Transport Mode Detection - Nimish Agarwal (170440)

Setup

In [1]:

```
#  Mounting Drive
from google.colab import drive
drive.mount('/content/drive')
%cd /content/drive
```

```
Mounted at /content/drive
/content/drive
```

In [2]:

```
# Importing Libraries
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from datetime import datetime, timedelta
import time
import io
```

In [3]:

```
MAIN_DIR = 'My Drive/4th year Stuff/CE784A/TMD_Dataset/'
DATASET_DIR = MAIN_DIR + 'cleaned.csv'
```

Part 1 - Reading and Exploring Dataset

In [4]:

```
df = pd.read_csv(DATASET_DIR)
df.head()
```

Out[4]:

	user	timestamp	x	y	z	class
0	a2d80ed662f34d32951eb1c6ed076c313e358b73	2018-06-04 16:26:55.053	0.78	-9.13	-3.74	bus
1	a2d80ed662f34d32951eb1c6ed076c313e358b73	2018-06-04 16:26:55.111	0.79	-9.11	-3.75	bus
2	a2d80ed662f34d32951eb1c6ed076c313e358b73	2018-06-04 16:26:55.169	0.80	-9.12	-3.75	bus
3	a2d80ed662f34d32951eb1c6ed076c313e358b73	2018-06-04 16:26:55.228	0.78	-9.14	-3.76	bus
4	a2d80ed662f34d32951eb1c6ed076c313e358b73	2018-06-04 16:26:55.286	0.83	-9.12	-3.80	bus

In [5]:

```
print(df.info())
print('classes: ', df['class'].unique())
# Unique users
print('Unique users: ', len(df['user'].unique()))
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5653053 entries, 0 to 5653052
Data columns (total 6 columns):
 #   Column     Dtype
---  ------     -----
 0   user       object
 1   timestamp  object
 2   x          float64
```

```
 3   y          float64
 4   z          float64
 5   class      object
dtypes: float64(3), object(3)
memory usage: 258.8+ MB
None
classes:  ['bus' 'walk' 'car' 'bike' 'train' 'e-bike']
Unique users:  32
```

In [6]:

```
df.describe()
```

Out[6]:

	x	y	z
count	5.653053e+06	5.653053e+06	5.653053e+06
mean	1.499442e+00	1.483885e+00	2.484874e+00
std	4.657316e+00	6.262899e+00	5.800348e+00
min	-7.321000e+01	-7.840000e+01	-7.844000e+01
25%	-1.300000e+00	-1.790000e+00	-9.600000e-01
50%	7.100000e-01	2.130000e+00	3.500000e+00
75%	4.650000e+00	6.260000e+00	7.320000e+00
max	7.840000e+01	7.834000e+01	7.840000e+01

Part 2 - Number of Unique Sequences

In [7]:

```
df['timestamp'] =  pd.to_datetime(df["timestamp"])
df_temp = df[['user','class','timestamp']]
```

In [8]:

```
start=time.time()
 # get time difference by Row[i] - Row[i-1]
temp = (abs(df_temp['timestamp'][1:].reset_index(drop=True) - df_temp['timestamp'][:-1])
> timedelta(seconds = 10))
 # Changing mode
temp = temp | (df_temp['class'][1:].reset_index(drop=True) != df_temp['class'][:-1])
df_temp['gap'] = pd.concat([pd.DataFrame(data = [True]), temp  ] ).reset_index(drop=True
)
```

```
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:6: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_g
uide/indexing.html#returning-a-view-versus-a-copy
```

Per user per trasportation mode, No. of Unique Sequences

In [9]:

```
# Grouping dataset based on
df_temp2 = (df_temp.groupby(['user','class','gap']).count()).reset_index()
# Findng no. of unique sequences
df_temp2 = df_temp2[df_temp2.gap != False]
# taking 3 columns for simplicity
df_temp2 = df_temp2[['user','class','timestamp']]
df_temp2 = df_temp2.rename(columns={"timestamp":"Sequences"})
df_temp2 = df_temp2.reset_index(drop=True).groupby(["user","class","Sequences"]).count()
```

```
#dropping index
pd.set_option('display.max_rows', len(df_temp2))
display(df_temp2)
pd.reset_option('display.max_rows')
end=time.time()
print("Time to run the code :" ,end-start)
```

user	class	Sequences
a2d80ed662f34d32951eb1c6ed076c313e358b73	bus	13
a526f3566e9c9024dfa7378eb4291d787a09fd37	car	15
	walk	19
a59868c6eb3645eedbb343ce8c336ec6f2ef2324	bike	39
	bus	27
	car	68
	walk	12
a92dee88f61123f923dccec01eeecf1a81953b36	bus	4
ac4c17afeb69b39169eb301ab592696a8f353976	car	20
	walk	58
adaaae1a67ea9e43abd60ba945eccda0cb8821e0	bus	22
	car	17
	walk	10
b138d165100ef60bc793cac143742eb5aea4d6ba	car	9
b45157069942d01310c3e7b74034166717bb25f9	car	3
	walk	2
b7b165e5637b5a0226068d907748f4bbfc61a320	car	194
	walk	10
c453226e3616ae821cdcb38f38481c2a20f2482f	bike	169
	bus	291
c5702d34b238fe68683f818e82cd3a3cd8a16366	bike	15
	bus	14
	walk	129
ca7950f223a8037b897d0547075dc138f9e43b20	walk	3
cace4ec0999436917986b4fa6e9317262c897bc2	car	72
cbde60baea002b694ecf2a3ff2d95be16b00efe1	bus	4
ce39f5d0705695fcd70a04ba6d84ac6beecd6f9c	bus	22
	car	80
d429974540bfd38c3367fe9f0c8682775ff4fa18	bus	6
	car	132
	walk	2
d7a1230d94f91a32cc079809748e52e8a4a6a22f	bike	152
	train	13
	walk	6
d7dd12d83c81574137f858034b99f4cc83ab0718	car	147
d8c047eaaee204b7b5cd71e2d67308b87b038ed3	car	12
	walk	24
dc0bdce306ec3b624fe0e6ecd1ffbd82cb970120	bike	115
	car	32

user	class	Sequences
	walk	5
dd82e3df4bebc74ed6b67877be79e29f401c16a3	car	68
	walk	2
dde95e125d89843f7032baa734ee4d34ec775aaf	bus	5
	car	2
	walk	8
de9892b879c83ea3d24fb4560873107cc4e86d48	car	114
	walk	36
dfcfc0404691b73b69884073159f90843f2ac35b	bus	50
	car	108
	walk	155
e429a95c532f1117130c11e4a18379d84fa4ffa9	bus	40
	car	39
eb9e7854290fd6ea9ebaf448b640fc1f1dbeb076	bus	2
	train	1
	walk	2
ecfb0929250fb6dda66a4065441230ab27f094e5	car	158
	e-bike	16
	train	1
ed623d28c1e0071632a6110b8f8ed93f8af78b99	bus	10
	car	117
	walk	4
f1b7331b66e404c11eebb22933e733117bbb12c9	bike	172
	car	139
	walk	73
f5edd999397145a2ec1b244226fc83f99631760c	bus	16
	walk	13
f7ae1ce141c26db40ea8b090fb568a0c965310aa	car	2
faae5be800be2dfa897eea0bd2e5988cd53c4ec0	bike	136
	car	10
	walk	35

```
Time to run the code : 1.8916699886322021
```

