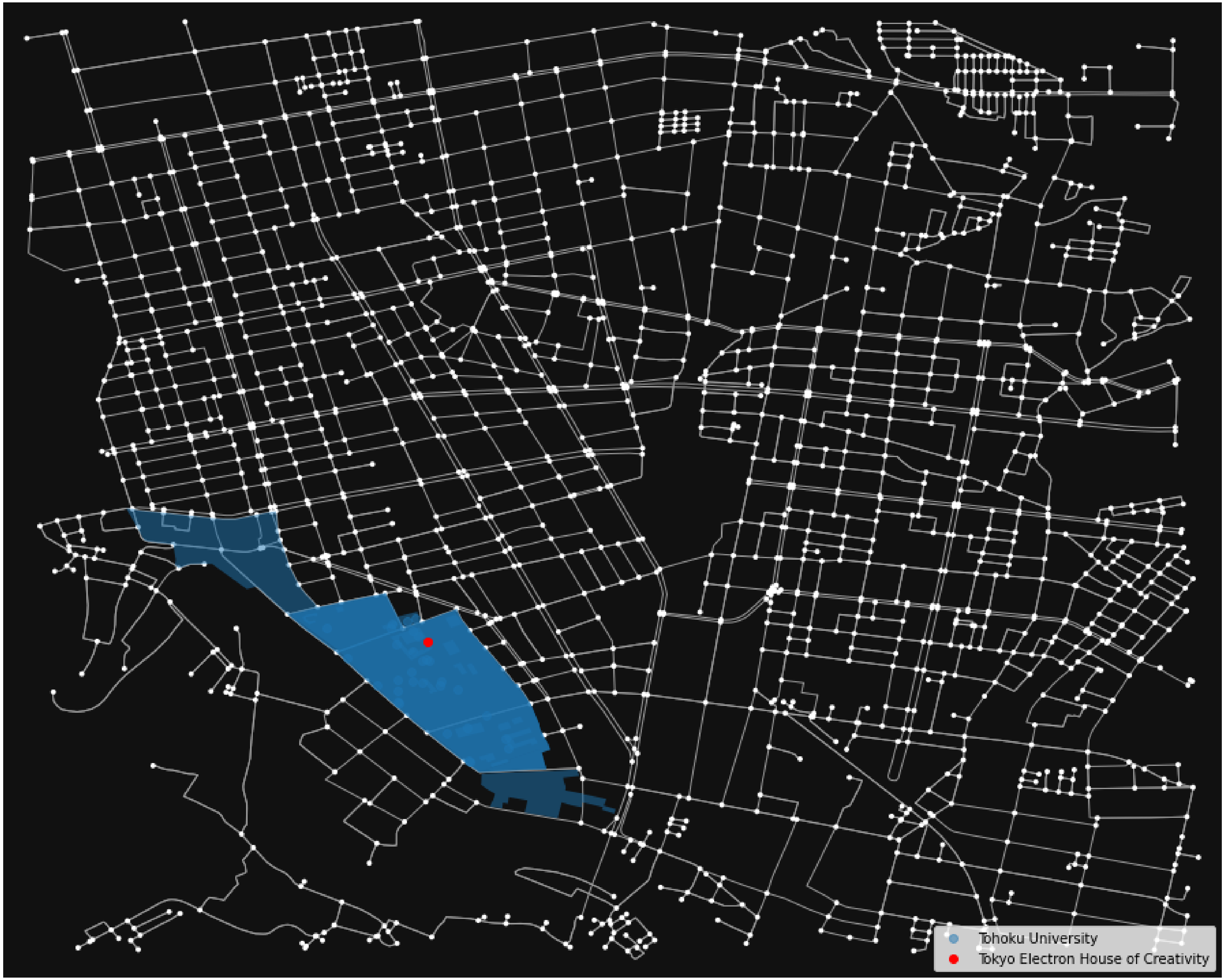
How do we represent road networks and GPS sequences computationally?

```
In [2]: bignetwork = ox.graph_from_address(
        "Sendai, Minamimachi-dori, Chuo 3-chome, Aoba Ward, Sendai, Miyagi Prefecture
        dist=1750, network_type='drive')

        fig, ax = ox.plot_graph(bignetwork, figsize = (16,16),show=False,close=False)

        campus = ox.geometries.geometries_from_place('Katahira Campus ',tags = {'name
        campus.plot(ax=ax, alpha=0.5)

        gpd.GeoSeries([Point((140.87387,38.25448))]).plot(ax=ax, color='red')

        ax.legend(handles=[ax.collections[4],ax.collections[5]],
                  labels=['Tohoku University', 'Tokyo Electron House of Creativity'],
                  loc = 'lower right')
```

```
Out[2]: <AxesSubplot:>

Out[2]: <AxesSubplot:>

Out[2]: <matplotlib.legend.Legend at 0x7f678f643070>
```


