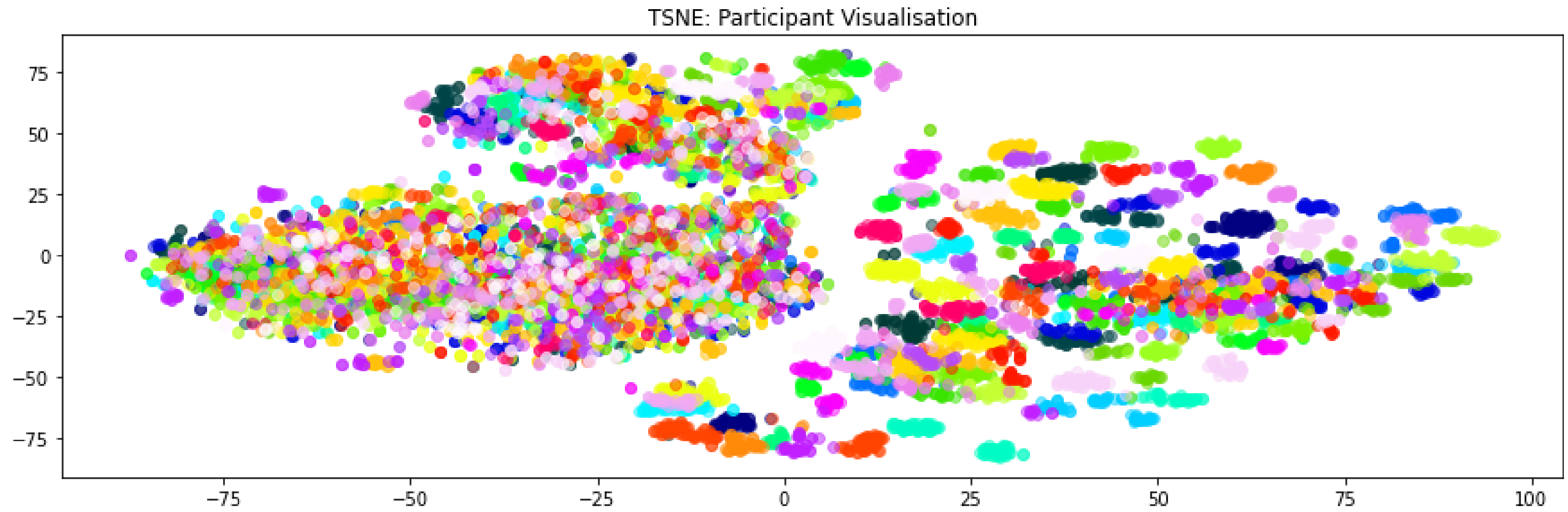
In [11]:
```
plt.figure(figsize = (15, 7))
sns.boxplot(x = "Activity", y = "angleYgravityMean", showfliers = True, data = train_df)
plt.axhline(y = 0, linestyle = "--")
plt.title("Box plot of angleYgravityMean ", fontsize = 15)
plt.ylabel("Accelerator Gravity Mean on Y-axis", fontsize = 15)
plt.xlabel("")
plt.tick_params(labelsize = 15)
plt.xticks(rotation = 40)
plt.show()
```