Part 3 - Time Window Partition

In [10]:

```
df = pd.read_csv(DATASET_DIR)
df['timestamp'] =  df['timestamp'].astype('datetime64[s]')
```

In [11]:

```
start=time.time()
def helper_func(temp):
    temp = temp["timestamp"]
    temp = pd.DataFrame(data = temp).set_index("timestamp")
    temp["val"] = np.ones(len(temp))
    temp = temp.groupby(temp.index).count()
    temp = temp.resample('5s', origin='start').count()
    return len(temp[temp.val != 0])
```

In [14]:

```
# preprocessing data
df_temp = df[['user','class','timestamp']]
temp = (abs(df_temp['timestamp'][1:].reset_index(drop=True) - df_temp['timestamp'][:-1])
> timedelta(seconds = 10))
df_temp['gap'] = pd.concat([pd.DataFrame(data = [True]), temp  ] ).reset_index(drop=True
)
df_temp2 = df_temp[df_temp["gap"] == True]
df_temp2 = (df_temp2.groupby(['user','class','gap']).apply(lambda x : x)).reset_index().
drop(['gap'], axis=1)
df_temp2["end_timestamp"] = df_temp.reset_index()["timestamp"].iloc[(df_temp2["index"]-1
).to_numpy()[1:]].reset_index(drop=True)
df_temp2["end_timestamp"].iloc[-1] = df["timestamp"].iloc[-1]
df_temp2[">than5sec"] = ((df_temp2["end_timestamp"] - df_temp2["timestamp"])  >= timedel
ta(seconds = 5))
df_temp2["start_index"] = (df_temp2["index"].to_numpy())
df_temp2["end_index"] = np.concatenate((((df_temp2["index"]-1).to_numpy()[1:]),[len(df)-
1]),axis = 0)
# starting and ending of each sequence
df_temp3 = df_temp2[df_temp2[">than5sec"] == True]
a = list(range(df_temp3["start_index"].iloc[0] , df_temp3["end_index"].iloc[0]-df_temp3[
"start_index"].iloc[0]+1 ))
for i in range(1,len(df_temp3)):
    a.extend(list(range(df_temp3["start_index"].iloc[i] , df_temp3["end_index"].iloc[i]
+1) ))
df6 = df.iloc[a]

df_temp3 = pd.DataFrame(df6.groupby(["user","class"]).apply(helper_func))
df_temp3 = df_temp3.reset_index().rename(columns={0:"#5_SecWindowSequences"}).groupby(["
user","class","#5_SecWindowSequences"]).count()
df_temp3 = df_temp3.reset_index().groupby(["class"]).sum().reset_index()
display(df_temp3)
end=time.time()
print("Time to run the code :" ,end-start)
```

```
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:4: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_g
uide/indexing.html#returning-a-view-versus-a-copy
  after removing the cwd from sys.path.
/usr/local/lib/python3.6/dist-packages/pandas/core/indexing.py:670: SettingWithCopyWarnin
g:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_g
uide/indexing.html#returning-a-view-versus-a-copy
  iloc._setitem_with_indexer(indexer, value)
```

	class	#5_SecWindowSequences
0	bike	2958
1	bus	10543
2	car	20419
3	e-bike	78
4	train	594
5	walk	5825

```
Time to run the code : 38.75357675552368
```

Part 4 - Feature Engineering

Extracting statistical features

In [15]:

```
def feature_extraction(temp):
    return temp.set_index("timestamp").resample('5s', origin='start').agg({'x':['mean','
max','min','std'],'y':['mean','max','min','std'],'z':['mean','max','min','std']})
```

In [16]:

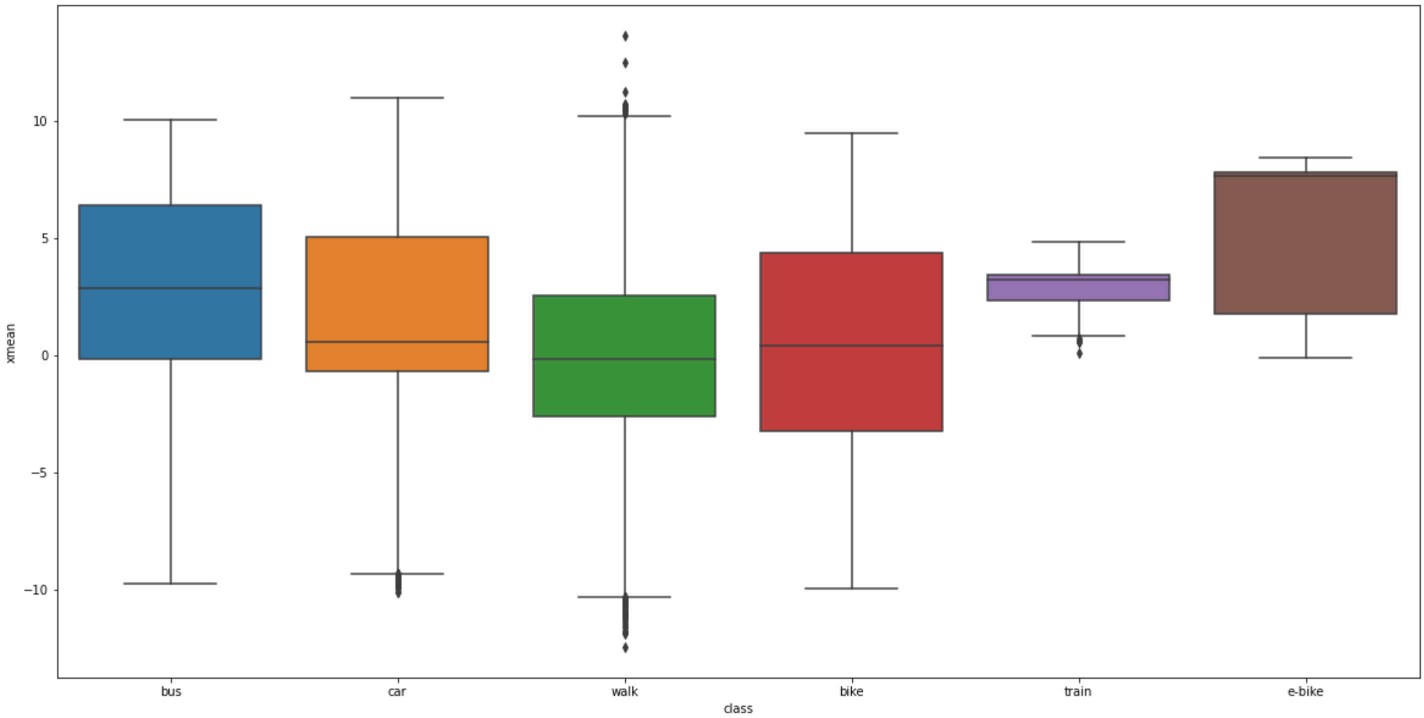
```
df_temp3 = pd.DataFrame(df6.groupby(["user","class"]).apply(feature_extraction)).reset_i
ndex().dropna()
df_temp3.columns = [''.join(col).strip() for col in df_temp3.columns.values]
df_temp3.head()
print(df_temp3.shape)
```

