Lecture7.2_Map visualization

April 18, 2024

1 Map visualization

1. Creating Busan Map

[ ]:
```
import folium

busan =[35.1797957, 129.0727983]
m = folium.Map(location = busan, \
                zoom_start = 12, width=800,height=500)
m
```

[ ]:
```
<folium.folium.Map at 0x17894ca2310>
```

[ ]:
```
from branca.element import Figure
fig = Figure(width=600, height=400)
busan =[35.1797957, 129.0727983]
m = folium.Map(location = busan, zoom_start = 12 )
fig.add_child(m)
```

[ ]:
```
<branca.element.Figure at 0x1789e9b6e50>
```

Layer

[ ]:
```
fig2 = Figure(width=600, height=400)
m2 = folium.Map(location = busan, zoom_start = 12)
folium.TileLayer('Stamen Terrain').add_to(m2)
folium.TileLayer('Stamen Toner').add_to(m2)
folium.TileLayer('Stamen Water Color').add_to(m2)
folium.TileLayer('cartodbpositron').add_to(m2)
folium.TileLayer('cartodbdark_matter').add_to(m2)
folium.LayerControl().add_to(m2)
fig2.add_child(m2)
```

[ ]:
```
<branca.element.Figure at 0x1789e9b6110>
```

Marker

[ ]:
```
fig3 = Figure(width=600, height=400)
# Infos
```

```
pnu = [35.23379098528912, 129.08090997889803]
pnu_station=[35.22884833731382, 129.09063225747852]
# map
m3 = folium.Map( pnu, zoom_start=15, tiles='Stamen Toner')

# Marker for PNU
folium.Marker(pnu, popup='PNU', \
              tooltip='Click here to see Popup', \
              icon=folium.Icon(icon='bookmark', color='red', prefix='fa')).
 ↪add_to(m3)

# Makrer for PNU subway
folium.Marker(pnu_station, popup='PNU Subwary', \
              icon=folium.Icon(icon='subway', color='blue', prefix='fa')).
 ↪add_to(m3)

fig3.add_child(m3)
```

[ ]:
```
<branca.element.Figure at 0x1789e9cc3d0>
```

Maker cluster

[ ]:
```
import pandas as pd
import folium
from folium import Marker
from folium.plugins import MarkerCluster
```

[ ]:
```
# # upload actor.csv file
# from google.colab import files
# file_uploaded = files.upload()
```

[ ]:
```
df = pd.read_csv('subway.csv')
df.head()
```

[ ]:
```
   Unnamed: 0                                          \
0           0            1   35.048670  128.964100
1           1             1   35.057820  128.971300
2           2              1   35.065265  128.979873
3           3             1   35.074433  128.977041
4           4              1   35.081090  128.977500


0     [35.04867, 128.9641]
1     [35.05782, 128.9713]
2  [35.065265, 128.979873]
3  [35.074433, 128.977041]
4     [35.08109, 128.9775]
```

[ ]:
```
fig_marker = Figure(width=1024, height=768)
fig_cluster = Figure(width=1024, height=768)
map_marker = folium.Map(location=[35.1795543, 129.0756416],␣
 ↪tiles="OpenStreetMap", zoom_start=11)
map_cluster = folium.Map(location=[35.1795543, 129.0756416],␣
 ↪tiles="OpenStreetMap", zoom_start=11)
```

[ ]:
```
for _, i in df.iterrows():
    Marker(location = [i['  '], i['  ']],
           popup = "<pre>" + "  : " + str(i['  ']) + "<br>" + "  : " +␣
 ↪str(i['  ']) + "<br>" + "</pre>",
           icon = folium.Icon(color = 'blue')
           ).add_to(map_marker)

fig_marker.add_child(map_marker)
```

[ ]:
```
<branca.element.Figure at 0x1789e9cf910>
```

[ ]:
```
cluster = MarkerCluster()
for _, i in df.iterrows():
    cluster.add_child(
        Marker(location = [i['  '], i['  ']],
               popup = "<pre>" + "  : " + str(i['  ']) + "<br>" + "  : " +␣
 ↪str(i['  ']) + "<br>" + "</pre>",)
    ).add_to(map_cluster)

fig_cluster.add_child(map_cluster)
```