● Tohoku University
● Tokyo Electron House of Creativity

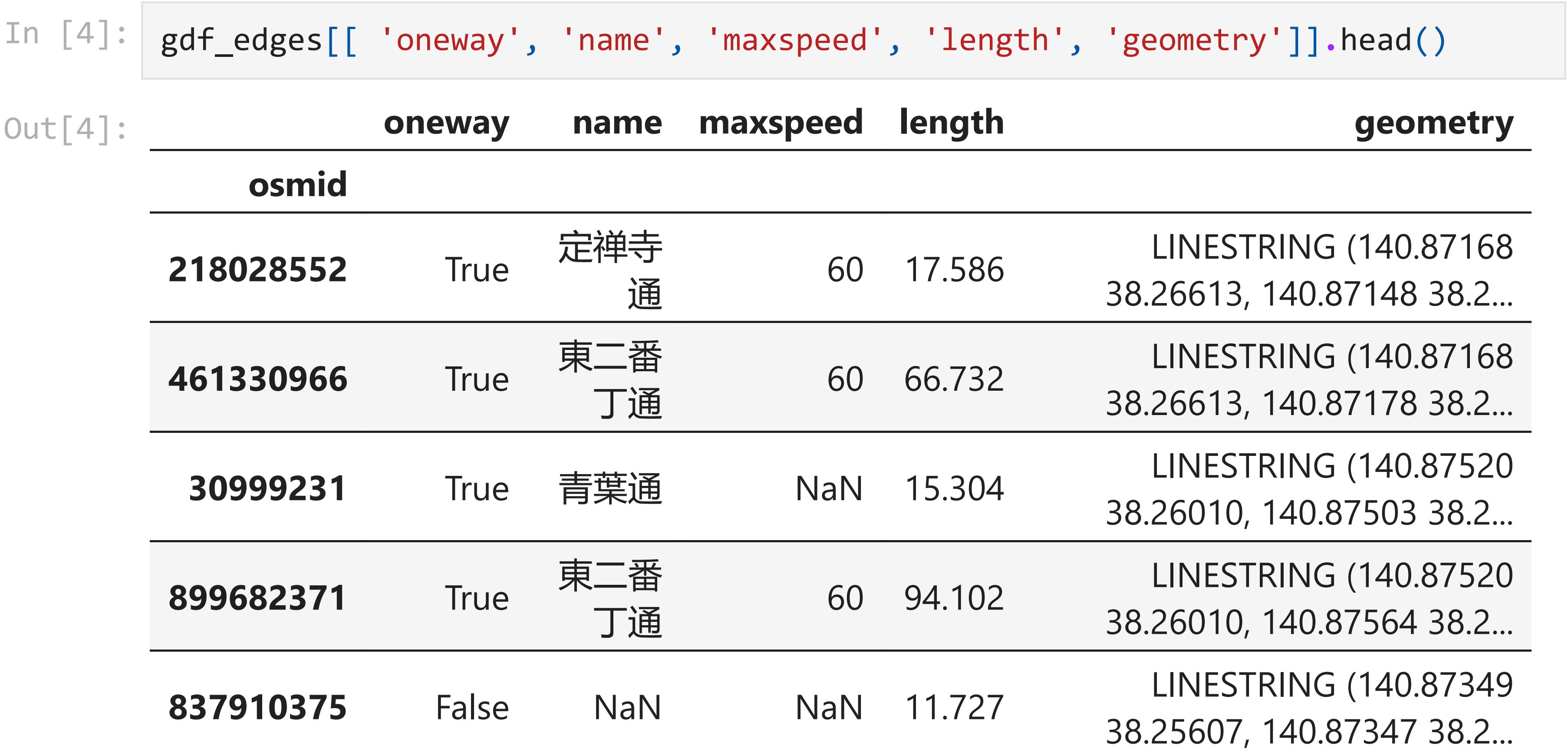
The default format that OSMnx models networks is as `MultiDiGraph` objects. In order to manipulate these objects geometrically, we will need to convert this to `GeoDataFrame`.