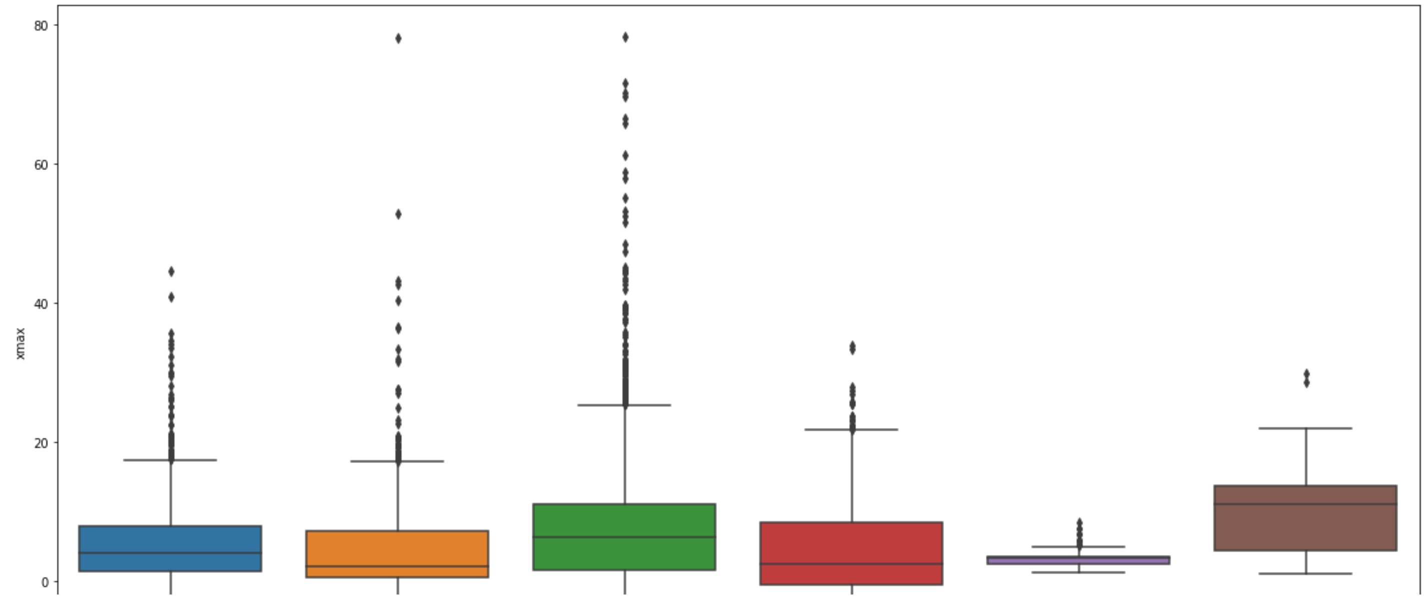
```
(40366, 15)
```

Box Plots

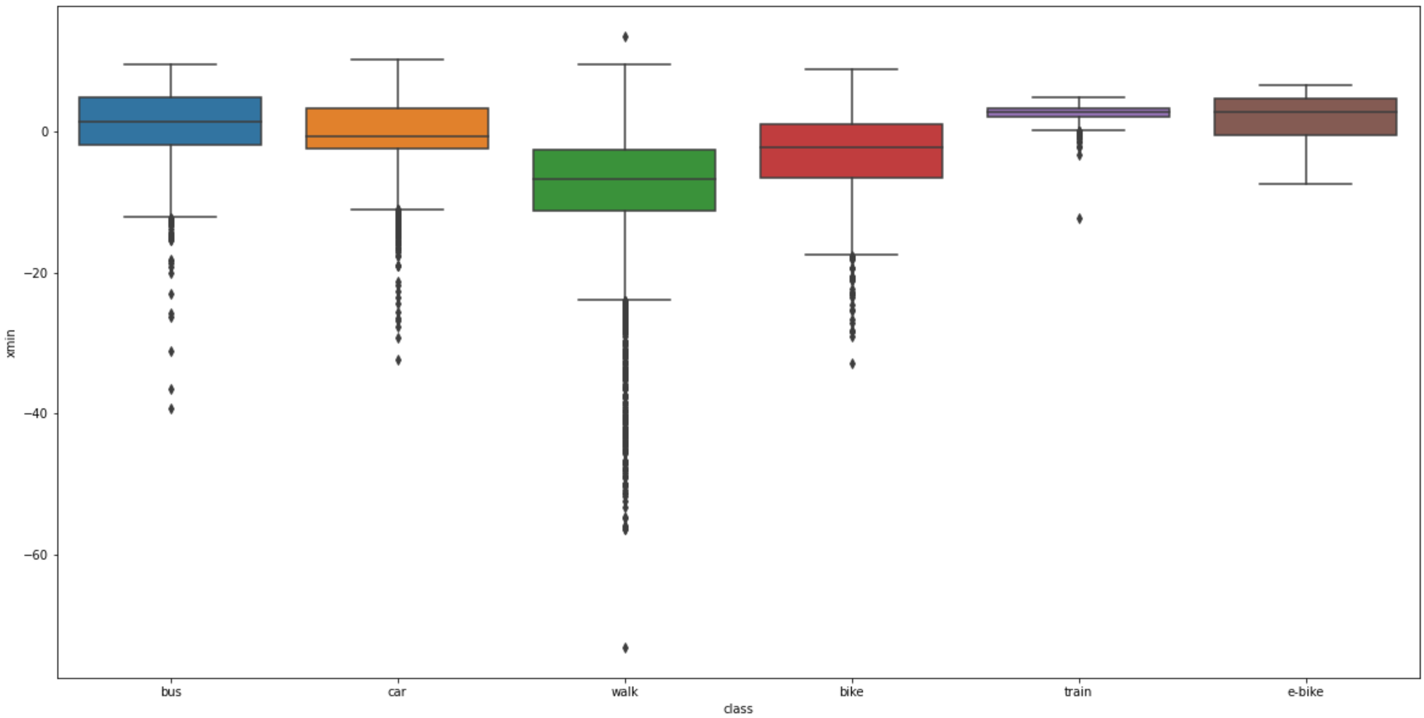
In [34]:

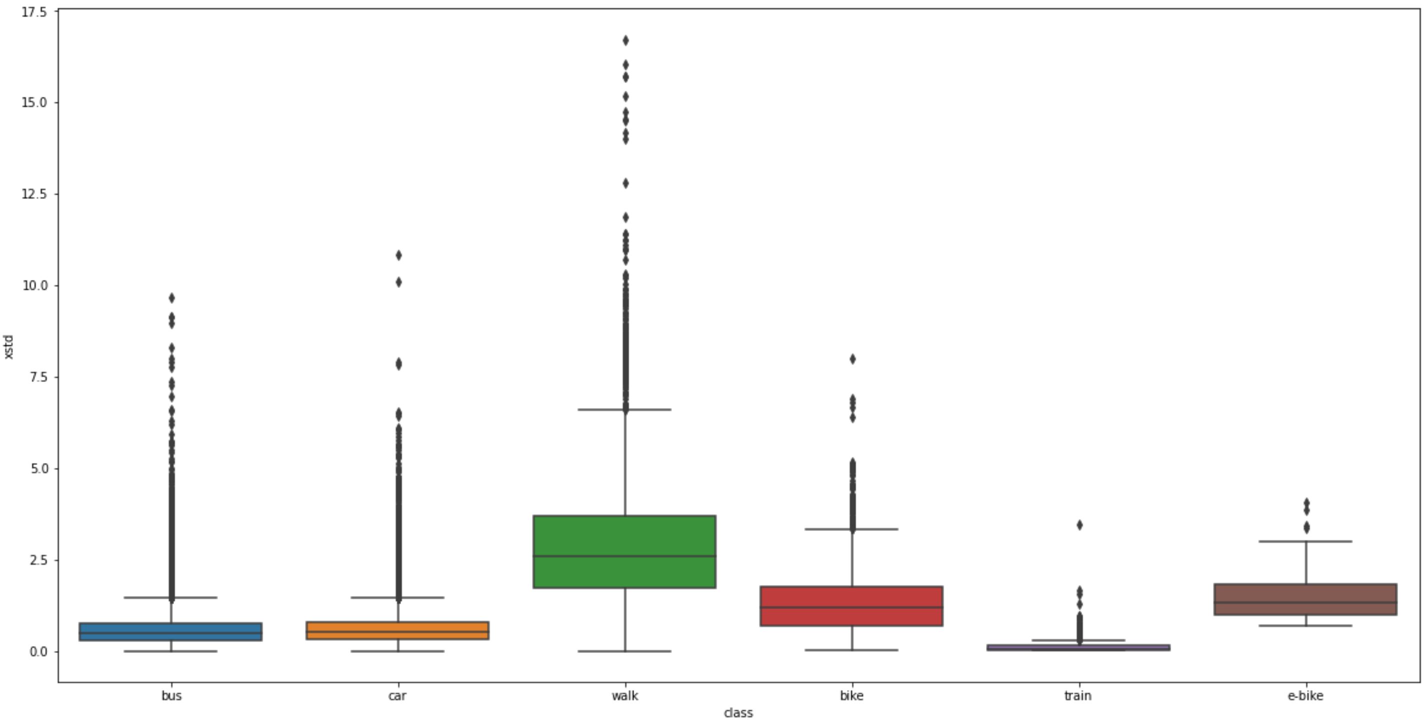
```
# Box Plots
fig, axes = plt.subplots(nrows=12, ncols=1, figsize=(20,12*12))
for i in range(3,15):
    sns.boxplot(x=df_temp3["class"], y=df_temp3.iloc[:,i], data=df_temp3, ax=axes[i-3])
```