[ ]:
```
<branca.element.Figure at 0x1789e91d8d0>
```

Add Geojson to draw a boundary

[ ]:
```
import pandas as pd
import folium
from folium import Marker
from folium.plugins import MarkerCluster
import json
```

[ ]:
```
# from google.colab import files
# file_uploaded = files.upload()
```

[ ]:
```
busan_geojson = json.load(open('busan_gu.json', encoding='utf-8'))
busan_geojson["features"][0]
```

[ ]:
```
{'type': 'Feature',
 'id': ' ',
 'properties': {'code': '21010',
  'name': ' ',
```

```
  'name_eng': 'Jung-gu',
  'base_year': '2013'},
 'geometry': {'type': 'Polygon',
  'coordinates': [[[129.032, 35.116],
    [129.038, 35.112],
    [129.042, 35.111],
    [129.041, 35.108],
    [129.038, 35.104],
    [129.038, 35.098],
    [129.037, 35.097],
    [129.029, 35.096],
    [129.026, 35.096],
    [129.024, 35.1],
    [129.022, 35.102],
    [129.021, 35.106],
    [129.023, 35.109],
    [129.024, 35.109],
    [129.026, 35.111],
    [129.028, 35.11],
    [129.028, 35.115],
    [129.032, 35.116]]]}}
```

[ ]:
```
fig3 = Figure(width=600, height=400)
busan =[35.1797957, 129.0727983]
m = folium.Map(location=busan, zoom_start=10, titles="Busan Gu Boundaries")
folium.GeoJson(busan_geojson).add_to(m)

fig3.add_child(m)
```

[ ]:
```
<branca.element.Figure at 0x1789e953ed0>
```

[ ]:
```
# from google.colab import files
# file_uploaded = files.upload()
```

[ ]:
```
busan_df = pd.read_csv("./busan.csv", encoding="cp949", index_col=0)
busan_df
```

[ ]:

gu	price	population	area	density
	15515	44852	2.83	15849
	28665	112621	13.98	8056
	20729	89144	9.74	9152
	17024	121934	14.20	8587
	28781	365337	29.67	12313
	35607	267735	16.63	16100
	29597	286093	26.81	10671
	23090	299547	39.37	7609

```
34649      414611   51.47     8055
17942      332765   41.77     7967
29778      247725   65.28     3795
30080      128611  181.49      709
30590      208844   12.10    17260
39199      178028   10.21    17437
19993      229010   36.09     6346
22341      167162  218.30      766
```

[ ]:
```
fig = Figure(width=800, height=600)
busan =[35.1797957, 129.0727983]
busan_map = folium.Map(location=busan, zoom_start=10)
folium.Choropleth(geo_data=busan_geojson,
          data=busan_df["price"],
          columns =[df.index, busan_df["price"]],
          fill_color="PuRd",
          key_on="feature.id").add_to(busan_map)
fig.add_child(busan_map)
```

[ ]:
```
<branca.element.Figure at 0x1789e93b7d0>
```

2 Bike Sharing in the Bay Area

[ ]:
```
import pandas as pd
import matplotlib
matplotlib.use('Agg')
%matplotlib inline
import matplotlib.pyplot as plt
#import plotly.express as px
#import plotly.graph_objects as go
plt.style.use('fivethirtyeight')
import numpy as np
```

[ ]:
```
url = "https://raw.githubusercontent.com/data-8/textbook/main/assets/data/trip.
  ↪csv"
trip = pd.read_csv(url)
trip
```

