Logistics_Dataset_ML_by_Diptyajit_Das

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0.0.1 Problem Statement

The largest and fastest-growing fully integrated player in India's logistics sector by revenue in Fiscal 2021 aims to build the operating system for commerce. This ambition is driven by their commitment to world-class infrastructure, superior logistics operations, and cutting-edge engineering and technology capabilities. The Data team plays a pivotal role by leveraging data to enhance the quality, efficiency, and profitability of the business, setting it apart from competitors.

To achieve these objectives, the company needs to process and understand the vast amounts of data generated from its data engineering pipelines. The tasks involved include:

1. **Data Cleaning and Sanitization**: Raw data collected from various sources often contains noise, missing values, and inconsistencies. The first step is to clean and sanitize this data to ensure its quality and reliability.

2. **Feature Engineering**: Transforming raw data into meaningful features is crucial for building effective models. This step involves manipulating and extracting useful information from raw fields, which can be used as input for machine learning models.

3. **Data Analysis and Interpretation**: Understanding the patterns, trends, and insights within the raw data is essential. This involves exploratory data analysis (EDA) to uncover hidden patterns and relationships.

4. **Forecasting Model Development**: Using the processed and engineered features, the data science team aims to build robust forecasting models. These models will help in predicting future trends, demands, and other key metrics that drive business decisions.

The goal is to develop a comprehensive approach that addresses the following key aspects:

- **Data Cleaning**: Removing noise, handling missing values, and correcting inconsistencies in the data.
- **Feature Engineering**: Creating new features and transforming existing ones to improve model performance.
- **Exploratory Data Analysis**: Gaining insights from the data through visualization and statistical analysis.
- **Forecasting**: Developing and validating predictive models to forecast future trends and metrics.

By addressing these tasks, the company aims to leverage data to drive strategic decisions, optimize operations, and maintain its competitive edge in the logistics industry. This project will involve a series of steps including data preprocessing, feature extraction, exploratory analysis, and model building, all aimed at transforming raw data into actionable insights and accurate forecasts.

0.0.2 Data Dictionary

This data dictionary provides detailed descriptions of the fields present in the dataset.

Field Name	Description
data	Indicates whether the data is for testing or training purposes.
trip_creation_time	Timestamp of when the trip was created.
route_schedule_uuid	Unique identifier for a particular route schedule.
route_type	Type of transportation used.
FTL	Full Truck Load: Shipments that get to the destination sooner as the truck makes no other pickups or drop-offs along the way.
Carting	Handling system consisting of small vehicles (carts).
trip_uuid	Unique ID given to a particular trip (A trip may include different source and destination centers).
source_center	Source ID of trip origin.
source_name	Source Name of trip origin.
destination_center	Destination ID of trip.
destination_name	Destination Name of trip.
od_start_time	Trip start time.
od_end_time	Trip end time.
start_scan_to_end_scan	Time taken to deliver from source to destination.
is_cutoff	Unknown field.
cutoff_factor	Unknown field.
cutoff_timestamp	Unknown field.
actual_distance_to_destination	Distance in kilometers between the source and destination warehouse.
actual_time	Actual time taken to complete the delivery (cumulative).
osrm_time	Time calculated by an open-source routing engine, which computes the shortest path between points in a given map (includes usual traffic and distance) (cumulative).
osrm_distance	Distance calculated by an open-source routing engine, which computes the shortest path between points in a given map (includes usual traffic and distance) (cumulative).
factor	Unknown field.
segment_actual_time	Time taken by a segment (subset) of the package delivery.
segment_osrm_time	OSRM segment time, which is the time taken by a segment (subset) of the package delivery, as calculated by the open-source routing engine.
segment_osrm_distance	OSRM segment distance, which is the distance covered by a segment (subset) of the package delivery, as calculated by the open-source routing engine.
segment_factor	Unknown field.

[1]:

```python
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from scipy.stats import ttest_ind
from sklearn.ensemble import RandomForestRegressor, StackingRegressor
from sklearn.model_selection import RandomizedSearchCV
from xgboost import XGBRegressor
from sklearn.linear_model import Ridge
from sklearn.metrics import mean_squared_error
```

[2]:

```python
df = pd.read_csv('logistics_data.txt')
```

- Removing null values

[3]:

```python
df = df.dropna(how='any')
df = df.reset_index(drop=True)
```

- Converting time columns into pandas datatime

[4]:

```python
df['od_start_time'] =  pd.to_datetime(df['od_start_time'])
df['od_end_time']  =  pd.to_datetime(df['od_end_time'])
```

[5]:

```python
df.head(5)
```

[5]:

```
       data          trip_creation_time  \
0  training  2018-09-20 02:35:36.476840
1  training  2018-09-20 02:35:36.476840
2  training  2018-09-20 02:35:36.476840
3  training  2018-09-20 02:35:36.476840
4  training  2018-09-20 02:35:36.476840

                                 route_schedule_uuid route_type  \
0  thanos::sroute:eb7bfc78-b351-4c0e-a951-fa3d5c3…    Carting
1  thanos::sroute:eb7bfc78-b351-4c0e-a951-fa3d5c3…    Carting
2  thanos::sroute:eb7bfc78-b351-4c0e-a951-fa3d5c3…    Carting
3  thanos::sroute:eb7bfc78-b351-4c0e-a951-fa3d5c3…    Carting
4  thanos::sroute:eb7bfc78-b351-4c0e-a951-fa3d5c3…    Carting

                 trip_uuid source_center                 source_name  \
0  trip-153741093647649320  IND388121AAA  Anand_VUNagar_DC (Gujarat)
1  trip-153741093647649320  IND388121AAA  Anand_VUNagar_DC (Gujarat)
2  trip-153741093647649320  IND388121AAA  Anand_VUNagar_DC (Gujarat)
3  trip-153741093647649320  IND388121AAA  Anand_VUNagar_DC (Gujarat)
4  trip-153741093647649320  IND388121AAA  Anand_VUNagar_DC (Gujarat)

  destination_center               destination_name  \
0       IND388620AAB  Khambhat_MotvdDPP_D (Gujarat)
1       IND388620AAB  Khambhat_MotvdDPP_D (Gujarat)
2       IND388620AAB  Khambhat_MotvdDPP_D (Gujarat)
3       IND388620AAB  Khambhat_MotvdDPP_D (Gujarat)
4       IND388620AAB  Khambhat_MotvdDPP_D (Gujarat)

               od_start_time  …           cutoff_timestamp  \
0 2018-09-20 03:21:32.418600  …        2018-09-20 04:27:55
```