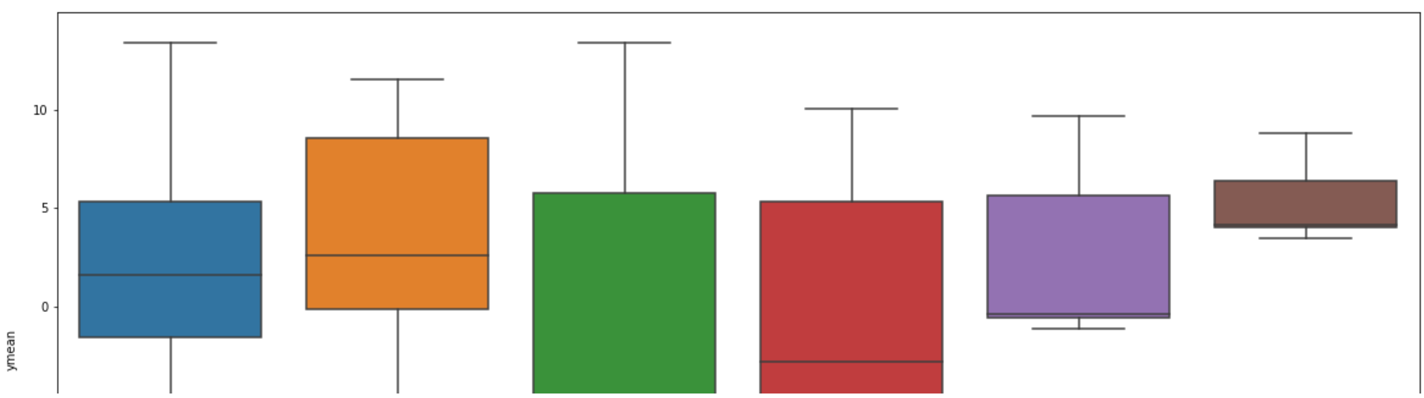


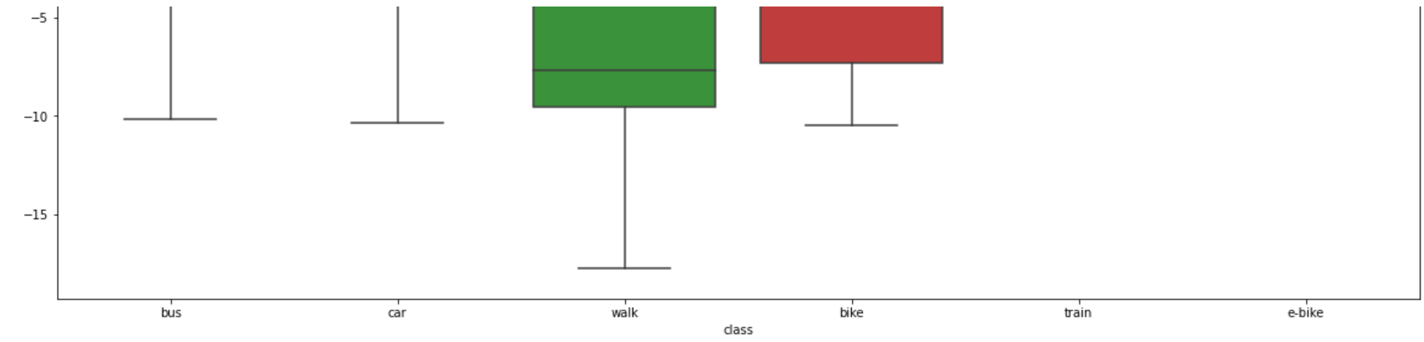



bus
car
walk
bike
train
e-bike
class

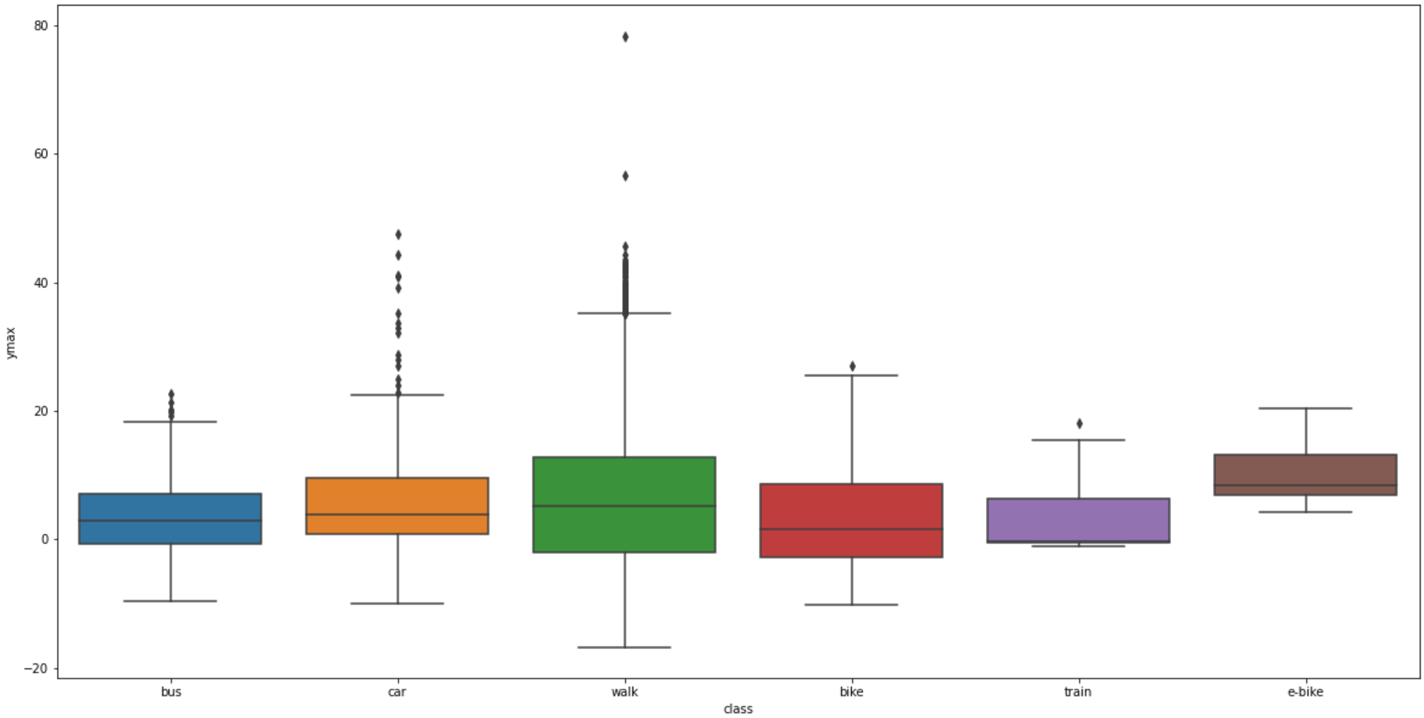

0
−20
−40
−60
xmin
bus
car
walk
bike
train
e-bike
class


17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
xstd
bus
car
walk
bike
train
e-bike
class

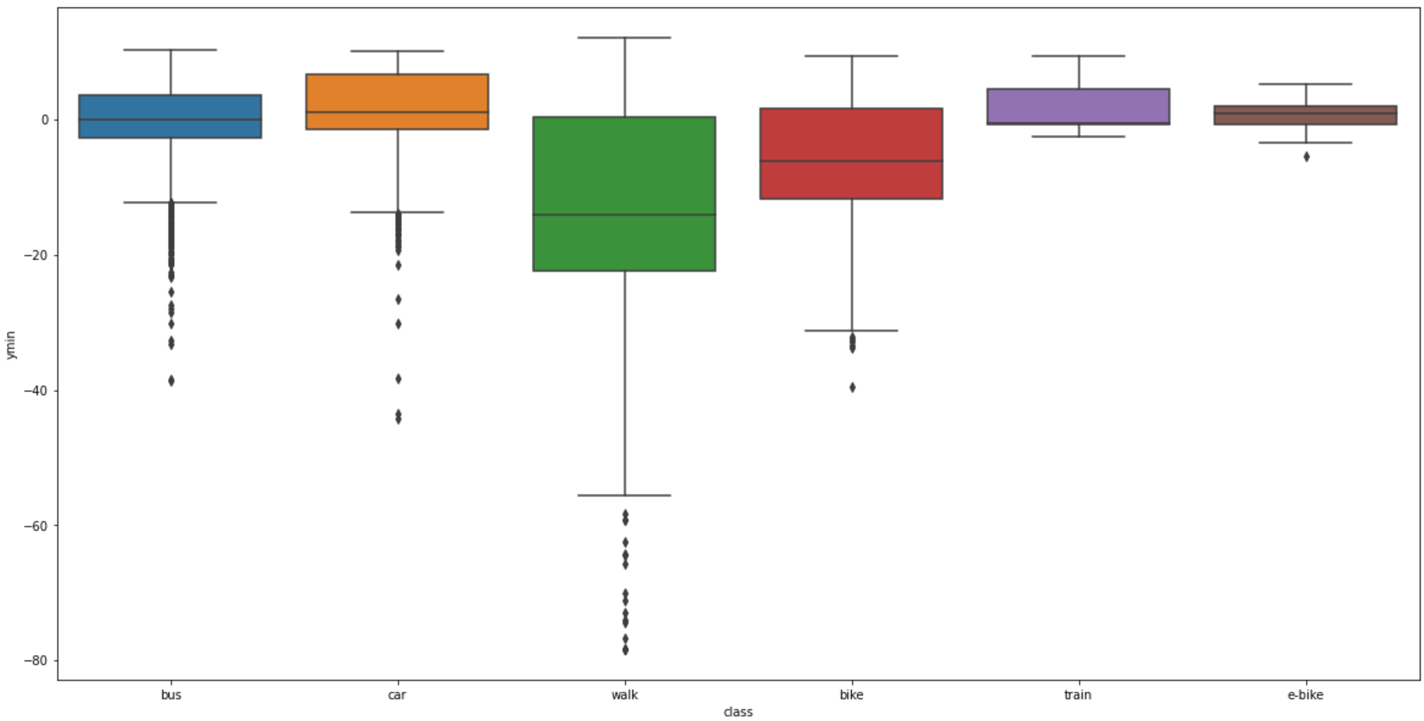

10
5
0
ymean



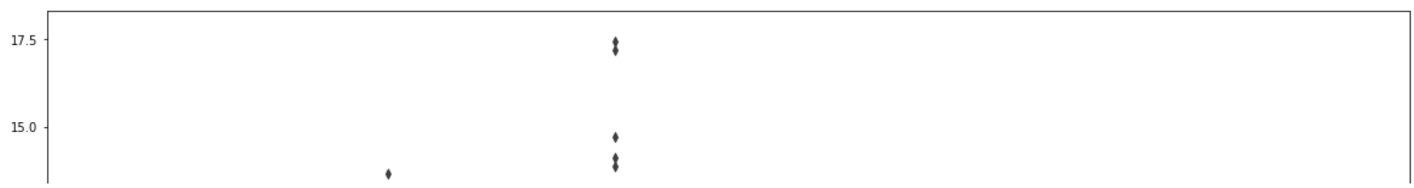
−5
−10
−15
bus
car
walk
bike
train
e-bike
class



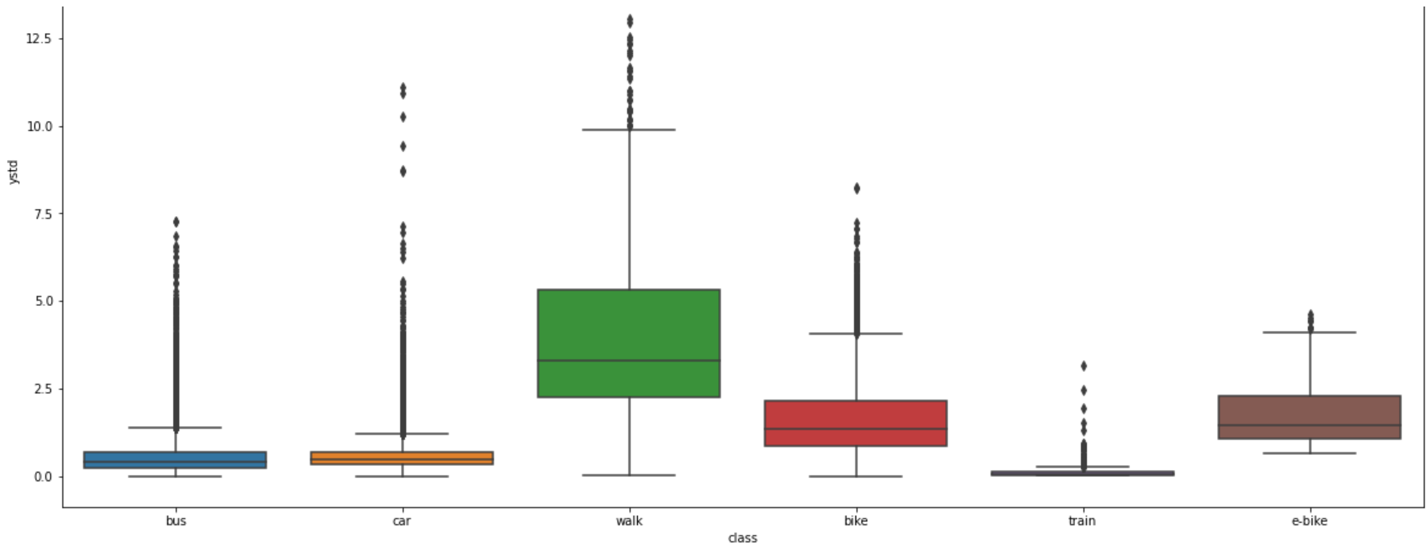
80
60
40
20
0
−20
ymax
bus
car
walk
bike
train
e-bike
class