[ ]:
```
        Trip ID  Duration       Start Date  \
0        913460       765  8/31/2015 23:26
1        913459      1036  8/31/2015 23:11
2        913455       307  8/31/2015 23:13
3        913454       409  8/31/2015 23:10
4        913453       789  8/31/2015 23:09
…           …       …              …
354147   432951       619    9/1/2014 4:21
```

```
354148   432950      6712    9/1/2014 3:16
354149   432949       538    9/1/2014 0:05
354150   432948       568    9/1/2014 0:05
354151   432947       569    9/1/2014 0:05

                             Start Station  Start Terminal         End Date  \
0       Harry Bridges Plaza (Ferry Building)              50  8/31/2015 23:39
1                San Antonio Shopping Center              31  8/31/2015 23:28
2                           Post at Kearny              47  8/31/2015 23:18
3                     San Jose City Hall              10  8/31/2015 23:17
4                   Embarcadero at Folsom              51  8/31/2015 23:22
…                                     …             …            …
354147                  Powell Street BART              39    9/1/2014 4:32
354148  Harry Bridges Plaza (Ferry Building)              50    9/1/2014 5:08
354149             South Van Ness at Market              66    9/1/2014 0:14
354150             South Van Ness at Market              66    9/1/2014 0:15
354151             South Van Ness at Market              66    9/1/2014 0:15

                                  End Station  End Terminal  Bike #  \
0       San Francisco Caltrain (Townsend at 4th)            70     288
1                         Mountain View City Hall            27      35
2                               2nd at South Park            64     468
3                            San Salvador at 1st             8      68
4                         Embarcadero at Sansome            60     487
…                                           …           …     …
354147                          Townsend at 7th            65     335
354148  San Francisco Caltrain (Townsend at 4th)            70     259
354149                            5th at Howard            57     466
354150                            5th at Howard            57     461
354151                            5th at Howard            57     318

       Subscriber Type Zip Code
0           Subscriber     2139
1           Subscriber    95032
2           Subscriber    94107
3           Subscriber    95113
4             Customer     9069
…                …      …
354147      Subscriber    94118
354148        Customer    44100
354149        Customer       32
354150        Customer       32
354151        Customer       32

[354152 rows x 11 columns]
```

[ ]:
```
import seaborn as sns

# focus commute less than 1800 sec (30 mins.). Free trip
commute = trip[trip.Duration < 1800]
TotalDuration = commute['Duration'].sum()
commute['PercDur']= commute['Duration']/TotalDuration
commute
```

```
C:\Users\rnjsa\AppData\Local\Temp\ipykernel_8588\3195304035.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_guide/indexing.html#returning-a-view-versus-a-copy
  commute['PercDur']= commute['Duration']/TotalDuration
```

[ ]:

	Trip ID	Duration	Start Date	\
0	913460	765	8/31/2015 23:26	
1	913459	1036	8/31/2015 23:11	
2	913455	307	8/31/2015 23:13	
3	913454	409	8/31/2015 23:10	
4	913453	789	8/31/2015 23:09	
…	…	…	…	
354146	432952	240	9/1/2014 4:59	
354147	432951	619	9/1/2014 4:21	
354149	432949	538	9/1/2014 0:05	
354150	432948	568	9/1/2014 0:05	
354151	432947	569	9/1/2014 0:05	

	Start Station	Start Terminal	End Date	\
0	Harry Bridges Plaza (Ferry Building)	50	8/31/2015 23:39	
1	San Antonio Shopping Center	31	8/31/2015 23:28	
2	Post at Kearny	47	8/31/2015 23:18	
3	San Jose City Hall	10	8/31/2015 23:17	
4	Embarcadero at Folsom	51	8/31/2015 23:22	
…	…	…	…	
354146	South Van Ness at Market	66	9/1/2014 5:03	
354147	Powell Street BART	39	9/1/2014 4:32	
354149	South Van Ness at Market	66	9/1/2014 0:14	
354150	South Van Ness at Market	66	9/1/2014 0:15	
354151	South Van Ness at Market	66	9/1/2014 0:15	