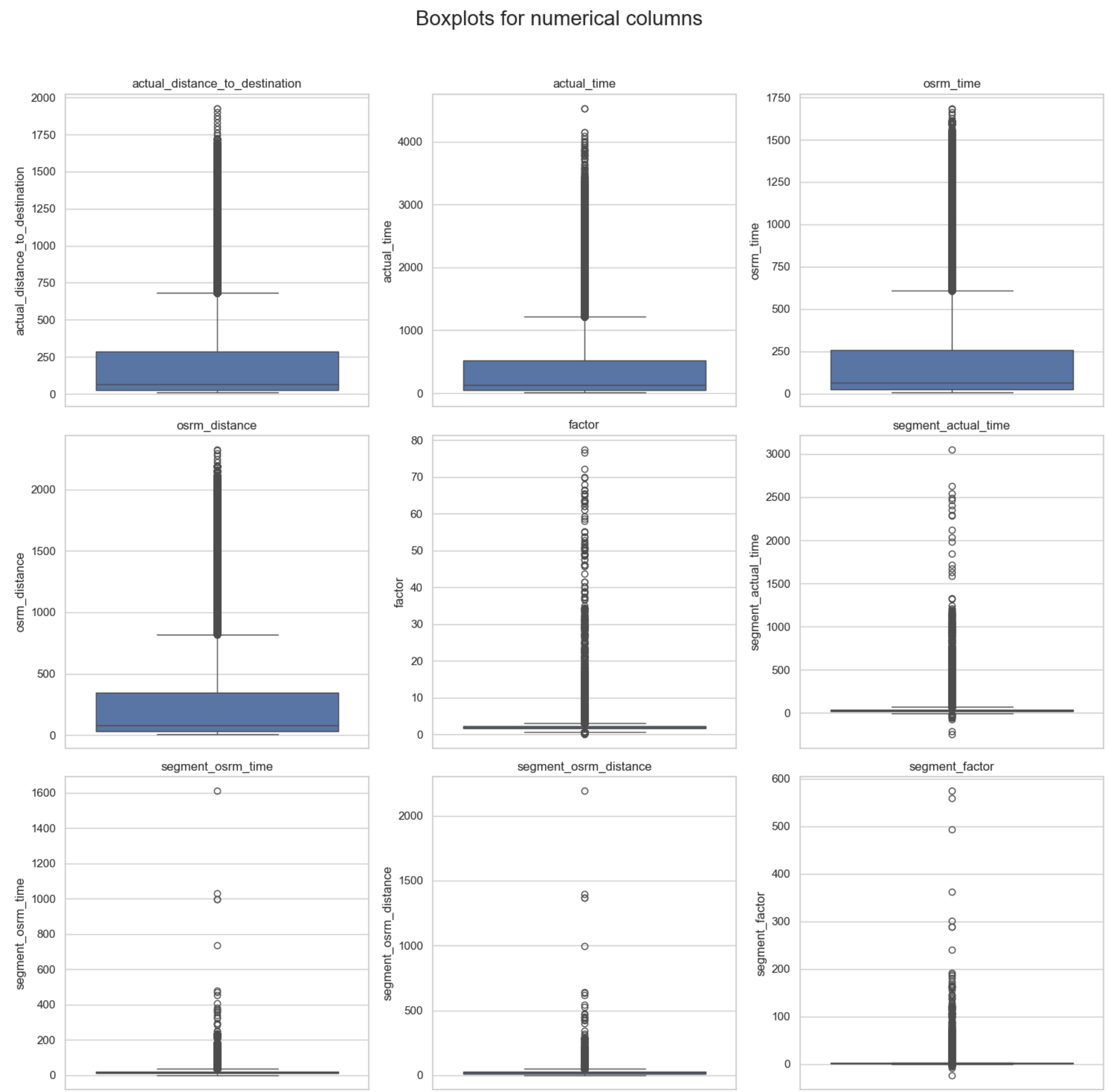
```
1 2018-09-20 03:21:32.418600  …         2018-09-20 04:17:55
2 2018-09-20 03:21:32.418600  …  2018-09-20 04:01:19.505586
3 2018-09-20 03:21:32.418600  …         2018-09-20 03:39:57
4 2018-09-20 03:21:32.418600  …         2018-09-20 03:33:55

   actual_distance_to_destination  actual_time  osrm_time osrm_distance  \
0                       10.435660         14.0       11.0       11.9653
1                       18.936842         24.0       20.0       21.7243
2                       27.637279         40.0       28.0       32.5395
3                       36.118028         62.0       40.0       45.5620
4                       39.386040         68.0       44.0       54.2181

     factor  segment_actual_time  segment_osrm_time  segment_osrm_distance  \
0  1.272727                 14.0               11.0                11.9653
1  1.200000                 10.0                9.0                 9.7590
2  1.428571                 16.0                7.0                10.8152
3  1.550000                 21.0               12.0                13.0224
4  1.545455                  6.0                5.0                 3.9153

   segment_factor
0        1.272727
1        1.111111
2        2.285714
3        1.750000
4        1.200000

[5 rows x 24 columns]
```

```
[6]: df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 144316 entries, 0 to 144315
Data columns (total 24 columns):
 #   Column                          Non-Null Count   Dtype
---  ------                          --------------   -----
 0   data                            144316 non-null  object
 1   trip_creation_time              144316 non-null  object
 2   route_schedule_uuid             144316 non-null  object
 3   route_type                      144316 non-null  object
 4   trip_uuid                       144316 non-null  object
 5   source_center                   144316 non-null  object
 6   source_name                     144316 non-null  object
 7   destination_center              144316 non-null  object
 8   destination_name                144316 non-null  object
 9   od_start_time                   144316 non-null  datetime64[ns]
 10  od_end_time                     144316 non-null  datetime64[ns]
 11  start_scan_to_end_scan          144316 non-null  float64
 12  is_cutoff                       144316 non-null  bool
 13  cutoff_factor                   144316 non-null  int64
 14  cutoff_timestamp                144316 non-null  object
 15  actual_distance_to_destination  144316 non-null  float64
 16  actual_time                     144316 non-null  float64
 17  osrm_time                       144316 non-null  float64
 18  osrm_distance                   144316 non-null  float64
 19  factor                          144316 non-null  float64
 20  segment_actual_time             144316 non-null  float64
 21  segment_osrm_time               144316 non-null  float64
 22  segment_osrm_distance           144316 non-null  float64
 23  segment_factor                  144316 non-null  float64
dtypes: bool(1), datetime64[ns](2), float64(10), int64(1), object(10)
memory usage: 25.5+ MB
```

[10]:

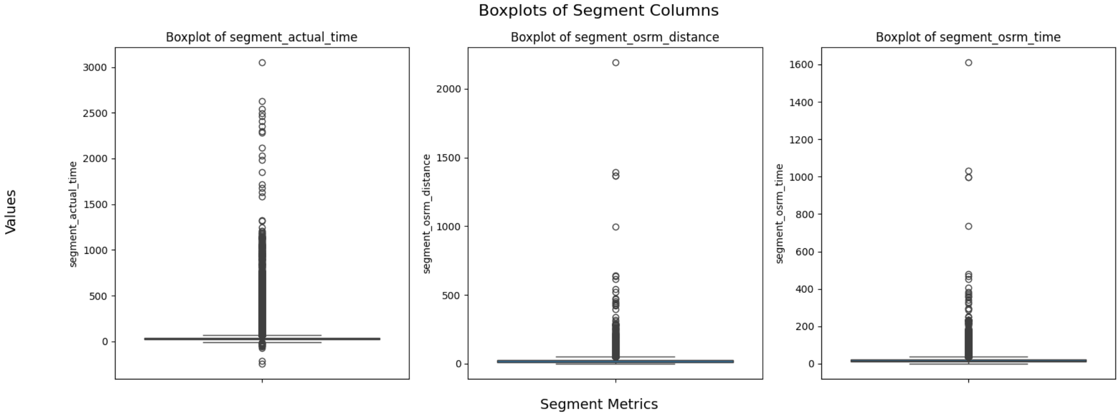
```python
columns = [
    "actual_distance_to_destination",
    "actual_time",
    "osrm_time",
    "osrm_distance",
    "factor",
    "segment_actual_time",
    "segment_osrm_time",
    "segment_osrm_distance",
    "segment_factor"
]

sns.set(style="whitegrid")

fig, axes = plt.subplots(3, 3, figsize=(15, 15))
fig.suptitle('Boxplots for numerical columns', fontsize=20)

axes = axes.flatten()

for i, column in enumerate(columns):
    sns.boxplot(data=df[column], ax=axes[i])
    axes[i].set_title(column)
    axes[i].set_xlabel('')

for j in range(len(columns), len(axes)):
    fig.delaxes(axes[j])

plt.tight_layout(rect=[0, 0, 1, 0.96])
plt.show()
```



- Grouping by sub-journey in the trip

```
[7]: df['segment_key'] = df['trip_uuid'] + df['source_center'] +␣
      ↪df['destination_center']

     segment_cols = ['segment_actual_time', 'segment_osrm_distance',␣
      ↪'segment_osrm_time']

     fig, axes = plt.subplots(1, 3, figsize=(18, 6))

     for ax, col in zip(axes, segment_cols):
         sns.boxplot(data=df, y=col, ax=ax)
         ax.set_title(f'Boxplot of {col}')
```

```
    ax.set_xlabel('')

fig.text(0.5, 0.04, 'Segment Metrics', ha='center', fontsize=14)
fig.text(0.04, 0.5, 'Values', va='center', rotation='vertical', fontsize=14)

plt.suptitle('Boxplots of Segment Columns', fontsize=16)
plt.show()

for col in segment_cols:
    df[col + '_sum'] = df.groupby('segment_key')[col].cumsum()


df[['segment_key']+[col + '_sum' for col in segment_cols]]
```



[7]:

```
                                             segment_key  \
0        trip-153741093647649320IND388121AAAIND388620AAB
1        trip-153741093647649320IND388121AAAIND388620AAB
2        trip-153741093647649320IND388121AAAIND388620AAB
3        trip-153741093647649320IND388121AAAIND388620AAB
4        trip-153741093647649320IND388121AAAIND388620AAB
…                                                    …
144311   trip-153746066843555182IND131028AABIND000000ACB
144312   trip-153746066843555182IND131028AABIND000000ACB
144313   trip-153746066843555182IND131028AABIND000000ACB
144314   trip-153746066843555182IND131028AABIND000000ACB
144315   trip-153746066843555182IND131028AABIND000000ACB

         segment_actual_time_sum  segment_osrm_distance_sum  \
0                           14.0                    11.9653
1                           24.0                    21.7243
2                           40.0                    32.5395
3                           61.0                    45.5619
```

```
4                          67.0                    49.4772
…                         …                        …
144311                     92.0                    65.3487
144312                    118.0                    82.7212
144313                    138.0                   103.4265
144314                    155.0                   122.3150
144315                    423.0                   131.1238

        segment_osrm_time_sum
0                        11.0
1                        20.0
2                        27.0
3                        39.0
4                        44.0
…                       …
144311                   94.0
144312                  115.0
144313                  149.0
144314                  176.0
144315                  185.0

[144316 rows x 4 columns]
```

- aggregating at sub-journey level

[8]:

```
create_segment_dict = {

    'data' : 'first',
    'trip_creation_time': 'first',
    'route_schedule_uuid' : 'first',
    'route_type' : 'first',
    'trip_uuid' : 'first',
    'source_center' : 'first',
    'source_name' : 'first',

    'destination_center' : 'last',
    'destination_name' : 'last',

    'od_start_time' : 'first',
    'od_end_time' : 'first',
    'start_scan_to_end_scan' : 'first',


    'actual_distance_to_destination' : 'last',
    'actual_time' : 'last',

    'osrm_time' : 'last',
    'osrm_distance' : 'last',

    'segment_actual_time_sum' : 'last',
    'segment_osrm_distance_sum' : 'last',
    'segment_osrm_time_sum' : 'last',

    }
```

- Groupby mini-trips, sorting by time

[9]:
```
segment = df.groupby('segment_key').agg(create_segment_dict).reset_index()
segment = segment.sort_values(by=['segment_key','od_end_time'], ascending=True).
 ↪reset_index()
```