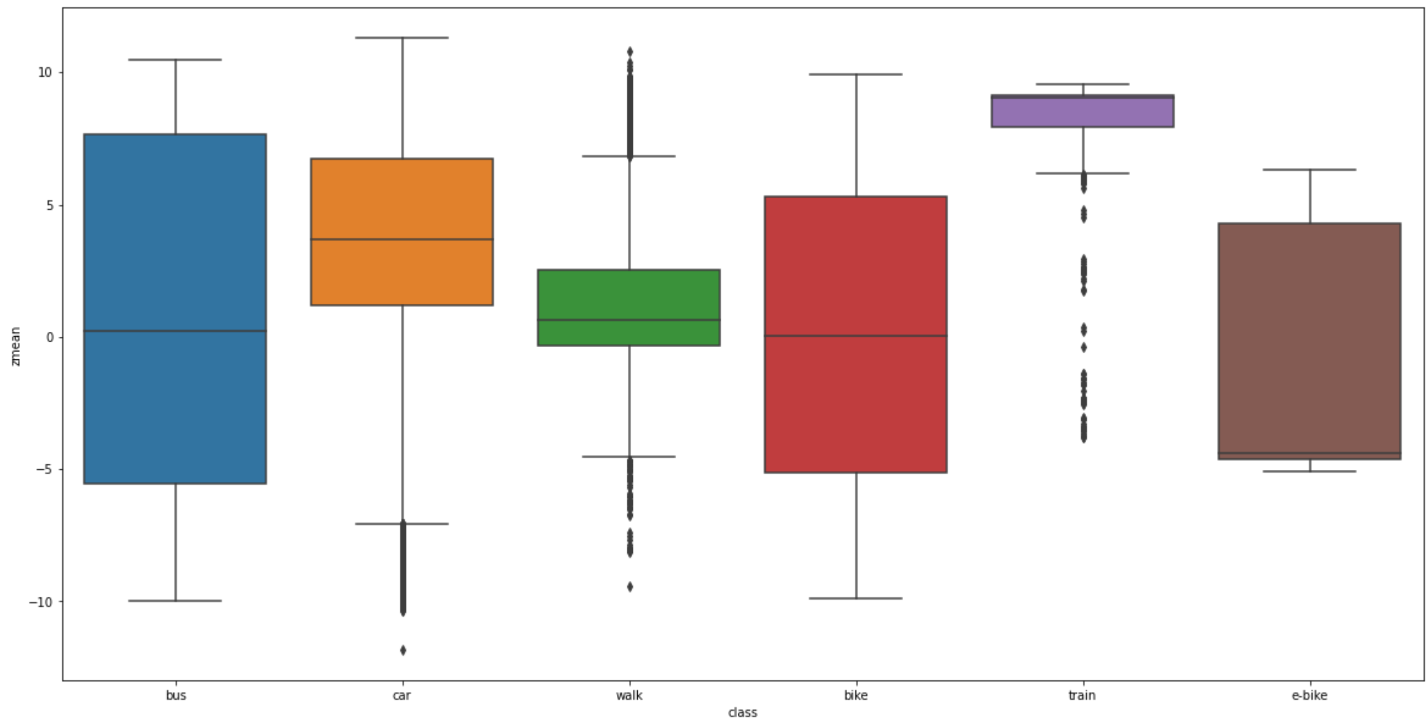


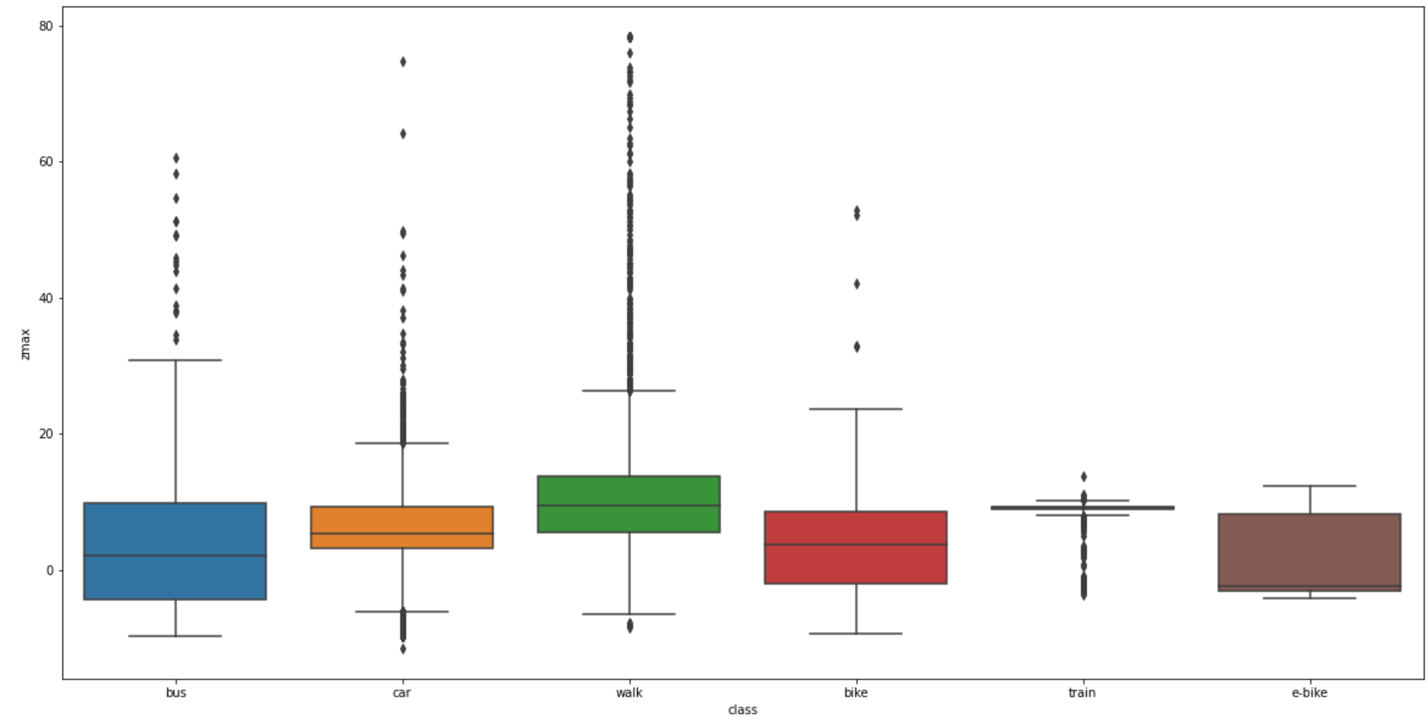
0
−20
−40
−60
−80
ymin
bus
car
walk
bike
train
e-bike
class