In [3]:

```
gdf_nodes, gdf_edges = ox.graph_to_gdfs(bignetwork)
#gdf_edges.dtypes
gdf_edges = gdf_edges.reset_index([0,1,2])
gdf_edges = gdf_edges.set_index('osmid')
gdf_nodes[['geometry']].head()
```

Out[3]:

	geometry
osmid	
244879417	POINT (140.87168 38.26613)
244879418	POINT (140.87520 38.26010)
301789611	POINT (140.87349 38.25607)
301789618	POINT (140.87595 38.25510)
301789634	POINT (140.87949 38.25282)



```
In [4]: gdf_edges[[ 'oneway', 'name', 'maxspeed', 'length', 'geometry']].head()
```

Out[4]:

	oneway	name	maxspeed	length	geometry
osmid					
218028552	True	定禅寺通	60	17.586	LINESTRING (140.87168 38.26613, 140.87148 38.2...
461330966	True	東二番丁通	60	66.732	LINESTRING (140.87168 38.26613, 140.87178 38.2...
30999231	True	青葉通	NaN	15.304	LINESTRING (140.87520 38.26010, 140.87503 38.2...
899682371	True	東二番丁通	60	94.102	LINESTRING (140.87520 38.26010, 140.87564 38.2...
837910375	False	NaN	NaN	11.727	LINESTRING (140.87349 38.25607, 140.87347 38.2...

Now let's look at the GPS data from a day walking around Sendai.

In [5]:

```
# Enable KML driver
fiona.drvsupport.supported_drivers["KML"] = "rw"

# Read file from KML
#fp = "history-2022-06-21.kml"
fp = "7-13-22.geojson"
with open(fp) as f:
    data = json.load(f)
    tripdata_nodes = gpd.GeoDataFrame.from_features(data)
tripdata_nodes = tripdata_nodes.sort_values(by='timestamp').reset_index(drop=
tripdata_edges = mm_utils.point_to_traj(tripdata_nodes)
```

In [6]:

```
fig, ax = ox.plot_graph(bignetwork, figsize = (16,16),show=False, close=False
tripdata_nodes.plot(ax=ax)
tripdata_edges.plot(ax=ax)
ax.legend(handles=[ax.collections[3]],labels=['Trip around Sendai'], loc = 'l
```

Out[6]:

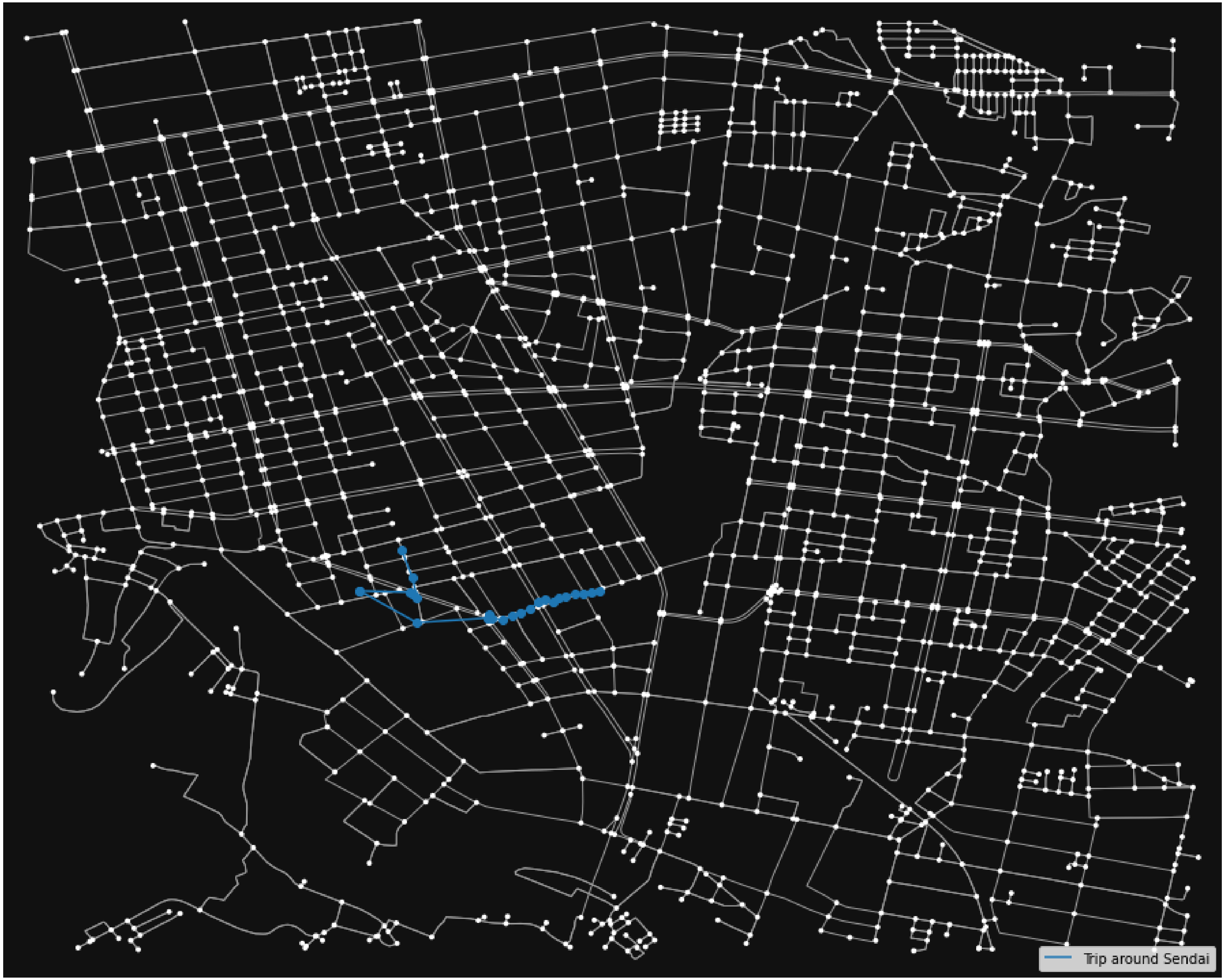
```
<AxesSubplot:>
```

Out[6]:

```
<AxesSubplot:>
```

Out[6]:

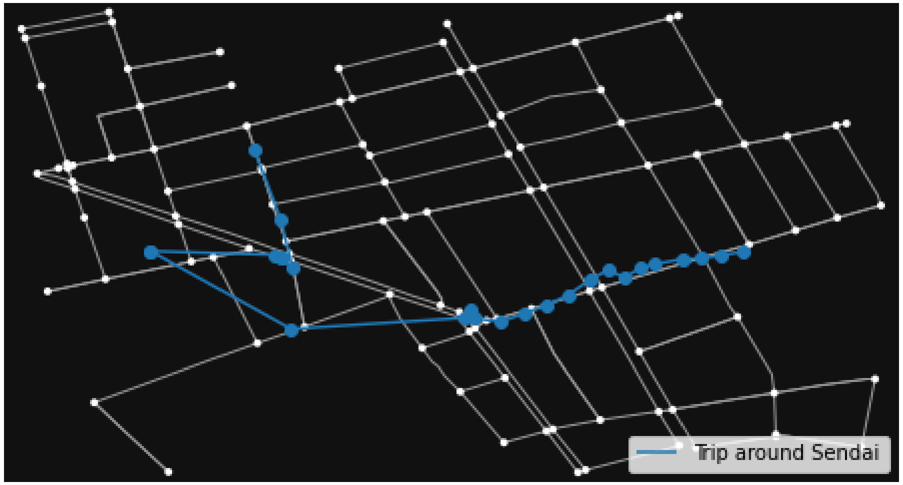
```
<matplotlib.legend.Legend at 0x7f6732183f40>
```


Trip around Sendai

Let's zoom in a bit.

```
In [7]: smallnetwork = mm_utils.df_to_network(tripdata_nodes, as_gdf = False)
        fig, ax = ox.plot_graph(smallnetwork, figsize=(8,8), show=False, close=False)
        tripdata_nodes.plot(ax=ax)
        tripdata_edges.plot(ax=ax)
        ax.legend(handles=[ax.collections[3]],labels=['Trip around Sendai'], loc = 'l
```

```
Out[7]: <AxesSubplot:>

Out[7]: <AxesSubplot:>

Out[7]: <matplotlib.legend.Legend at 0x7f678f62f0a0>
```