[10]:
```
segment
```

[10]:
```
       index                                      segment_key      data  \
0          0  trip-153671041653548748IND209304AAAIND000000ACB  training
1          1  trip-153671041653548748IND462022AAAIND209304AAA  training
2          2  trip-153671042288605164IND561203AABIND562101AAA  training
3          3  trip-153671042288605164IND572101AAAIND561203AAB  training
4          4  trip-153671043369099517IND000000ACBIND160002AAC  training
…      …                                              …       …
26217  26217  trip-153861115439069069IND628204AAAIND627657AAA      test
26218  26218  trip-153861115439069069IND628613AAAIND627005AAA      test
26219  26219  trip-153861115439069069IND628801AAAIND628204AAA      test
26220  26220  trip-153861118270144424IND583119AAAIND583101AAA      test
26221  26221  trip-153861118270144424IND583201AAAIND583119AAA      test

               trip_creation_time  \
0      2018-09-12 00:00:16.535741
1      2018-09-12 00:00:16.535741
2      2018-09-12 00:00:22.886430
3      2018-09-12 00:00:22.886430
4      2018-09-12 00:00:33.691250
…                               …
26217  2018-10-03 23:59:14.390954
26218  2018-10-03 23:59:14.390954
26219  2018-10-03 23:59:14.390954
26220  2018-10-03 23:59:42.701692
26221  2018-10-03 23:59:42.701692

                                     route_schedule_uuid route_type  \
0      thanos::sroute:d7c989ba-a29b-4a0b-b2f4-288cdc6…        FTL
1      thanos::sroute:d7c989ba-a29b-4a0b-b2f4-288cdc6…        FTL
2      thanos::sroute:3a1b0ab2-bb0b-4c53-8c59-eb2a2c0…    Carting
3      thanos::sroute:3a1b0ab2-bb0b-4c53-8c59-eb2a2c0…    Carting
4      thanos::sroute:de5e208e-7641-45e6-8100-4d9fb1e…        FTL
```

```
…                                                  …        …
26217  thanos::sroute:c5f2ba2c-8486-4940-8af6-d1d2a6a…    Carting
26218  thanos::sroute:c5f2ba2c-8486-4940-8af6-d1d2a6a…    Carting
26219  thanos::sroute:c5f2ba2c-8486-4940-8af6-d1d2a6a…    Carting
26220  thanos::sroute:412fea14-6d1f-4222-8a5f-a517042…        FTL
26221  thanos::sroute:412fea14-6d1f-4222-8a5f-a517042…        FTL

                     trip_uuid source_center  \
0      trip-153671041653548748  IND209304AAA
1      trip-153671041653548748  IND462022AAA
2      trip-153671042288605164  IND561203AAB
3      trip-153671042288605164  IND572101AAA
4      trip-153671043369099517  IND000000ACB
…                        …           …
26217  trip-153861115439069069  IND628204AAA
26218  trip-153861115439069069  IND628613AAA
26219  trip-153861115439069069  IND628801AAA
26220  trip-153861118270144424  IND583119AAA
26221  trip-153861118270144424  IND583201AAA

                              source_name destination_center  …  \
0      Kanpur_Central_H_6 (Uttar Pradesh)       IND000000ACB  …
1      Bhopal_Trnsport_H (Madhya Pradesh)       IND209304AAA  …
2       Doddablpur_ChikaDPP_D (Karnataka)       IND562101AAA  …
3           Tumkur_Veersagr_I (Karnataka)       IND561203AAB  …
4           Gurgaon_Bilaspur_HB (Haryana)       IND160002AAC  …
…                                   …                …  …
26217  Tirchchndr_Shnmgprm_D (Tamil Nadu)       IND627657AAA  …
26218   Peikulam_SriVnktpm_D (Tamil Nadu)       IND627005AAA  …
26219        Eral_Busstand_D (Tamil Nadu)       IND628204AAA  …
26220       Sandur_WrdN1DPP_D (Karnataka)       IND583101AAA  …
26221                  Hospet (Karnataka)       IND583119AAA  …

                   od_start_time                od_end_time  \
0     2018-09-12 16:39:46.858469 2018-09-13 13:40:23.123744
1     2018-09-12 00:00:16.535741 2018-09-12 16:39:46.858469
2     2018-09-12 02:03:09.655591 2018-09-12 03:01:59.598855
3     2018-09-12 00:00:22.886430 2018-09-12 02:03:09.655591
4     2018-09-14 03:40:17.106733 2018-09-14 17:34:55.442454
…                          …                        …
26217 2018-10-04 02:29:04.272194 2018-10-04 03:31:11.183797
26218 2018-10-04 04:16:39.894872 2018-10-04 05:47:45.162682
26219 2018-10-04 01:44:53.808000 2018-10-04 02:29:04.272194
26220 2018-10-04 03:58:40.726547 2018-10-04 08:46:09.166940
26221 2018-10-04 02:51:44.712656 2018-10-04 03:58:40.726547

      start_scan_to_end_scan  actual_distance_to_destination  actual_time  \
0                     1260.0                       383.759164        732.0
1                      999.0                       440.973689        830.0
2                       58.0                        24.644021         47.0
3                      122.0                        48.542890         96.0
4                      834.0                       237.439610        611.0
…                       …                             …          …
26217                   62.0                        33.627182         51.0
26218                   91.0                        33.673835         90.0
26219                   44.0                        12.661945         30.0
26220                  287.0                        40.546740        233.0
26221                   66.0                        25.534793         42.0

       osrm_time  osrm_distance  segment_actual_time_sum  \
0          329.0       446.5496                    728.0
1          388.0       544.8027                    820.0
2           26.0        28.1994                     46.0
3           42.0        56.9116                     95.0
4          212.0       281.2109                    608.0
…            …            …                      …
26217       41.0        42.5213                     49.0
26218       48.0        40.6080                     89.0
26219       14.0        16.0185                     29.0
26220       42.0        52.5303                    233.0
26221       26.0        28.0484                     41.0

       segment_osrm_distance_sum  segment_osrm_time_sum
0                       670.6205                  534.0
1                       649.8528                  474.0
2                        28.1995                   26.0
3                        55.9899                   39.0
4                       317.7408                  231.0
…                          …                     …
26217                    42.1431                   42.0
26218                    78.5869                   77.0
26219                    16.0184                   14.0
26220                    52.5303                   42.0
26221                    28.0484                   25.0

[26222 rows x 21 columns]
```

[11]:
```
segment[segment['trip_uuid'] == 'trip-153671041653548748']
```

[11]:
```
   index                                     segment_key      data  \
0      0  trip-153671041653548748IND209304AAAIND000000ACB  training
1      1  trip-153671041653548748IND462022AAAIND209304AAA  training

           trip_creation_time  \
0  2018-09-12 00:00:16.535741
1  2018-09-12 00:00:16.535741

                                 route_schedule_uuid route_type  \
0  thanos::sroute:d7c989ba-a29b-4a0b-b2f4-288cdc6…        FTL
1  thanos::sroute:d7c989ba-a29b-4a0b-b2f4-288cdc6…        FTL

              trip_uuid source_center                         source_name  \
0  trip-153671041653548748  IND209304AAA  Kanpur_Central_H_6 (Uttar Pradesh)
1  trip-153671041653548748  IND462022AAA  Bhopal_Trnsport_H (Madhya Pradesh)

  destination_center  …              od_start_time  \
0       IND000000ACB  … 2018-09-12 16:39:46.858469
1       IND209304AAA  … 2018-09-12 00:00:16.535741

              od_end_time start_scan_to_end_scan  \
0 2018-09-13 13:40:23.123744                 1260.0
1 2018-09-12 16:39:46.858469                  999.0

   actual_distance_to_destination  actual_time  osrm_time  osrm_distance  \
0                      383.759164        732.0      329.0       446.5496
1                      440.973689        830.0      388.0       544.8027

   segment_actual_time_sum  segment_osrm_distance_sum  segment_osrm_time_sum
0                    728.0                   670.6205                  534.0
1                    820.0                   649.8528                  474.0

[2 rows x 21 columns]
```

[12]:

```
segment.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 26222 entries, 0 to 26221
Data columns (total 21 columns):
 #   Column                          Non-Null Count  Dtype
---  ------                          --------------  -----
 0   index                           26222 non-null  int64
 1   segment_key                     26222 non-null  object
 2   data                            26222 non-null  object
 3   trip_creation_time              26222 non-null  object
 4   route_schedule_uuid             26222 non-null  object
 5   route_type                      26222 non-null  object
 6   trip_uuid                       26222 non-null  object
 7   source_center                   26222 non-null  object
 8   source_name                     26222 non-null  object
 9   destination_center              26222 non-null  object
 10  destination_name                26222 non-null  object
 11  od_start_time                   26222 non-null  datetime64[ns]
 12  od_end_time                     26222 non-null  datetime64[ns]
 13  start_scan_to_end_scan          26222 non-null  float64
 14  actual_distance_to_destination  26222 non-null  float64
 15  actual_time                     26222 non-null  float64
 16  osrm_time                       26222 non-null  float64
 17  osrm_distance                   26222 non-null  float64
 18  segment_actual_time_sum         26222 non-null  float64
 19  segment_osrm_distance_sum       26222 non-null  float64
 20  segment_osrm_time_sum           26222 non-null  float64
dtypes: datetime64[ns](2), float64(8), int64(1), object(10)
memory usage: 4.2+ MB
```

0.0.3 Calculate time taken between od_start_time and od_end_time and keep it as a feature. ‘

- od_time_diff_hour is matching with start_scan_to_end_scan

[13]:

```
segment['od_time_diff_hour'] = (segment['od_end_time'] -␣
 ↪segment['od_start_time']).dt.total_seconds() / (60)
segment['od_time_diff_hour']
```

[13]:

```
0        1260.604421
1         999.505379
2          58.832388
3         122.779486
4         834.638929
            …
26217      62.115193
26218      91.087797
26219      44.174403
26220     287.474007
26221      66.933565
Name: od_time_diff_hour, Length: 26222, dtype: float64
```