	End Station	End Terminal	Bike #	\
0	San Francisco Caltrain (Townsend at 4th)	70	288	
1	Mountain View City Hall	27	35	
2	2nd at South Park	64	468	
3	San Salvador at 1st	8	68	

```
4                          Embarcadero at Sansome             60     487
…                                             …           …     …
354146         Civic Center BART (7th at Market)             72     292
354147                            Townsend at 7th             65     335
354149                              5th at Howard             57     466
354150                              5th at Howard             57     461
354151                              5th at Howard             57     318

       Subscriber Type Zip Code   PercDur
0           Subscriber     2139  0.000004
1           Subscriber    95032  0.000006
2           Subscriber    94107  0.000002
3           Subscriber    95113  0.000002
4             Customer     9069  0.000004
…                  …      …        …
354146      Subscriber    94102  0.000001
354147      Subscriber    94118  0.000003
354149        Customer       32  0.000003
354150        Customer       32  0.000003
354151        Customer       32  0.000003

[338343 rows x 12 columns]
```

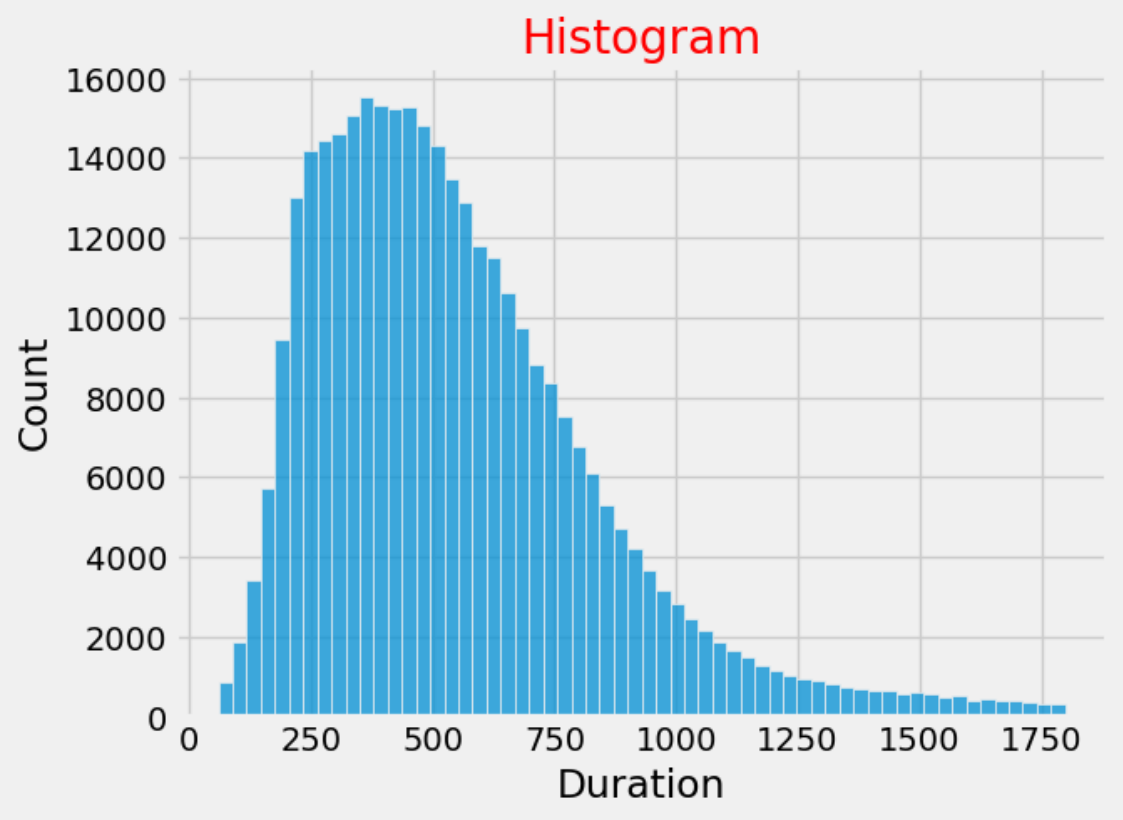
[ ]:
```
commute = trip[trip.Duration < 1800]
commute
```