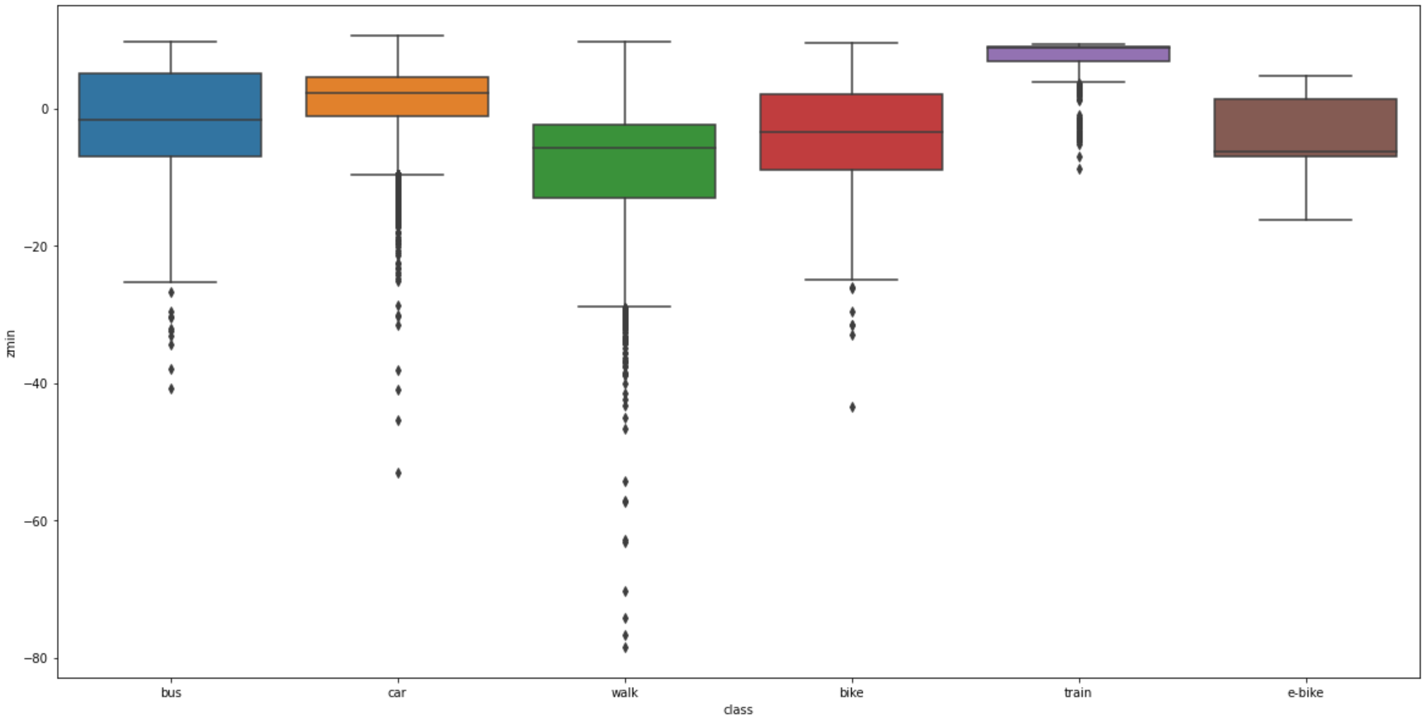


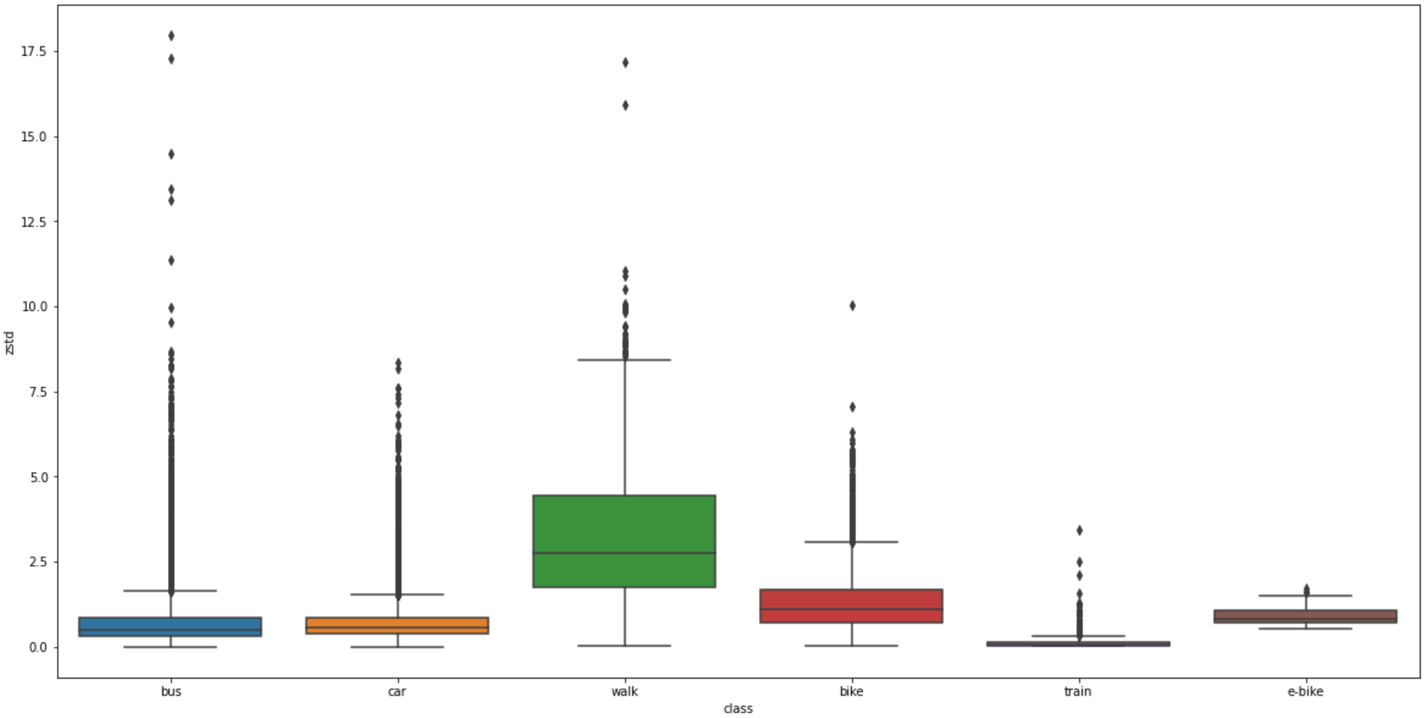
17.5
15.0


12.5
10.0
7.5
5.0
2.5
0.0
ystd
bus
car
walk
bike
train
e-bike
class


10
5
0
−5
−10
zmean
bus
car
walk
bike
train
e-bike
class


80
60
40
20
0
zmax
bus
car
walk
bike
train
e-bike
class





Part 5 - Creating Balanced Dataset

In [18]:

```
# Choosing 78 rows from each mode randomly
MinDataPoints = min(df_temp3.groupby(['class']).apply(lambda x: len(x)))
print("Minimum Data Points in any Transportatation Mode => ", MinDataPoints)

def fun2(temp):
    return temp.sample(n = 78)
df_new = df_temp3.groupby(["class"]).apply(fun2)
df_new =  df_new.reset_index(drop=True).iloc[:,1:].drop('timestamp',axis = 1).rename(col
umns={'class':'target'})
pd.DataFrame(df_new.groupby(["target"]).apply(lambda x:len(x))).rename(columns={0:"#Data
Points"}).reset_index()
```

```
Minimum Data Points in any Transportatation Mode =>  78
```