[14]:

```
segment
```

[14]:

```
        index                                      segment_key      data  \
0           0  trip-153671041653548748IND209304AAAIND000000ACB  training
1           1  trip-153671041653548748IND462022AAAIND209304AAA  training
2           2  trip-153671042288605164IND561203AABIND562101AAA  training
3           3  trip-153671042288605164IND572101AAAIND561203AAB  training
4           4  trip-153671043369099517IND000000ACBIND160002AAC  training
…         …                                                …       …
26217   26217  trip-153861115439069069IND628204AAAIND627657AAA      test
26218   26218  trip-153861115439069069IND628613AAAIND627005AAA      test
26219   26219  trip-153861115439069069IND628801AAAIND628204AAA      test
26220   26220  trip-153861118270144424IND583119AAAIND583101AAA      test
26221   26221  trip-153861118270144424IND583201AAAIND583119AAA      test
```

```
               trip_creation_time  \
0      2018-09-12 00:00:16.535741
1      2018-09-12 00:00:16.535741
2      2018-09-12 00:00:22.886430
3      2018-09-12 00:00:22.886430
4      2018-09-12 00:00:33.691250
…                           …
26217  2018-10-03 23:59:14.390954
26218  2018-10-03 23:59:14.390954
26219  2018-10-03 23:59:14.390954
26220  2018-10-03 23:59:42.701692
26221  2018-10-03 23:59:42.701692

                                     route_schedule_uuid route_type  \
0      thanos::sroute:d7c989ba-a29b-4a0b-b2f4-288cdc6…        FTL
1      thanos::sroute:d7c989ba-a29b-4a0b-b2f4-288cdc6…        FTL
2      thanos::sroute:3a1b0ab2-bb0b-4c53-8c59-eb2a2c0…    Carting
3      thanos::sroute:3a1b0ab2-bb0b-4c53-8c59-eb2a2c0…    Carting
4      thanos::sroute:de5e208e-7641-45e6-8100-4d9fb1e…        FTL
…                                                  …        …
26217  thanos::sroute:c5f2ba2c-8486-4940-8af6-d1d2a6a…    Carting
26218  thanos::sroute:c5f2ba2c-8486-4940-8af6-d1d2a6a…    Carting
26219  thanos::sroute:c5f2ba2c-8486-4940-8af6-d1d2a6a…    Carting
26220  thanos::sroute:412fea14-6d1f-4222-8a5f-a517042…        FTL
26221  thanos::sroute:412fea14-6d1f-4222-8a5f-a517042…        FTL

                     trip_uuid source_center  \
0      trip-153671041653548748  IND209304AAA
1      trip-153671041653548748  IND462022AAA
2      trip-153671042288605164  IND561203AAB
3      trip-153671042288605164  IND572101AAA
4      trip-153671043369099517  IND000000ACB
…                        …            …
26217  trip-153861115439069069  IND628204AAA
26218  trip-153861115439069069  IND628613AAA
26219  trip-153861115439069069  IND628801AAA
26220  trip-153861118270144424  IND583119AAA
26221  trip-153861118270144424  IND583201AAA

                              source_name destination_center  …  \
0      Kanpur_Central_H_6 (Uttar Pradesh)       IND000000ACB  …
1      Bhopal_Trnsport_H (Madhya Pradesh)       IND209304AAA  …
2       Doddablpur_ChikaDPP_D (Karnataka)       IND562101AAA  …
3           Tumkur_Veersagr_I (Karnataka)       IND561203AAB  …
4           Gurgaon_Bilaspur_HB (Haryana)       IND160002AAC  …
…                                   …                …  …
```

```
26217  Tirchchndr_Shnmgprm_D (Tamil Nadu)       IND627657AAA  …
26218   Peikulam_SriVnktpm_D (Tamil Nadu)       IND627005AAA  …
26219        Eral_Busstand_D (Tamil Nadu)       IND628204AAA  …
26220       Sandur_WrdN1DPP_D (Karnataka)       IND583101AAA  …
26221                  Hospet (Karnataka)       IND583119AAA  …

                     od_end_time start_scan_to_end_scan  \
0     2018-09-13 13:40:23.123744                 1260.0
1     2018-09-12 16:39:46.858469                  999.0
2     2018-09-12 03:01:59.598855                   58.0
3     2018-09-12 02:03:09.655591                  122.0
4     2018-09-14 17:34:55.442454                  834.0
…                          …                    …
26217 2018-10-04 03:31:11.183797                   62.0
26218 2018-10-04 05:47:45.162682                   91.0
26219 2018-10-04 02:29:04.272194                   44.0
26220 2018-10-04 08:46:09.166940                  287.0
26221 2018-10-04 03:58:40.726547                   66.0

      actual_distance_to_destination  actual_time  osrm_time  osrm_distance  \
0                         383.759164        732.0      329.0       446.5496
1                         440.973689        830.0      388.0       544.8027
2                          24.644021         47.0       26.0        28.1994
3                          48.542890         96.0       42.0        56.9116
4                         237.439610        611.0      212.0       281.2109
…                             …          …        …            …
26217                      33.627182         51.0       41.0        42.5213
26218                      33.673835         90.0       48.0        40.6080
26219                      12.661945         30.0       14.0        16.0185
26220                      40.546740        233.0       42.0        52.5303
26221                      25.534793         42.0       26.0        28.0484

       segment_actual_time_sum  segment_osrm_distance_sum  \
0                        728.0                   670.6205
1                        820.0                   649.8528
2                         46.0                    28.1995
3                         95.0                    55.9899
4                        608.0                   317.7408
…                        …                        …
26217                     49.0                    42.1431
26218                     89.0                    78.5869
26219                     29.0                    16.0184
26220                    233.0                    52.5303
26221                     41.0                    28.0484

       segment_osrm_time_sum  od_time_diff_hour
0                      534.0        1260.604421
```

```
1                       474.0         999.505379
2                        26.0          58.832388
3                        39.0         122.779486
4                       231.0         834.638929
…                       …               …
26217                    42.0          62.115193
26218                    77.0          91.087797
26219                    14.0          44.174403
26220                    42.0         287.474007
26221                    25.0          66.933565

[26222 rows x 22 columns]
```

[15]:

```
create_trip_dict = {

    'data' : 'first',
    'trip_creation_time': 'first',
    'route_schedule_uuid' : 'first',
    'route_type' : 'first',
    'trip_uuid' : 'first',

    'source_center' : 'first',
    'source_name' : 'first',

    'destination_center' : 'last',
    'destination_name' : 'last',

    'start_scan_to_end_scan' : 'sum',
    'od_time_diff_hour' : 'sum',

    'actual_distance_to_destination' : 'sum',
    'actual_time' : 'sum',
    'osrm_time' : 'sum',
    'osrm_distance' : 'sum',

    'segment_actual_time_sum' : 'sum',
    'segment_osrm_distance_sum' : 'sum',
    'segment_osrm_time_sum' : 'sum',

    }
```

[16]:

```
trip = segment.groupby('trip_uuid').agg(create_trip_dict).reset_index(drop =␣
  ↪True)
```