[ ]:
```
        Trip ID  Duration       Start Date  \
0        913460       765  8/31/2015 23:26
1        913459      1036  8/31/2015 23:11
2        913455       307  8/31/2015 23:13
3        913454       409  8/31/2015 23:10
4        913453       789  8/31/2015 23:09
…         …       …              …
354146   432952       240    9/1/2014 4:59
354147   432951       619    9/1/2014 4:21
354149   432949       538    9/1/2014 0:05
354150   432948       568    9/1/2014 0:05
354151   432947       569    9/1/2014 0:05

                            Start Station  Start Terminal         End Date  \
0       Harry Bridges Plaza (Ferry Building)              50  8/31/2015 23:39
1                 San Antonio Shopping Center             31  8/31/2015 23:28
2                           Post at Kearny                47  8/31/2015 23:18
3                       San Jose City Hall                10  8/31/2015 23:17
4                     Embarcadero at Folsom               51  8/31/2015 23:22
…                                       …             …             …
354146              South Van Ness at Market              66    9/1/2014 5:03
```

```
354147                    Powell Street BART              39    9/1/2014 4:32
354149              South Van Ness at Market              66    9/1/2014 0:14
354150              South Van Ness at Market              66    9/1/2014 0:15
354151              South Van Ness at Market              66    9/1/2014 0:15

                                    End Station  End Terminal  Bike #  \
0       San Francisco Caltrain (Townsend at 4th)            70     288
1                         Mountain View City Hall           27      35
2                               2nd at South Park           64     468
3                            San Salvador at 1st             8      68
4                          Embarcadero at Sansome           60     487
…                                             …           …      …
354146         Civic Center BART (7th at Market)            72     292
354147                             Townsend at 7th           65     335
354149                               5th at Howard           57     466
354150                               5th at Howard           57     461
354151                               5th at Howard           57     318

       Subscriber Type Zip Code
0           Subscriber     2139
1           Subscriber    95032
2           Subscriber    94107
3           Subscriber    95113
4             Customer     9069
…                  …      …
354146      Subscriber    94102
354147      Subscriber    94118
354149        Customer       32
354150        Customer       32
354151        Customer       32

[338343 rows x 11 columns]
```

[ ]:
```
commute = trip[trip.Duration < 1800]
fig, ax = plt.subplots()
ax=sns.histplot(data=commute, x = "Duration", bins=60)
ax.set_xlabel("Duration")
ax.set_ylabel("Count")
ax.set_title("Histogram", size=20, color="red")
plt.show()
```

```
c:\Users\rnjsa\anaconda3\Lib\site-packages\seaborn\_oldcore.py:1119:
FutureWarning: use_inf_as_na option is deprecated and will be removed in a
future version. Convert inf values to NaN before operating instead.
  with pd.option_context('mode.use_inf_as_na', True):
```



2.1 Exploring the Data with group and pivot

[ ]:
```
starts = commute.groupby('Start Station')['Start Station'].count()
starts
```

[ ]:
```
Start Station
2nd at Folsom                                  7841
2nd at South Park                              9274
2nd at Townsend                               13674
5th at Howard                                  7394
Adobe on Almaden                                522
                                               ...
Temporary Transbay Terminal (Howard at Beale)  14298
Townsend at 7th                                13579
University and Emerson                           248
Washington at Kearny                            2395
Yerba Buena Center of the Arts (3rd @ Howard)   5249
Name: Start Station, Length: 70, dtype: int64
```

[ ]:
```
starts = commute.groupby('Start Station')['Start Station'].count().
↪reset_index(name='count').sort_values(by='count', ascending=False)
```

```
starts
```

[ ]:
```
                                  Start Station  count
49       San Francisco Caltrain (Townsend at 4th)  25858
50        San Francisco Caltrain 2 (330 Townsend)  21523
23           Harry Bridges Plaza (Ferry Building)  15543
65  Temporary Transbay Terminal (Howard at Beale)  14298
2                                 2nd at Townsend  13674
..                                            …    …
31                                    Mezes Park    189
41                    Redwood City Medical Center    139
55                        San Mateo County Center    108
42                    Redwood City Public Library    101
20                              Franklin at Maple     62

[70 rows x 2 columns]
```