In [8]:

```
from algorithms import fmm_bin
from fmm import FastMapMatchConfig
### Define map matching configurations

k = 8
radius = 0.003
gps_error = 0.0005

# create a text trap and redirect stdout
#text_trap = io.StringIO()
#sys.stdout = text_trap

fmm_config = FastMapMatchConfig(k,radius,gps_error)
cfg_file = None



fmm_sim = fmm_bin.FMM(cfg = fmm_config)

fmm_sim.run(tripdata_edges)

# now restore stdout function
#sys.stdout = sys.__stdout__
```

```
/home/gjgress/G-RIPS-2022-Mitsubishi-A/Code/algorithms/fmm_bin.py:50:
UserWarning: Column names longer than 10 characters will be truncated
when saved to ESRI Shapefile.
  gdf_nodes.to_file(filepath_nodes, encoding=encoding)
```

```
[2022-07-15 01:12:42.821] [info] [network.cpp:72] Read network from f
```

```
ile temp/network_edges.shp
[2022-07-15 01:12:42.830] [info] [network.cpp:170] Number of edges 21
8 nodes 104
[2022-07-15 01:12:42.830] [info] [network.cpp:171] Field index: id 12
source 0 target 1
[2022-07-15 01:12:42.830] [info] [network.cpp:174] Read network done.
[2022-07-15 01:12:42.875] [info] [network_graph.cpp:17] Construct gra
ph from network edges start
[2022-07-15 01:12:42.875] [info] [network_graph.cpp:30] Graph nodes 1
04 edges 218
[2022-07-15 01:12:42.875] [info] [network_graph.cpp:31] Construct gra
ph from network edges end
[2022-07-15 01:12:42.875] [info] [ubodt_gen_algorithm.cpp:76] Start t
o generate UBODT with delta 0.02
[2022-07-15 01:12:42.875] [info] [ubodt_gen_algorithm.cpp:77] Output
format csv
[2022-07-15 01:12:42.881] [info] [ubodt_gen_algorithm.cpp:105] Progre
ss 10 / 104
[2022-07-15 01:12:42.882] [info] [ubodt_gen_algorithm.cpp:105] Progre
ss 20 / 104
[2022-07-15 01:12:42.883] [info] [ubodt_gen_algorithm.cpp:105] Progre
ss 30 / 104
[2022-07-15 01:12:42.883] [info] [ubodt_gen_algorithm.cpp:105] Progre
ss 40 / 104
[2022-07-15 01:12:42.884] [info] [ubodt_gen_algorithm.cpp:105] Progre
ss 50 / 104
[2022-07-15 01:12:42.887] [info] [ubodt_gen_algorithm.cpp:105] Progre
ss 60 / 104
[2022-07-15 01:12:42.888] [info] [ubodt_gen_algorithm.cpp:105] Progre
ss 70 / 104
[2022-07-15 01:12:42.891] [info] [ubodt_gen_algorithm.cpp:105] Progre
```

```
ss 80 / 104
[2022-07-15 01:12:42.893] [info] [ubodt_gen_algorithm.cpp:105] Progre
ss 90 / 104
[2022-07-15 01:12:42.894] [info] [ubodt_gen_algorithm.cpp:105] Progre
ss 100 / 104
[2022-07-15 01:12:42.900] [info] [ubodt.cpp:208] Reading UBODT file
(CSV format) from /tmp/tmp2htuo9dz
[2022-07-15 01:12:42.906] [info] [ubodt.cpp:243] Finish reading UBODT
with rows 9805
[2022-07-15 01:12:42.907] [info] [gps_reader.cpp:337] GPS data in tra
jectory shapefile format
[2022-07-15 01:12:42.907] [info] [gps_reader.cpp:45] Read trajectory
from file /tmp/tmphjew8268.shp
[2022-07-15 01:12:42.907] [warning] [gps_reader.cpp:69] Timestamp col
umn timestamp not found
[2022-07-15 01:12:42.907] [info] [gps_reader.cpp:81] Total number of
trajectories 24
[2022-07-15 01:12:42.907] [info] [gps_reader.cpp:82] Finish reading m
eta data
```

In [13]:

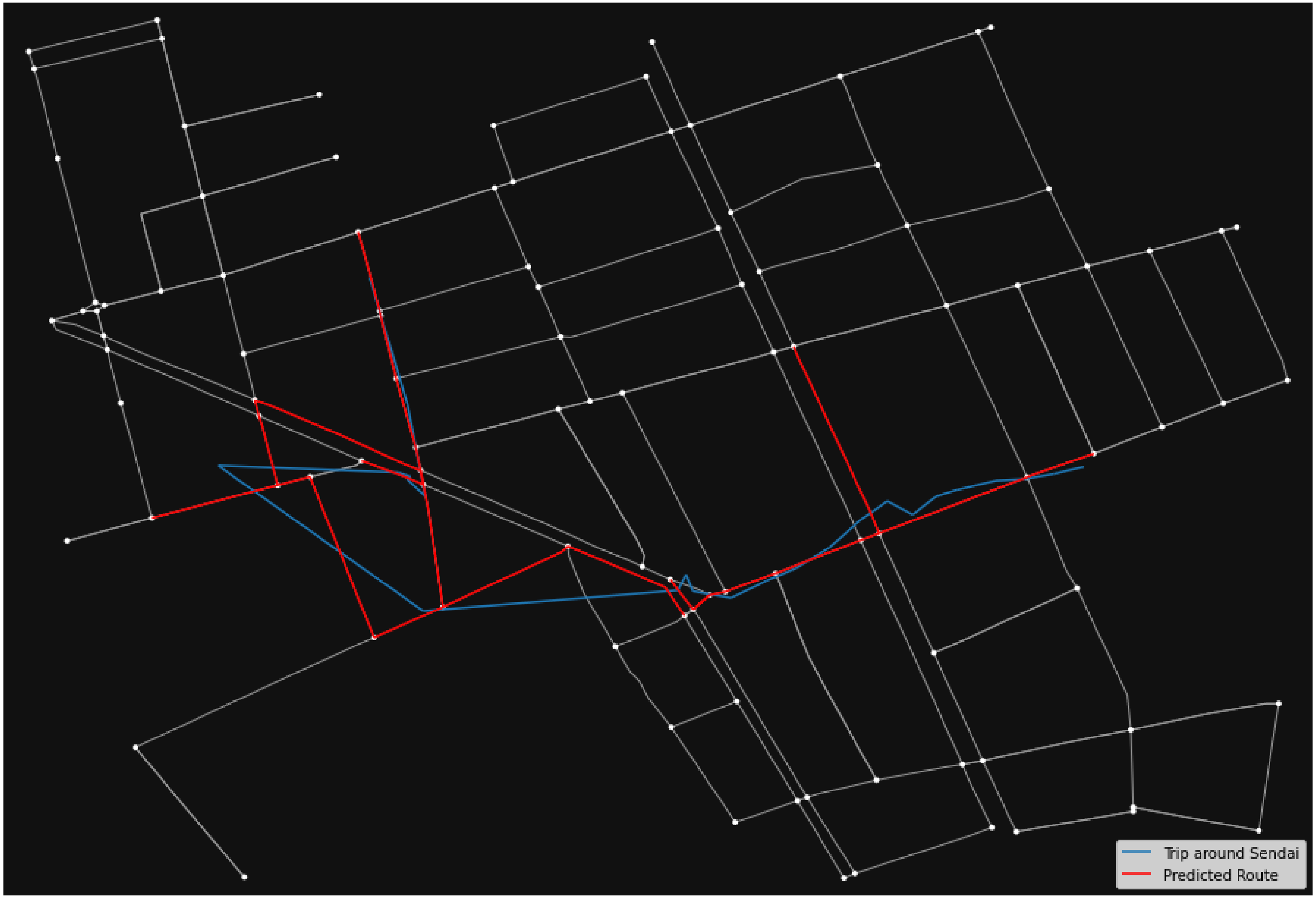
```
fmm_sim.results[['index', 'osmid', 'geometry']].head()
```

Out[13]:

	index	osmid	geometry
0	0	837910375	LINESTRING (140.87349 38.25607, 140.87347 38.2...
1	1	[837910369, 837910371]	LINESTRING (140.87349 38.25607, 140.87335 38.2...
2	4	32896012	LINESTRING (140.87595 38.25510, 140.87576 38.2...
3	11	153276508	LINESTRING (140.87697 38.25709, 140.87702 38.2...
4	13	837910348	LINESTRING (140.87916 38.25612, 140.87909 38.2...

```
In [11]: mm_utils.plot(network = smallnetwork, input_data = tripdata_edges, results =
         plt.gca().legend(handles=[plt.gca().collections[2],plt.gca().collections[3]],
```

```
Out[11]: <matplotlib.legend.Legend at 0x7f673022d480>
```


Trip around Sendai
Predicted Route