[17]:

```
trip
```

```
[17]:            data         trip_creation_time  \
      0      training  2018-09-12 00:00:16.535741
      1      training  2018-09-12 00:00:22.886430
      2      training  2018-09-12 00:00:33.691250
      3      training  2018-09-12 00:01:00.113710
      4      training  2018-09-12 00:02:09.740725
      …         …                          …
      14782      test  2018-10-03 23:55:56.258533
      14783      test  2018-10-03 23:57:23.863155
      14784      test  2018-10-03 23:57:44.429324
      14785      test  2018-10-03 23:59:14.390954
      14786      test  2018-10-03 23:59:42.701692

                                           route_schedule_uuid route_type   \
      0      thanos::sroute:d7c989ba-a29b-4a0b-b2f4-288cdc6…        FTL
      1      thanos::sroute:3a1b0ab2-bb0b-4c53-8c59-eb2a2c0…    Carting
      2      thanos::sroute:de5e208e-7641-45e6-8100-4d9fb1e…        FTL
      3      thanos::sroute:f0176492-a679-4597-8332-bbd1c7f…    Carting
      4      thanos::sroute:d9f07b12-65e0-4f3b-bec8-df06134…        FTL
      …                                                  …        …
      14782  thanos::sroute:8a120994-f577-4491-9e4b-b7e4a14…    Carting
      14783  thanos::sroute:b30e1ec3-3bfa-4bd2-a7fb-3b75769…    Carting
      14784  thanos::sroute:5609c268-e436-4e0a-8180-3db4a74…    Carting
      14785  thanos::sroute:c5f2ba2c-8486-4940-8af6-d1d2a6a…    Carting
      14786  thanos::sroute:412fea14-6d1f-4222-8a5f-a517042…        FTL

                           trip_uuid source_center  \
      0      trip-153671041653548748  IND209304AAA
      1      trip-153671042288605164  IND561203AAB
      2      trip-153671043369099517  IND000000ACB
      3      trip-153671046011330457  IND400072AAB
      4      trip-153671052974046625  IND583101AAA
      …                         …           …
      14782  trip-153861095625827784  IND160002AAC
      14783  trip-153861104386292051  IND121004AAB
      14784  trip-153861106442901555  IND208006AAA
      14785  trip-153861115439069069  IND627005AAA
      14786  trip-153861118270144424  IND583119AAA

                                     source_name destination_center  \
      0       Kanpur_Central_H_6 (Uttar Pradesh)       IND209304AAA
      1        Doddablpur_ChikaDPP_D (Karnataka)       IND561203AAB
      2            Gurgaon_Bilaspur_HB (Haryana)       IND000000ACB
      3                 Mumbai Hub (Maharashtra)       IND401104AAA
      4                   Bellary_Dc (Karnataka)       IND583119AAA
      …                                      …                …
      14782       Chandigarh_Mehmdpur_H (Punjab)       IND160002AAC
```

```
14783         FBD_Balabhgarh_DPC (Haryana)       IND121004AAA
14784   Kanpur_GovndNgr_DC (Uttar Pradesh)       IND208006AAA
14785  Tirunelveli_VdkkuSrt_I (Tamil Nadu)       IND628204AAA
14786        Sandur_WrdN1DPP_D (Karnataka)       IND583119AAA

                         destination_name  start_scan_to_end_scan  \
0      Kanpur_Central_H_6 (Uttar Pradesh)                  2259.0   
1       Doddablpur_ChikaDPP_D (Karnataka)                   180.0   
2           Gurgaon_Bilaspur_HB (Haryana)                  3933.0   
3          Mumbai_MiraRd_IP (Maharashtra)                   100.0   
4           Sandur_WrdN1DPP_D (Karnataka)                   717.0   
…                                   …                     …
14782      Chandigarh_Mehmdpur_H (Punjab)                   257.0   
14783      Faridabad_Blbgarh_DC (Haryana)                    60.0   
14784  Kanpur_GovndNgr_DC (Uttar Pradesh)                   421.0   
14785  Tirchchndr_Shnmgprm_D (Tamil Nadu)                   347.0   
14786       Sandur_WrdN1DPP_D (Karnataka)                   353.0   

       od_time_diff_hour  actual_distance_to_destination  actual_time  \
0            2260.109800                      824.732854       1562.0   
1             181.611874                       73.186911        143.0   
2            3934.362520                     1927.404273       3347.0   
3             100.494935                       17.175274         59.0   
4             718.349042                      127.448500        341.0   
…                  …                             …          …
14782         258.028928                       57.762332         83.0   
14783          60.590521                       15.513784         21.0   
14784         422.119867                       38.684839        282.0   
14785         348.512862                      134.723836        264.0   
14786         354.407571                       66.081533        275.0   

       osrm_time  osrm_distance  segment_actual_time_sum  \
0          717.0       991.3523                   1548.0   
1           68.0        85.1110                    141.0   
2         1740.0      2354.0665                   3308.0   
3           15.0        19.6800                     59.0   
4          117.0       146.7918                    340.0   
…          …            …                      …
14782       62.0        73.4630                     82.0   
14783       12.0        16.0882                     21.0   
14784       48.0        58.9037                    281.0   
14785      179.0       171.1103                    258.0   
14786       68.0        80.5787                    274.0   

       segment_osrm_distance_sum  segment_osrm_time_sum  
0                      1320.4733                 1008.0  
1                        84.1894                   65.0  
```

```
2                      2545.2678                 1941.0
3                        19.8766                   16.0
4                       146.7919                  115.0
…                          …                    …
14782                    64.8551                   62.0
14783                    16.0883                   11.0
14784                   104.8866                   88.0
14785                   223.5324                  221.0
14786                    80.5787                   67.0

[14787 rows x 18 columns]
```

```
[18]: trip[['actual_time', 'segment_actual_time_sum']]
```

```
[18]:        actual_time  segment_actual_time_sum
      0           1562.0                   1548.0
      1            143.0                    141.0
      2           3347.0                   3308.0
      3             59.0                     59.0
      4            341.0                    340.0
      …             …                       …
      14782         83.0                     82.0
      14783         21.0                     21.0
      14784        282.0                    281.0
      14785        264.0                    258.0
      14786        275.0                    274.0

      [14787 rows x 2 columns]
```

```
[19]: np.mean(trip.actual_time-trip.segment_actual_time_sum),np.std(trip.
       ↪actual_time-trip.segment_actual_time_sum,ddof=1)
```

```
[19]: (3.2468384391695406, 5.783804118246755)
```

0.0.4 Actual time and aggregated segment time does not differ much. The difference has mean of 3.25 mins and standard deviation of 5.78 minutes.

```
[20]: trip
```

```
[20]:            data          trip_creation_time  \
      0      training  2018-09-12 00:00:16.535741
      1      training  2018-09-12 00:00:22.886430
      2      training  2018-09-12 00:00:33.691250
      3      training  2018-09-12 00:01:00.113710
      4      training  2018-09-12 00:02:09.740725
      …          …                          …
      14782      test  2018-10-03 23:55:56.258533
      14783      test  2018-10-03 23:57:23.863155
```

```
14784      test  2018-10-03 23:57:44.429324
14785      test  2018-10-03 23:59:14.390954
14786      test  2018-10-03 23:59:42.701692

                                     route_schedule_uuid route_type  \
0      thanos::sroute:d7c989ba-a29b-4a0b-b2f4-288cdc6…        FTL
1      thanos::sroute:3a1b0ab2-bb0b-4c53-8c59-eb2a2c0…    Carting
2      thanos::sroute:de5e208e-7641-45e6-8100-4d9fb1e…        FTL
3      thanos::sroute:f0176492-a679-4597-8332-bbd1c7f…    Carting
4      thanos::sroute:d9f07b12-65e0-4f3b-bec8-df06134…        FTL
…                                                  …        …
14782  thanos::sroute:8a120994-f577-4491-9e4b-b7e4a14…    Carting
14783  thanos::sroute:b30e1ec3-3bfa-4bd2-a7fb-3b75769…    Carting
14784  thanos::sroute:5609c268-e436-4e0a-8180-3db4a74…    Carting
14785  thanos::sroute:c5f2ba2c-8486-4940-8af6-d1d2a6a…    Carting
14786  thanos::sroute:412fea14-6d1f-4222-8a5f-a517042…        FTL

                     trip_uuid source_center  \
0      trip-153671041653548748  IND209304AAA
1      trip-153671042288605164  IND561203AAB
2      trip-153671043369099517  IND000000ACB
3      trip-153671046011330457  IND400072AAB
4      trip-153671052974046625  IND583101AAA
…                          …           …
14782  trip-153861095625827784  IND160002AAC
14783  trip-153861104386292051  IND121004AAB
14784  trip-153861106442901555  IND208006AAA
14785  trip-153861115439069069  IND627005AAA
14786  trip-153861118270144424  IND583119AAA

                               source_name destination_center  \
0        Kanpur_Central_H_6 (Uttar Pradesh)       IND209304AAA
1         Doddablpur_ChikaDPP_D (Karnataka)       IND561203AAB
2             Gurgaon_Bilaspur_HB (Haryana)       IND000000ACB
3                  Mumbai Hub (Maharashtra)       IND401104AAA
4                    Bellary_Dc (Karnataka)       IND583119AAA
…                                    …                …
14782        Chandigarh_Mehmdpur_H (Punjab)       IND160002AAC
14783          FBD_Balabhgarh_DPC (Haryana)       IND121004AAA
14784    Kanpur_GovndNgr_DC (Uttar Pradesh)       IND208006AAA
14785   Tirunelveli_VdkkuSrt_I (Tamil Nadu)       IND628204AAA
14786         Sandur_WrdN1DPP_D (Karnataka)       IND583119AAA

                         destination_name  start_scan_to_end_scan  \
0      Kanpur_Central_H_6 (Uttar Pradesh)                  2259.0
1       Doddablpur_ChikaDPP_D (Karnataka)                   180.0
2           Gurgaon_Bilaspur_HB (Haryana)                  3933.0
```

```
3          Mumbai_MiraRd_IP (Maharashtra)                    100.0
4           Sandur_WrdN1DPP_D (Karnataka)                    717.0
…                                   …                      …
14782      Chandigarh_Mehmdpur_H (Punjab)                    257.0
14783      Faridabad_Blbgarh_DC (Haryana)                     60.0
14784  Kanpur_GovndNgr_DC (Uttar Pradesh)                    421.0
14785  Tirchchndr_Shnmgprm_D (Tamil Nadu)                    347.0
14786       Sandur_WrdN1DPP_D (Karnataka)                    353.0

       od_time_diff_hour  actual_distance_to_destination  actual_time  \
0            2260.109800                      824.732854       1562.0
1             181.611874                       73.186911        143.0
2            3934.362520                     1927.404273       3347.0
3             100.494935                       17.175274         59.0
4             718.349042                      127.448500        341.0
…                  …                              …          …
14782         258.028928                       57.762332         83.0
14783          60.590521                       15.513784         21.0
14784         422.119867                       38.684839        282.0
14785         348.512862                      134.723836        264.0
14786         354.407571                       66.081533        275.0

       osrm_time  osrm_distance  segment_actual_time_sum  \
0          717.0       991.3523                   1548.0
1           68.0        85.1110                    141.0
2         1740.0      2354.0665                   3308.0
3           15.0        19.6800                     59.0
4          117.0       146.7918                    340.0
…          …            …                       …
14782       62.0        73.4630                     82.0
14783       12.0        16.0882                     21.0
14784       48.0        58.9037                    281.0
14785      179.0       171.1103                    258.0
14786       68.0        80.5787                    274.0

       segment_osrm_distance_sum  segment_osrm_time_sum
0                      1320.4733                 1008.0
1                        84.1894                   65.0
2                      2545.2678                 1941.0
3                        19.8766                   16.0
4                       146.7919                  115.0
…                          …                     …
14782                    64.8551                   62.0
14783                    16.0883                   11.0
14784                   104.8866                   88.0
14785                   223.5324                  221.0
14786                    80.5787                   67.0
```

```
      [14787 rows x 18 columns]
```

```
[21]: trip[trip['trip_uuid'] == 'trip-153741093647649320']
```

```
[21]:           data          trip_creation_time  \
      5917  training  2018-09-20 02:35:36.476840

                                          route_schedule_uuid route_type  \
      5917  thanos::sroute:eb7bfc78-b351-4c0e-a951-fa3d5c3…    Carting

                          trip_uuid source_center                 source_name  \
      5917  trip-153741093647649320  IND388121AAA  Anand_VUNagar_DC (Gujarat)

           destination_center            destination_name  start_scan_to_end_scan  \
      5917       IND388320AAA  Anand_Vaghasi_IP (Gujarat)                   195.0

            od_time_diff_hour  actual_distance_to_destination  actual_time  \
      5917         195.386819                       82.981842        170.0

            osrm_time  osrm_distance  segment_actual_time_sum  \
      5917       89.0       107.4515                    167.0

            segment_osrm_distance_sum  segment_osrm_time_sum
      5917                   102.7106                   88.0
```

```
[22]: trip[['actual_distance_to_destination','osrm_distance']]
```

```
[22]:        actual_distance_to_destination  osrm_distance
      0                          824.732854       991.3523
      1                           73.186911        85.1110
      2                         1927.404273      2354.0665
      3                           17.175274        19.6800
      4                          127.448500       146.7918
      …                               …            …
      14782                       57.762332        73.4630
      14783                       15.513784        16.0882
      14784                       38.684839        58.9037
      14785                      134.723836       171.1103
      14786                       66.081533        80.5787

      [14787 rows x 2 columns]
```