[ ]:
```
commute.groupby(['Start Station', 'End Station'])['End Station'].count()
```

[ ]:
```
Start Station                                 End Station
2nd at Folsom                                 2nd at Folsom
54

                                              2nd at South Park
295

                                              2nd at Townsend
437

                                              5th at Howard
113

                                              Beale at Market
127

                …
Yerba Buena Center of the Arts (3rd @ Howard)  Steuart at Market
202

                                              Temporary Transbay Terminal
(Howard at Beale)    113

                                              Townsend at 7th
261

                                              Washington at Kearny
66

                                              Yerba Buena Center of the Arts
(3rd @ Howard)     73
Name: End Station, Length: 1629, dtype: int64
```

[ ]:
```
commute.groupby(['Start Station', 'End Station'])['End Station'].count().
↪reset_index(name='count')
```

[ ]:
```
                                    Start Station  \
0                                    2nd at Folsom
1                                    2nd at Folsom
2                                    2nd at Folsom
3                                    2nd at Folsom
4                                    2nd at Folsom
…                                              …
1624  Yerba Buena Center of the Arts (3rd @ Howard)
1625  Yerba Buena Center of the Arts (3rd @ Howard)
1626  Yerba Buena Center of the Arts (3rd @ Howard)
1627  Yerba Buena Center of the Arts (3rd @ Howard)
1628  Yerba Buena Center of the Arts (3rd @ Howard)

                                      End Station  count
0                                    2nd at Folsom     54
1                                2nd at South Park    295
2                                  2nd at Townsend    437
3                                    5th at Howard    113
4                                  Beale at Market    127
…                                              …    …
1624                             Steuart at Market    202
1625  Temporary Transbay Terminal (Howard at Beale)    113
1626                               Townsend at 7th    261
1627                          Washington at Kearny     66
1628  Yerba Buena Center of the Arts (3rd @ Howard)     73

[1629 rows x 3 columns]
```

[ ]:
```
pd.pivot_table(commute,
               columns='Start Station',
               index='End Station',
               aggfunc='count').fillna(0).apply(np.int64)
```

[ ]:
```
                                                    Bike #                    \
Start Station                                2nd at Folsom 2nd at South Park
End Station
2nd at Folsom                                           54                190
2nd at South Park                                      295                164
2nd at Townsend                                        437                151
5th at Howard                                          113                177
Adobe on Almaden                                         0                  0
…                                                      …                  …
Temporary Transbay Terminal (Howard at Beale)          414                437
Townsend at 7th                                        347                309
University and Emerson                                   0                  0
Washington at Kearny                                   142                142
Yerba Buena Center of the Arts (3rd @ Howard)           83                180
```

```
                                                                    \
Start Station                                 2nd at Townsend 5th at Howard
End Station
2nd at Folsom                                             554           107
2nd at South Park                                          71           180
2nd at Townsend                                           185            92
5th at Howard                                             148            83
Adobe on Almaden                                            0             0
…                                                           …             …
Temporary Transbay Terminal (Howard at Beale)             486           561
Townsend at 7th                                           418           313
University and Emerson                                      0             0
Washington at Kearny                                       72            47
Yerba Buena Center of the Arts (3rd @ Howard)             174            90

                                                                 \
Start Station                                 Adobe on Almaden
End Station
2nd at Folsom                                                0
2nd at South Park                                            0
2nd at Townsend                                              0
5th at Howard                                                0
Adobe on Almaden                                            11
…                                                            …
Temporary Transbay Terminal (Howard at Beale)                0
Townsend at 7th                                              0
University and Emerson                                       0
Washington at Kearny                                         0
Yerba Buena Center of the Arts (3rd @ Howard)                0

                                                                       \
Start Station                                 Arena Green / SAP Center
End Station
2nd at Folsom                                                         0
2nd at South Park                                                     0
2nd at Townsend                                                       0
5th at Howard                                                         0
Adobe on Almaden                                                      4
…                                                                     …
Temporary Transbay Terminal (Howard at Beale)                         0
Townsend at 7th                                                       0
University and Emerson                                                0
Washington at Kearny                                                  0
Yerba Buena Center of the Arts (3rd @ Howard)                         0

                                                                  \
```