T-SNE VISUALIZATION

In [12]:
```python
# Plotting data
label_counts = label.value_counts()


# Create datasets
tsne_data = both_df.copy()
data_data = tsne_data.pop('Data')
subject_data = tsne_data.pop('subject')



# Scale data
scl = StandardScaler()
tsne_data = scl.fit_transform(tsne_data)



# Reduce dimensions (speed up)
pca = PCA(n_components=0.9, random_state=3)
tsne_data = pca.fit_transform(tsne_data)



# Transform data
tsne = TSNE(random_state=3)
tsne_transformed = tsne.fit_transform(tsne_data)




# Create subplots
fig, axarr = plt.subplots(2, 1, figsize=(15,10))



### Plot Activities
# Get colors
n = label.unique().shape[0]
colormap = get_cmap('viridis')
colors = [rgb2hex(colormap(col)) for col in np.arange(0, 1.01, 1/(n-1))]



# Plot each activity
for i, group in enumerate(label_counts.index):
    # Mask to separate sets
    mask = (label==group).values
    axarr[0].scatter(x=tsne_transformed[mask][:,0], y=tsne_transformed[mask][:,1], c=colors[i], alpha=0.5, label=group)
axarr[0].set_title('TSNE: Activity Visualisation')
axarr[0].legend()




### Plot Subjects
# Get colors
n = subject_data.unique().shape[0]
colormap = get_cmap('gist_ncar')
colors = [rgb2hex(colormap(col)) for col in np.arange(0, 1.01, 1/(n-1))]



# Plot each participant
for i, group in enumerate(subject_data.unique()):
# Mask to separate sets
    mask = (subject_data==group).values
    axarr[1].scatter(x=tsne_transformed[mask][:,0], y=tsne_transformed[mask][:,1], c=colors[i], alpha=0.5, label=group)



axarr[1].set_title('TSNE: Participant Visualisation')
plt.show()
```





BUILDING MACHINE LEARNING ALGORITHMS

In [13]:
```
# Split training testing data
enc = LabelEncoder()
label_encoded = enc.fit_transform(label)
X_train, X_test, y_train, y_test = train_test_split(tsne_data, label_encoded, random_state=3)
y = np.array(y_train).ravel() #2d to 1 conversion
```

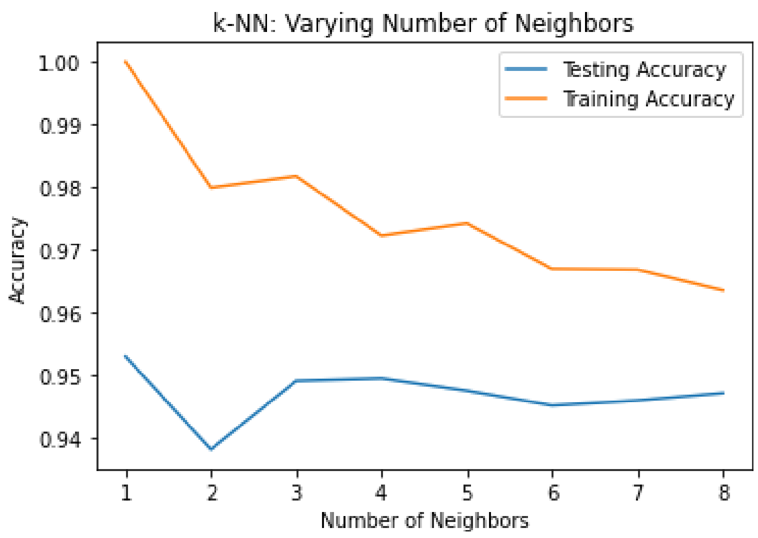
In [14]:
```
X_train
```

Out[14]:
```
array([[ 10.35528794, -11.708257  ,  -1.9538929 , ...,  -2.0137831 ,
         -0.65775352,  -0.17430295],
       [-15.21999946,   4.93821655,  -2.34910899, ...,   0.04858099,
          0.52365166,  -0.21157164],
       [-16.40948403,   5.83016746,  -0.87169788, ...,   0.25693282,
         -0.21584845,   0.18753504],
       ...,
       [ 29.41265996,   2.13264655,  -0.71372667, ...,   0.11345496,
         -0.38131181,  -0.14113574],
       [-16.56713876,   6.21671982,   1.38379393, ...,  -0.46927784,
         -0.6431541 ,   0.58002937],
       [ 10.37880965,   0.87889925,  -4.55301137, ...,  -0.06583317,
         -0.74240521,  -0.20095531]])
```