0.1 Hypothesis Testing to check if Osrm calculated distance is greated than actual distance

- Significance level(alpha) is set to .01
- H0 : mean of osrm distance is less than or equal to that of actual distance for each trip

- H1 : mean of osrm distance is greater than that of actual distance for each trip

[23]:
```
ttest_ind(trip.osrm_distance,trip.
 ↪actual_distance_to_destination,alternative='greater')
```

[23]:
```
TtestResult(statistic=10.076625835231006, pvalue=3.82952829449766e-24,
df=29572.0)
```

0.1.1 As pvalue<.01 we can conclude that osrm distance is greater than actual distance per trip.

0.2 Hypothesis Testing to check if actual time is greater than osrm time

- Significance level(alpha) is set to .01
- H0 : mean of actual time less than mean of osrm time for each trip
- H1 : mean of actual time greater than mean of osrm time for each trip

[24]:
```
ttest_ind(trip.actual_time,trip.segment_osrm_time_sum,alternative='greater')
```

[24]:
```
TtestResult(statistic=33.21041532061086, pvalue=8.847334685136661e-238,
df=29572.0)
```

0.2.1 As pvalue<.01 we can conclude that actual time is more than osrm time per trip.

0.3 Osrm calculations are not consistent as osrm distance is more than actual whereas osrm time is lesser than actual time.

[25]:
```
trip['destination_name'] = trip['destination_name'].str.lower() #lowering all␣
 ↪columns
trip['source_name'] = trip['source_name'].str.lower()
```

[26]:
```
def place2state(x):
    state = x.split('(')[1]
    return state[:-1]

def place2city(x):
    city = x.split(' (')[0]
    city = city.split('_')[0]

    if city == 'pnq vadgaon sheri dpc':
      return 'vadgaonsheri'

    # ['PNQ Pashan DPC', 'Bhopal MP Nagar', 'HBR Layout PC',
    #  'PNQ Rahatani DPC', 'Pune Balaji Nagar', 'Mumbai Antop Hill']

    if city in ['pnq pashan dpc','pnq rahatani dpc', 'pune balaji nagar']:
 ↪return 'pune'

```

```
    if city == 'hbr layout pc' : return 'bengaluru'
    if city == 'bhopal mp nagar' : return 'bhopal'
    if city == 'mumbai antop hill' : return 'mumbai'
    return city

def place2city_place(x):
    x = x.split(' (')[0]
    len_ = len(x.split('_'))
    if len_ >= 3:
        return x.split('_')[1]
    if len_ == 2:
        return x.split('_')[0]
    return x.split(' ')[0]


def place2code(x):
    x = x.split(' (')[0]
    if len(x.split('_')) >= 3 :
        return x.split('_')[-1]
    return 'none'
```

[27]:

```
trip['destination_state'] = trip['destination_name'].apply(lambda x:␣
 ↪place2state(x))
trip['destination_city']  = trip['destination_name'].apply(lambda x:␣
 ↪place2city(x))
trip['destination_place'] = trip['destination_name'].apply(lambda x:␣
 ↪place2city_place(x))
trip['destination_code']  = trip['destination_name'].apply(lambda x:␣
 ↪place2code(x))
```

[28]:

```
trip[['destination_state', 'destination_city', 'destination_place',␣
 ↪'destination_code']]
```

[28]:

```
      destination_state destination_city destination_place destination_code
0         uttar pradesh           kanpur           central                6
1             karnataka       doddablpur          chikadpp                d
2               haryana          gurgaon          bilaspur               hb
3           maharashtra           mumbai            mirard               ip
4             karnataka           sandur          wrdn1dpp                d
…                 …              …                …              …
14782            punjab       chandigarh          mehmdpur                h
14783           haryana        faridabad           blbgarh               dc
14784     uttar pradesh           kanpur          govndngr               dc
14785        tamil nadu       tirchchndr          shnmgprm                d
14786         karnataka           sandur          wrdn1dpp                d

[14787 rows x 4 columns]
```

[29]:

```
trip['source_state'] = trip['source_name'].apply(lambda x: place2state(x))
trip['source_city']  = trip['source_name'].apply(lambda x: place2city(x))
trip['source_place'] = trip['source_name'].apply(lambda x: place2city_place(x))
trip['source_code']  = trip['source_name'].apply(lambda x: place2code(x))
```

[30]:

```
trip[['source_state', 'source_city', 'source_place', 'source_code']]
```

[30]:

```
        source_state  source_city source_place source_code
0      uttar pradesh       kanpur      central           6
1          karnataka   doddablpur     chikadpp           d
2            haryana      gurgaon     bilaspur          hb
3        maharashtra   mumbai hub       mumbai        none
4          karnataka      bellary      bellary        none
…              …          …          …         …
14782         punjab   chandigarh     mehmdpur           h
14783        haryana          fbd   balabhgarh         dpc
14784  uttar pradesh       kanpur     govndngr          dc
14785     tamil nadu  tirunelveli     vdkkusrt           i
14786      karnataka       sandur     wrdn1dpp           d

[14787 rows x 4 columns]
```

[31]:

```
trip['trip_creation_time'] =  pd.to_datetime(trip['trip_creation_time'])

trip['trip_year'] = trip['trip_creation_time'].dt.year
trip['trip_month'] = trip['trip_creation_time'].dt.month
trip['trip_hour'] = trip['trip_creation_time'].dt.hour
trip['trip_day'] = trip['trip_creation_time'].dt.day
trip['trip_week'] = trip['trip_creation_time'].dt.isocalendar().week
trip['trip_dayofweek'] = trip['trip_creation_time'].dt.dayofweek
```

[32]:

```
trip[['trip_year', 'trip_month', 'trip_hour', 'trip_day', 'trip_week',␣
 ↪'trip_dayofweek']]
```

[32]:

```
       trip_year  trip_month  trip_hour  trip_day  trip_week  trip_dayofweek
0           2018           9          0        12         37               2
1           2018           9          0        12         37               2
2           2018           9          0        12         37               2
3           2018           9          0        12         37               2
4           2018           9          0        12         37               2
…          …         …        …       …        …             …
14782       2018          10         23         3         40               2
14783       2018          10         23         3         40               2
14784       2018          10         23         3         40               2
14785       2018          10         23         3         40               2
14786       2018          10         23         3         40               2
```

```
[14787 rows x 6 columns]
```

[33]:

```
trip.head(5)
```

[33]:

```
       data         trip_creation_time  \
0  training 2018-09-12 00:00:16.535741
1  training 2018-09-12 00:00:22.886430
2  training 2018-09-12 00:00:33.691250
3  training 2018-09-12 00:01:00.113710
4  training 2018-09-12 00:02:09.740725

                                 route_schedule_uuid route_type  \
0  thanos::sroute:d7c989ba-a29b-4a0b-b2f4-288cdc6…        FTL
1  thanos::sroute:3a1b0ab2-bb0b-4c53-8c59-eb2a2c0…    Carting
2  thanos::sroute:de5e208e-7641-45e6-8100-4d9fb1e…        FTL
3  thanos::sroute:f0176492-a679-4597-8332-bbd1c7f…    Carting
4  thanos::sroute:d9f07b12-65e0-4f3b-bec8-df06134…        FTL

                 trip_uuid source_center                         source_name  \
0  trip-153671041653548748  IND209304AAA  kanpur_central_h_6 (uttar pradesh)
1  trip-153671042288605164  IND561203AAB   doddablpur_chikadpp_d (karnataka)
2  trip-153671043369099517  IND000000ACB       gurgaon_bilaspur_hb (haryana)
3  trip-153671046011330457  IND400072AAB            mumbai hub (maharashtra)
4  trip-153671052974046625  IND583101AAA              bellary_dc (karnataka)

  destination_center                    destination_name  \
0       IND209304AAA  kanpur_central_h_6 (uttar pradesh)
1       IND561203AAB   doddablpur_chikadpp_d (karnataka)
2       IND000000ACB       gurgaon_bilaspur_hb (haryana)
3       IND401104AAA      mumbai_mirard_ip (maharashtra)
4       IND583119AAA       sandur_wrdn1dpp_d (karnataka)

   start_scan_to_end_scan  …   source_state  source_city  source_place  \
0                  2259.0  …  uttar pradesh       kanpur       central
1                   180.0  …      karnataka   doddablpur      chikadpp
2                  3933.0  …        haryana      gurgaon      bilaspur
3                   100.0  …    maharashtra   mumbai hub        mumbai
4                   717.0  …      karnataka      bellary       bellary

   source_code  trip_year  trip_month  trip_hour  trip_day trip_week  \
0            6       2018           9          0        12        37
1            d       2018           9          0        12        37
2           hb       2018           9          0        12        37
3         none       2018           9          0        12        37
4         none       2018           9          0        12        37

  trip_dayofweek
```