Out[18]:

	target	#DataPoints
0	bike	78
1	bus	78
2	car	78
3	e-bike	78
4	train	78
5	walk	78

In [19]:

```
df_new.shape
```

Out[19]:

```
(468, 13)
```

part 6 - Splitting dataset

Splitting

In [20]:

```
X = df_new.drop('target', axis=1)
Y = df_new['target']
```

In [21]:

```
from sklearn.model_selection import train_test_split

x, x_test, y, y_test = train_test_split (X, Y, test_size=0.2, train_size=0.8)
x_train, x_cv, y_train, y_cv = train_test_split(x,y, test_size = 0.25, train_size =0.75)
```

In [22]:

```
print('No. of Datapoints:')
print('Training = ', len(x_train))
print('Cross Validation = ', len(x_cv))
print('Testing = ', len(x_test))
```

```
No. of Datapoints:
Training =  280
Cross Validation =  94
Testing =  94
```

Part 7 - ML Model

LogRegr., SVM, decision tree and random forest classifier

In [23]:

```
# Turn the values into an array for feeding the classification algorithms.
x = x.values
x_train = x_train.values
x_test = x_test.values
x_cv = x_cv.values
y = y.values
y_train = y_train.values
y_test = y_test.values
y_cv = y_cv.values
```

In [24]:

```
from sklearn.linear_model import LogisticRegression
from sklearn.svm import SVC
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import precision_score, recall_score, f1_score, roc_auc_score, accur
acy_score, classification_report, confusion_matrix
from sklearn.model_selection import cross_val_score, KFold
from collections import Counter
from sklearn.pipeline import make_pipeline
import collections
import warnings
warnings.filterwarnings("ignore")
```

In [25]:

```
classifiers = {
    "LogisiticRegression": LogisticRegression(),
    "Support Vector Classifier": SVC(kernel='linear', C=1),
    "Decision Tree Classifier": DecisionTreeClassifier(),
    "Random Forest Classifier": RandomForestClassifier()
}

classrep = []
confusionmatrices = {}
predicts = {}
kfold = KFold(n_splits=4, random_state=42)
for key, classifier in classifiers.items():
    classifier.fit(x_train, y_train)
    results = cross_val_score(classifier, x, y, cv = kfold)
    print("Classifier: "+classifier.__class__.__name__+" has a cross val score Accuracy:
%.3f%% (%.3f%%)" % (results.mean()*100.0, results.std()*100.0))
    predictions = classifier.predict(x_test)
    print('Classification Report of ',key,':\n',classification_report(y_test, prediction
s))
    predicts[key] = predictions
    classrep.append(classification_report(y_test, predictions));
    confusionmatrices[key] = confusion_matrix(y_test,predictions);
```

```
Classifier: LogisticRegression has a cross val score Accuracy: 65.763% (2.441%)
Classification Report of  LogisiticRegression :
               precision    recall  f1-score   support

        bike       0.47      0.39      0.42        18
         bus       0.35      0.32      0.33        19
         car       0.67      0.50      0.57        20
      e-bike       0.71      0.94      0.81        18
       train       0.67      1.00      0.80         8
        walk       0.45      0.45      0.45        11

    accuracy                           0.56        94
   macro avg       0.55      0.60      0.57        94
weighted avg       0.55      0.56      0.55        94

Classifier: SVC has a cross val score Accuracy: 68.706% (2.451%)
Classification Report of  Support Vector Classifier :
               precision    recall  f1-score   support

        bike       0.42      0.44      0.43        18
         bus       0.47      0.47      0.47        19
         car       0.62      0.50      0.56        20
      e-bike       0.77      0.94      0.85        18
       train       0.89      1.00      0.94         8
        walk       0.33      0.27      0.30        11

    accuracy                           0.59        94
   macro avg       0.59      0.61      0.59        94
weighted avg       0.57      0.59      0.57        94

Classifier: DecisionTreeClassifier has a cross val score Accuracy: 59.326% (6.660%)
Classification Report of  Decision Tree Classifier :
               precision    recall  f1-score   support
```

```
        bike       0.50      0.50      0.50        18
         bus       0.47      0.42      0.44        19
         car       0.57      0.60      0.59        20
      e-bike       0.85      0.94      0.89        18
       train       0.83      0.62      0.71         8
        walk       0.58      0.64      0.61        11

    accuracy                           0.62        94
   macro avg       0.63      0.62      0.62        94
weighted avg       0.61      0.62      0.61        94

Classifier: RandomForestClassifier has a cross val score Accuracy: 76.733% (2.917%)
Classification Report of  Random Forest Classifier :
               precision    recall  f1-score   support

        bike       0.56      0.56      0.56        18
         bus       0.71      0.53      0.61        19
         car       0.71      0.75      0.73        20
      e-bike       0.85      0.94      0.89        18
       train       0.89      1.00      0.94         8
        walk       0.67      0.73      0.70        11

    accuracy                           0.72        94
   macro avg       0.73      0.75      0.74        94
weighted avg       0.72      0.72      0.72        94
```

Artificial Neural Network

In [26]:

```
# Implementing ANN
# multi-class classification with Keras
from keras.models import Sequential
from keras.layers import Dense
from keras.wrappers.scikit_learn import KerasClassifier
from keras.utils import np_utils
from sklearn.model_selection import cross_val_score
from sklearn.model_selection import KFold
from sklearn.preprocessing import LabelEncoder
from sklearn.pipeline import Pipeline
```

In [27]:

```
X = df_new.drop('target', axis=1)
Y = df_new['target']
```

In [28]:

```
encoder = LabelEncoder()
encoder.fit(Y)
encoded_Y = encoder.transform(Y)
# convert integers to dummy variables (i.e. one hot encoded)
dummy_y = np_utils.to_categorical(encoded_Y)
```

In [29]:

```
from sklearn.model_selection import train_test_split

x, x_test, y, y_test = train_test_split (X, dummy_y, test_size=0.2, train_size=0.8)
```

In [30]:

```
print(x.shape)
print(y.shape)
```

```
(374, 12)
(374, 6)
```

In [31]:

```
n_inputs = x.shape[1]
y_out = y.shape[1]

# Defining Model
def baseline_model():
    model = Sequential()
    model.add(Dense(n_inputs, input_shape=(n_inputs, ), activation='relu'))
    model.add(Dense(32, activation='relu'))
    model.add(Dense(y_out, activation='softmax'))
    # Compile model
    model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'
])
    return model
```

In [33]:

```
# Fitting and cross-validating ANN
estimator = KerasClassifier(build_fn=baseline_model, epochs=100, batch_size=5, verbose=0
)
kfold = KFold(n_splits=5, shuffle=True)
results = cross_val_score(estimator, x, y, cv=kfold)
print("Neural Network Accuracy: %.2f%% (std. dev - %.2f%%)" % (results.mean()*100, resul
ts.std()*100))
```

```
Neural Network Accuracy: 74.86% (std. dev - 4.26%)
```