KNN ALGORITHM

In [15]:
```python
import pandas as pd
import matplotlib.pyplot as plt
import numpy as np
from sklearn.neighbors import KNeighborsClassifier
knn = KNeighborsClassifier(n_neighbors=5)
knn.fit(X_train,y_train)



print("Printing train score:")
print(knn.score(X_train,y_train))



print("Printing test score:")
print(knn.score(X_test,y_test))



no_neighbors = np.arange(1, 9)
train_accuracy = np.empty(len(no_neighbors))
test_accuracy = np.empty(len(no_neighbors))



for i, k in enumerate(no_neighbors):
    # We instantiate the classifier
    knn = KNeighborsClassifier(n_neighbors=k)
    # Fit the classifier to the training data
    knn.fit(X_train,y_train)

    # Compute accuracy on the training set
    train_accuracy[i] = knn.score(X_train, y_train)



    # Compute accuracy on the testing set
    test_accuracy[i] = knn.score(X_test, y_test)



# Visualization of k values vs accuracy



plt.title('k-NN: Varying Number of Neighbors')
plt.plot(no_neighbors, test_accuracy, label = 'Testing Accuracy')



plt.plot(no_neighbors, train_accuracy, label = 'Training Accuracy')
plt.legend()
plt.xlabel('Number of Neighbors')
plt.ylabel('Accuracy')
plt.show()
```

```
Printing train score:
0.9742361470740549
Printing test score:
0.9475728155339805
```



LIGHT GRADIENT BOOSTING MACHINE

In [16]:
```
#Setting Parameters for lgbm model
parameters={"early_stopping_rounds":20,   #To avoid overfitting.
            "eval_metric" : 'auc',        # To specify the Evaluation metric.
            "eval_set" : [(X_test,y_test)],   #To set validation dataset.
            'eval_names': ['valid'],
            'verbose': 100,                 #To print the data while training the model.
            'categorical_feature': 'auto'}   #To specify the categorical columns in the dataset.
from scipy.stats import randint as sp_randint
from scipy.stats import uniform as sp_uniform
from sklearn.model_selection import RandomizedSearchCV, GridSearchCV
from scipy.stats import uniform as sp_uniform
```

In [17]:
```
#Create parameters to tune

parameter_tuning ={'max_depth': sp_randint(10,50), # To control the depth of the tree.
             'num_leaves': sp_randint(6, 50),     # To specify the number of leaves in the tree.. it should be large
             'learning_rate ': [0.1,0.01,0.001],  # To specify the learning rate. should be small
             'min_child_samples': sp_randint(100, 500),
             'min_child_weight': [1e-5, 1e-3, 1e-2, 1e-1, 1, 1e1, 1e2, 1e3, 1e4],
             'subsample': sp_uniform(loc=0.2, scale=0.8),
             'colsample_bytree': sp_uniform(loc=0.4, scale=0.6),
             'reg_alpha': [0, 1e-1, 1, 2, 5, 7, 10, 50, 100], #smaller the better
             'reg_lambda': [0, 1e-1, 1, 5, 10, 20, 50, 100]} #parameter should be small
```

In [19]:
```
import lightgbm as lgb
from lightgbm import LGBMClassifier
classifier = lgb.LGBMClassifier(random_state=300, silent=True, metric='None', n_jobs=4, n_estimators=5000)
#random searcg CV :Define a search space as a bounded domain of hyperparameter values and randomly
#sample points in that domain.
find_parameters = RandomizedSearchCV(
    estimator=classifier, param_distributions=parameter_tuning,
    n_iter=100,
    scoring='roc_auc',
    cv=5,
    refit=True,
    random_state=300,
    verbose=False)
```

In [20]:
```
find_parameters.fit(X_train, y_train, **parameters)
```

...

In [21]:
```
best_parameters = find_parameters.best_params_
best_parameters
```

Out[21]:
```
{'colsample_bytree': 0.6706735412200329,
 'learning_rate ': 0.01,
 'max_depth': 20,
 'min_child_samples': 109,
 'min_child_weight': 10.0,
 'num_leaves': 33,
 'reg_alpha': 50,
 'reg_lambda': 50,
 'subsample': 0.8256371463681569}
```

In [22]:
```
best_parameters_model = lgb.LGBMClassifier(**best_parameters)
best_parameters_model.set_params(**best_parameters)
```

Out[22]:
```
LGBMClassifier(colsample_bytree=0.6706735412200329, learning_rate =0.01,
               max_depth=20, min_child_samples=109, min_child_weight=10.0,
               num_leaves=33, reg_alpha=50, reg_lambda=50,
               subsample=0.8256371463681569)
```