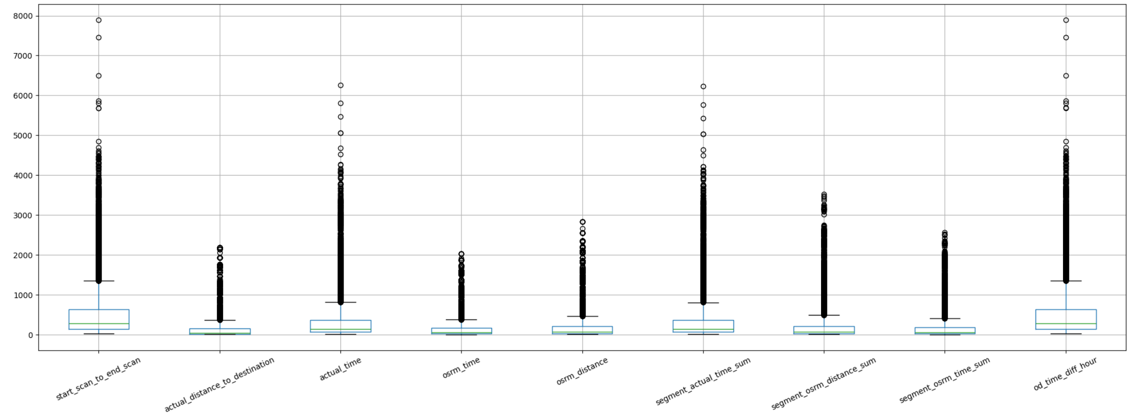
```
0               2
1               2
2               2
3               2
4               2

[5 rows x 32 columns]
```

[34]:
```
num_cols = ['start_scan_to_end_scan', 'actual_distance_to_destination',␣
 ↪'actual_time', 'osrm_time',
            'osrm_distance', 'segment_actual_time_sum',␣
 ↪'segment_osrm_distance_sum',
            'segment_osrm_time_sum', 'od_time_diff_hour']
cols=num_cols+['data','trip_month', 'trip_hour', 'trip_day', 'trip_week',␣
 ↪'trip_dayofweek']
```

0.3.1 Find outliers in numerical variable (you might find outliers in almost all the variables), and visualize it using visual analysis

[35]:
```
trip[num_cols].boxplot(rot=25, figsize=(25,8))
```

[35]:
```
<Axes: >
```



0.3.2 Handle the outliers using IQR method

[36]:
```
Q1 = trip[num_cols].quantile(0.25)
Q3 = trip[num_cols].quantile(0.75)

IQR = Q3 - Q1
```

[37]:
```
trip = trip[~((trip[num_cols] < (Q1 - 1.5 * IQR)) | (trip[num_cols] > (Q3 + 1.5␣
 ↪* IQR))).any(axis=1)]
```

```
trip = trip.reset_index(drop=True)
```

[38]:
```
trip
```

[38]:
```
           data          trip_creation_time  \
0      training 2018-09-12 00:00:22.886430
1      training 2018-09-12 00:01:00.113710
2      training 2018-09-12 00:02:09.740725
3      training 2018-09-12 00:02:34.161600
4      training 2018-09-12 00:04:22.011653
…           …                         …
12718      test 2018-10-03 23:55:56.258533
12719      test 2018-10-03 23:57:23.863155
12720      test 2018-10-03 23:57:44.429324
12721      test 2018-10-03 23:59:14.390954
12722      test 2018-10-03 23:59:42.701692

                                     route_schedule_uuid route_type  \
0      thanos::sroute:3a1b0ab2-bb0b-4c53-8c59-eb2a2c0…    Carting
1      thanos::sroute:f0176492-a679-4597-8332-bbd1c7f…    Carting
2      thanos::sroute:d9f07b12-65e0-4f3b-bec8-df06134…        FTL
3      thanos::sroute:9bf03170-d0a2-4a3f-aa4d-9aaab3d…    Carting
4      thanos::sroute:a97698cc-846e-41a7-916b-88b1741…    Carting
…                                                   …        …
12718  thanos::sroute:8a120994-f577-4491-9e4b-b7e4a14…    Carting
12719  thanos::sroute:b30e1ec3-3bfa-4bd2-a7fb-3b75769…    Carting
12720  thanos::sroute:5609c268-e436-4e0a-8180-3db4a74…    Carting
12721  thanos::sroute:c5f2ba2c-8486-4940-8af6-d1d2a6a…    Carting
12722  thanos::sroute:412fea14-6d1f-4222-8a5f-a517042…        FTL

                     trip_uuid source_center  \
0      trip-153671042288605164  IND561203AAB
1      trip-153671046011330457  IND400072AAB
2      trip-153671052974046625  IND583101AAA
3      trip-153671055416136166  IND600056AAA
4      trip-153671066201138152  IND600044AAD
…                          …           …
12718  trip-153861095625827784  IND160002AAC
12719  trip-153861104386292051  IND121004AAB
12720  trip-153861106442901555  IND208006AAA
12721  trip-153861115439069069  IND627005AAA
12722  trip-153861118270144424  IND583119AAA

                                source_name destination_center  \
0        doddablpur_chikadpp_d (karnataka)       IND561203AAB
1                  mumbai hub (maharashtra)       IND401104AAA
2                     bellary_dc (karnataka)       IND583119AAA
```

```
3         chennai_poonamallee (tamil nadu)       IND600056AAA
4        chennai_chrompet_dpc (tamil nadu)       IND600048AAA
…                                    …                 …
12718       chandigarh_mehmdpur_h (punjab)       IND160002AAC
12719         fbd_balabhgarh_dpc (haryana)       IND121004AAA
12720   kanpur_govndngr_dc (uttar pradesh)       IND208006AAA
12721  tirunelveli_vdkkusrt_i (tamil nadu)       IND628204AAA
12722        sandur_wrdn1dpp_d (karnataka)       IND583119AAA

                         destination_name  start_scan_to_end_scan  …  \
0       doddablpur_chikadpp_d (karnataka)                   180.0  …
1          mumbai_mirard_ip (maharashtra)                   100.0  …
2           sandur_wrdn1dpp_d (karnataka)                   717.0  …
3        chennai_poonamallee (tamil nadu)                   189.0  …
4        chennai_vandalur_dc (tamil nadu)                    98.0  …
…                                   …                     …  …
12718      chandigarh_mehmdpur_h (punjab)                   257.0  …
12719      faridabad_blbgarh_dc (haryana)                    60.0  …
12720  kanpur_govndngr_dc (uttar pradesh)                   421.0  …
12721  tirchchndr_shnmgprm_d (tamil nadu)                   347.0  …
12722       sandur_wrdn1dpp_d (karnataka)                   353.0  …

        source_state  source_city  source_place  source_code  trip_year  \
0          karnataka   doddablpur      chikadpp            d       2018
1        maharashtra   mumbai hub        mumbai         none       2018
2          karnataka      bellary       bellary         none       2018
3         tamil nadu      chennai       chennai         none       2018
4         tamil nadu      chennai      chrompet          dpc       2018
…              …          …           …          …        …
12718         punjab   chandigarh      mehmdpur            h       2018
12719        haryana          fbd    balabhgarh          dpc       2018
12720  uttar pradesh       kanpur      govndngr           dc       2018
12721     tamil nadu  tirunelveli      vdkkusrt            i       2018
12722      karnataka       sandur      wrdn1dpp            d       2018

       trip_month  trip_hour  trip_day trip_week trip_dayofweek
0               9          0        12        37              2
1               9          0        12        37              2
2               9          0        12        37              2
3               9          0        12        37              2
4               9          0        12        37              2
…           …        …       …       …            …
12718          10         23         3        40              2
12719          10         23         3        40              2
12720          10         23         3        40              2
12721          10         23         3        40              2
12722          10         23         3        40              2
```

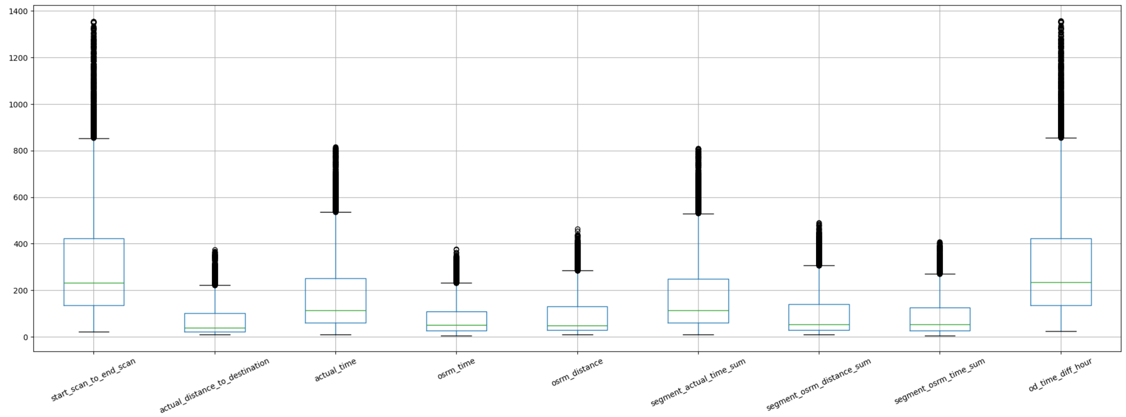
```
[12723 rows x 32 columns]
```

[39]:

```
trip[num_cols].boxplot(rot=25, figsize=(25,8))
```

[39]:

```
<Axes: >
```



1 Handling Categorical Variables

1.0.1 Only two route_type – Do one hot encoding

[40]:

```
trip['route_type'].value_counts()
```

[40]:

```
route_type
Carting    8812
FTL        3911
Name: count, dtype: int64
```

[41]:

```
trip['route_type'] = trip['route_type'].map({'FTL':0, 'Carting':1})
```

1.0.2 Normalize/ Standardize the numerical features using MinMaxScaler or StandardScaler

[42]:

```
from sklearn.preprocessing import StandardScaler
```

[43]:

```
scaler = StandardScaler()
scaler.fit(trip[num_cols])
```

[43]:

```
StandardScaler()
```

[44]:

```
trip[num_cols] = scaler.transform(trip[num_cols])
```

[45]:

```
trip[num_cols]
```

[45]:

```
       start_scan_to_end_scan  actual_distance_to_destination  actual_time  \
0                   -0.548546                        0.012060    -0.217856
1                   -0.861602                       -0.765152    -0.749015
2                    1.552838                        0.764988     1.034163
3                   -0.513328                       -0.662169    -0.736369
4                   -0.869428                       -0.877197    -0.970332
…                         …                              …            …
12718               -0.247231                       -0.201970    -0.597255
12719               -1.018130                       -0.788207    -0.989302
12720                0.394533                       -0.466688     0.661086
12721                0.104957                        0.865940     0.547267
12722                0.128436                       -0.086534     0.616823

       osrm_time  osrm_distance  segment_actual_time_sum  \
0      -0.144341      -0.073948                -0.221500
1      -0.877085      -0.804506                -0.743482
2       0.533102       0.614738                 1.045260
3      -0.766482      -0.710888                -0.737116
4      -0.904736      -0.890050                -0.966279
…          …              …                        …
12718  -0.227293      -0.204002                -0.597073
12719  -0.918561      -0.844610                -0.985376
12720  -0.420848      -0.366561                 0.669688
12721   1.390274       0.886261                 0.523279
12722  -0.144341      -0.124553                 0.625129

       segment_osrm_distance_sum  segment_osrm_time_sum  od_time_diff_hour
0                      -0.145358              -0.262662          -0.544839
1                      -0.823653              -0.878225          -0.861856
2                       0.514899               0.365464           1.552812
3                      -0.737295              -0.790288          -0.510150
4                      -0.906532              -0.915913          -0.871585
…                            …                      …                  …
12718                  -0.349273              -0.300349          -0.246189
12719                  -0.863608              -0.941038          -1.017809
12720                   0.072932               0.026276           0.395103
12721                   1.324267               1.697092           0.107436
12722                  -0.183439              -0.237537           0.130473

[12723 rows x 9 columns]
```

[46]:

```
trip[num_cols].describe()
```

[46]:

```
       start_scan_to_end_scan  actual_distance_to_destination   actual_time  \
count            1.272300e+04                    1.272300e+04  1.272300e+04
```

```
mean            -1.619566e-17                   -7.371818e-17 -8.041983e-17
std              1.000039e+00                    1.000039e+00  1.000039e+00
min             -1.162918e+00                   -8.785574e-01 -1.065181e+00
25%             -7.207269e-01                   -7.065920e-01 -7.363685e-01
50%             -3.411472e-01                   -4.689012e-01 -4.012322e-01
75%              4.023595e-01                    4.073375e-01  4.650634e-01
max              4.049455e+00                    4.178358e+00  4.031419e+00

          osrm_time  osrm_distance  segment_actual_time_sum  \
count  1.272300e+04   1.272300e+04             1.272300e+04
mean   4.467769e-17   3.797603e-17            -3.127438e-17
std    1.000039e+00   1.000039e+00             1.000039e+00
min   -1.001514e+00  -9.229378e-01            -1.061764e+00
25%   -7.111809e-01  -7.077649e-01            -7.371165e-01
50%   -3.931975e-01  -4.836339e-01            -3.997380e-01
75%    4.224989e-01   4.419548e-01             4.596223e-01
max    4.113871e+00   4.150641e+00             4.037107e+00

       segment_osrm_distance_sum  segment_osrm_time_sum  od_time_diff_hour
count               1.272300e+04           1.272300e+04       1.272300e+04
mean               -8.488760e-17           6.031487e-17       7.818595e-18
std                 1.000039e+00           1.000039e+00       1.000039e+00
min                -9.375981e-01          -1.003850e+00      -1.162915e+00
25%                -7.228116e-01          -7.274750e-01      -7.210516e-01
50%                -4.628077e-01          -4.134119e-01      -3.418602e-01
75%                 4.488499e-01           4.910897e-01       4.020802e-01
max                 4.130135e+00           4.046283e+00       4.050310e+00
```

2 Trying to predict actual_time from other features using stacked Xgboost and RandomForest

[47]:
```
df=trip[cols]
Train,test=df.loc[df.data=='training'],df.loc[df.data=='test']

X_train=Train[['actual_distance_to_destination','osrm_time','osrm_distance','segment_osrm_time
 ↪'trip_hour', 'trip_day', 'trip_week', 'trip_dayofweek']]
X_test=test[['actual_distance_to_destination','osrm_time','osrm_distance','segment_osrm_time_s
 ↪'trip_hour', 'trip_day', 'trip_week', 'trip_dayofweek']]
y_train=Train['actual_time']
y_test=test['actual_time']
```

2.1 Rf hypertune

[48]:

```
%%capture
'''rf_param_dist = {
    'n_estimators': [100, 200, 300, 400, 500],
    'max_depth': [None, 10, 20, 30, 40],
    'min_samples_split': [2, 5, 10, 15],
    'min_samples_leaf': [1, 2, 4, 6],
    'bootstrap': [True, False]
}

rf = RandomForestRegressor(random_state=95)

rf_random_search = RandomizedSearchCV(
    estimator=rf,
    param_distributions=rf_param_dist,
    n_iter=25,
    cv=3,
    n_jobs=-1,
    scoring='neg_mean_squared_error',
    random_state=95
)

rf_random_search.fit(X_train, y_train)

best_rf_params = rf_random_search.best_params_
best_rf_model = rf_random_search.best_estimator_
'''
```

[52]:

```
#Hypertuned
best_rf_params={'n_estimators': 400, 'min_samples_split': 2, 'min_samples_leaf':
  ↪ 4, 'max_depth': 40, 'bootstrap': True}
print("Best RandomForestRegressor parameters:", best_rf_params)
```

```
Best RandomForestRegressor parameters: {'n_estimators': 400,
'min_samples_split': 2, 'min_samples_leaf': 4, 'max_depth': 40, 'bootstrap':
True}
```

2.2 Xgb hypertune

[49]:

```
%%capture
'''xgb_param_dist = {
    'n_estimators': [100, 200, 300, 400, 500],
    'learning_rate': [0.01, 0.1, 0.2, 0.3],
    'max_depth': [3, 6, 9, 12],
    'subsample': [0.8, 0.9, 1.0],
    'colsample_bytree': [0.8, 0.9, 1.0]
}
```

```
xgb = XGBRegressor(random_state=95)

xgb_random_search = RandomizedSearchCV(
    estimator=xgb,
    param_distributions=xgb_param_dist,
    n_iter=25,
    cv=3,
    n_jobs=-1,
    scoring='neg_mean_squared_error',
    random_state=95
)

xgb_random_search.fit(X_train, y_train)

best_xgb_params = xgb_random_search.best_params_
best_xgb_model = xgb_random_search.best_estimator_
'''
```

[51]:

```
#Hypertuned
best_xgb_params={'subsample': 0.8, 'n_estimators': 300, 'max_depth': 9,␣
 ↪'learning_rate': 0.01, 'colsample_bytree': 1.0}
print("Best XGBRegressor parameters:", best_xgb_params)
```

```
Best XGBRegressor parameters: {'subsample': 0.8, 'n_estimators': 300,
'max_depth': 9, 'learning_rate': 0.01, 'colsample_bytree': 1.0}
```

[56]:

```
base_models = [
    ('rf', RandomForestRegressor(**best_rf_params)),
    ('xgb', XGBRegressor(**best_xgb_params))
]

meta_model = Ridge()
stacking_regressor = StackingRegressor(
    estimators=base_models,
    final_estimator=meta_model,
)
stacking_regressor.fit(X_train, y_train)
y_pred = stacking_regressor.predict(X_test)
mse = mean_squared_error(y_test, y_pred)
print(f"Mean Squared Error: {np.sqrt(mse):.4f}")
print(f"R^2: {stacking_regressor.score(X_test,y_test)}")
```

```
Mean Squared Error: 0.4712
R^2: 0.7658266336351892
```

2.2.1 RMSE is .47 which is quite less so its good.

2.2.2 R^2 is .77 which is also quite good.

2.3 Recomendations:

- Osrm routing consistency should be checked as distance is significantly more whereas time is less.
- North, South and West Zones corridors have significant traffic of orders. But, we have a smaller presence in Central, Eastern and North-Eastern zone. However it would be difficult to conclude this, by looking at just 2 months data. It is worth investigating and increasing our presence in these regions.
- From state point of view, we have heavy traffic in Mahrashtra followed by Karnataka. This is a good indicator that we need to plan for resources on ground in these 2 states on priority. Especially, during festive seasons.
- Use the regressor with proper data to get predicted actual time of delivery.

[ ]:

```

```