In [23]:
```
# Create the model

lgbm = LGBMClassifier(colsample_bytree=0.6706735412200329, learning_rate =0.01,
               max_depth=20, min_child_samples=109, min_child_weight=10.0,
               num_leaves=33, reg_alpha=50, reg_lambda=50,
               subsample=0.8256371463681569)
lgbm = lgbm.fit(X_train, y_train)



#Test the model
score = accuracy_score(y_true=y_train, y_pred=lgbm.predict(X_train))
print('Accuracy on trainset:\t{:.4f}\n'.format(score))
```

```
Accuracy on trainset:   0.8602
```

In [24]:
```
# Create the model
lgbm = LGBMClassifier(colsample_bytree=0.6735412200329, learning_rate =0.10,
               max_depth=20, min_child_samples=109, min_child_weight=10.0,
               num_leaves=33, reg_alpha=0, reg_lambda=0,
               subsample=0.8256371463681569)
lgbm = lgbm.fit(X_train, y_train)



#Test the model
score = accuracy_score(y_true=y_test, y_pred=lgbm.predict(X_test))
print('Accuracy on testset:\t{:.4f}\n'.format(score))
```

```
Accuracy on testset:    0.9515
```

In [25]:
```
# Store the data
data = []
# Iterate over each activity
for activity in label_counts.index:
    # Create dataset
    act_data = both_df[label==activity].copy()
    act_data_data = act_data.pop('Data')
    act_subject_data = act_data.pop('subject')

    # Scale data
    scl = StandardScaler()
    act_data = scl.fit_transform(act_data)



    # Reduce dimensions
    pca = PCA(n_components=0.9, random_state=3)
    act_data = pca.fit_transform(act_data)




    # Split training testing data
    enc = LabelEncoder()
    label_encoded = enc.fit_transform(act_subject_data)
    X_train, X_test, y_train, y_test = train_test_split(act_data, label_encoded, random_state=3)




    # Fit basic model
    print('Activity: {}'.format(activity))
    lgbm = LGBMClassifier(colsample_bytree=0.6735412200329, learning_rate =0.10,
               max_depth=20, min_child_samples=109, min_child_weight=10.0,
               num_leaves=33, reg_alpha=0, reg_lambda=0,
               subsample=0.8256371463681569)
    lgbm = lgbm.fit(X_train, y_train)

    score = accuracy_score(y_true=y_test, y_pred=lgbm.predict(X_test))
    print('Accuracy on testset:\t{:.4f}\n'.format(score))
    data.append([activity, score])
```

```
Activity: LAYING
Accuracy on testset:    0.5802

Activity: STANDING
Accuracy on testset:    0.4927

Activity: SITTING
Accuracy on testset:    0.4225

Activity: WALKING
Accuracy on testset:    0.9490

Activity: WALKING_UPSTAIRS
Accuracy on testset:    0.8653

Activity: WALKING_DOWNSTAIRS
Accuracy on testset:    0.8267
```

In [26]:

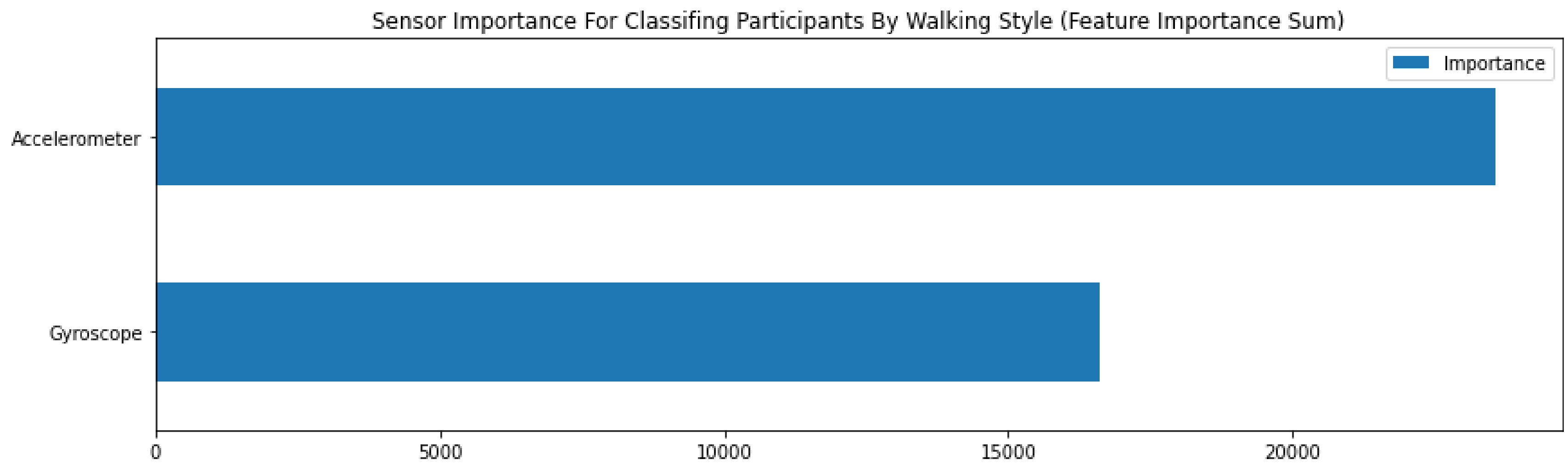
```python
# Create duration datafrae
duration_df = (both_df.groupby([label, subject_data])['Data'].count().reset_index().groupby('Activity').agg({'Data':'mean'}
activity_df = pd.DataFrame(data, columns=['Activity', 'Accuracy']).set_index('Activity')
activity_df.join(duration_df)
```

Out[26]:

Activity	Accuracy	Seconds
LAYING	0.580247	82.944000
STANDING	0.492662	81.322667
SITTING	0.422472	75.818667
WALKING	0.948956	73.472000
WALKING_UPSTAIRS	0.865285	65.877333
WALKING_DOWNSTAIRS	0.826705	59.989333

In [27]:

```python
#get importsnces
tsne_data = both_df[label=='WALKING'].copy()
data_data = tsne_data.pop('Data')
subject_data = tsne_data.pop('subject')

# Scale data
scl = StandardScaler()
tsne_data = scl.fit_transform(tsne_data)

# Split training testing data
enc = LabelEncoder()
label_encoded = enc.fit_transform(subject_data)
X_train, X_test, y_train, y_test = train_test_split(tsne_data, label_encoded, random_state=3)


# Create model
lgbm = LGBMClassifier(n_estimators=500, random_state=3)
lgbm = lgbm.fit(X_train, y_train)

# Get importances
features = both_df.drop(['Data', 'subject'], axis=1).columns
importances = lgbm.feature_importances_

# Sum importances
data = {'Gyroscope':0, 'Accelerometer':0}
for importance, feature in zip(importances, features):
    if 'Gyro' in feature:
        data['Gyroscope'] += importance
    if 'Acc' in feature:
        data['Accelerometer'] += importance

# Create dataframe and plot
sensor_df = pd.DataFrame.from_dict(data, orient='index').rename(columns={0:'Importance'})
sensor_df.plot(kind='barh', figsize=(14,4), title='Sensor Importance For Classifing Participants By Walking Style (Feature
plt.show()
```



In [28]:
```
# Group the data by participant and compute total duration of staircase walking
mask = label.isin(['WALKING_UPSTAIRS', 'WALKING_DOWNSTAIRS'])
duration_df = (both_df[mask].groupby([label[mask], 'subject'])['Data'].count() * 1.28)



# Create plot
plot_data = duration_df.reset_index().sort_values('Data', ascending=False)
plot_data['Activity'] = plot_data['Activity'].map({'WALKING_UPSTAIRS':'Upstairs', 'WALKING_DOWNSTAIRS':'Downstairs'})



plt.figure(figsize=(15,5))
sns.barplot(data=plot_data, x='subject', y='Data', hue='Activity')
plt.title('Participants Compared By Their Staircase Walking Duration')
plt.xlabel('Participants')
plt.ylabel('Total Duration [s]')
plt.show()
```