Start Station	Beale at Market
End Station	
2nd at Folsom	40
2nd at South Park	208
2nd at Townsend	608
5th at Howard	59
Adobe on Almaden	0
…	…
Temporary Transbay Terminal (Howard at Beale)	531
Townsend at 7th	55
University and Emerson	0
Washington at Kearny	57
Yerba Buena Center of the Arts (3rd @ Howard)	65

\

Start Station	Broadway St at Battery St
End Station	
2nd at Folsom	21
2nd at South Park	85
2nd at Townsend	350
5th at Howard	130
Adobe on Almaden	0
…	…
Temporary Transbay Terminal (Howard at Beale)	549
Townsend at 7th	43
University and Emerson	0
Washington at Kearny	25
Yerba Buena Center of the Arts (3rd @ Howard)	34

\

Start Station	California Ave Caltrain Station
End Station	
2nd at Folsom	0
2nd at South Park	0
2nd at Townsend	0
5th at Howard	0
Adobe on Almaden	0
…	…
Temporary Transbay Terminal (Howard at Beale)	0
Townsend at 7th	0
University and Emerson	82
Washington at Kearny	0
Yerba Buena Center of the Arts (3rd @ Howard)	0

\

Start Station	Castro Street and El Camino Real
End Station	

```
2nd at Folsom                                                    0
2nd at South Park                                                0
2nd at Townsend                                                  0
5th at Howard                                                    0
Adobe on Almaden                                                 0
…                                                              …
Temporary Transbay Terminal (Howard at Beale)                    0
Townsend at 7th                                                  0
University and Emerson                                           0
Washington at Kearny                                             0
Yerba Buena Center of the Arts (3rd @ Howard)                    0
```

```
                                                …                  Zip Code  \
Start Station                                   … South Van Ness at Market
End Station                                     …
2nd at Folsom                                   …                        38
2nd at South Park                               …                        66
2nd at Townsend                                 …                        72
5th at Howard                                   …                       116
Adobe on Almaden                                …                         0
…                                             …                         …
Temporary Transbay Terminal (Howard at Beale)   …                       314
Townsend at 7th                                 …                       344
University and Emerson                          …                         0
Washington at Kearny                            …                        62
Yerba Buena Center of the Arts (3rd @ Howard)   …                        75
```

```
                                                                          \
Start Station                                Spear at Folsom St James Park
End Station
2nd at Folsom                                             57             0
2nd at South Park                                        152             0
2nd at Townsend                                          508             0
5th at Howard                                            102             0
Adobe on Almaden                                           0            14
…                                                        …             …
Temporary Transbay Terminal (Howard at Beale)             69             0
Townsend at 7th                                          464             0
University and Emerson                                     0             0
Washington at Kearny                                      24             0
Yerba Buena Center of the Arts (3rd @ Howard)            141             0
```

```
                                                                  \
Start Station                                Stanford in Redwood City
End Station
2nd at Folsom                                                    0
2nd at South Park                                                0
```

```
2nd at Townsend                                                    0
5th at Howard                                                      0
Adobe on Almaden                                                   0
…                                                                  …
Temporary Transbay Terminal (Howard at Beale)                      0
Townsend at 7th                                                    0
University and Emerson                                             0
Washington at Kearny                                               0
Yerba Buena Center of the Arts (3rd @ Howard)                      0

                                                                   \
Start Station                                 Steuart at Market
End Station
2nd at Folsom                                                 39
2nd at South Park                                            374
2nd at Townsend                                             2349
5th at Howard                                                182
Adobe on Almaden                                               0
…                                                              …
Temporary Transbay Terminal (Howard at Beale)                119
Townsend at 7th                                              734
University and Emerson                                         0
Washington at Kearny                                         107
Yerba Buena Center of the Arts (3rd @ Howard)                214

             \
Start Station                                 Temporary Transbay Terminal
(Howard at Beale)
End Station
2nd at Folsom
237
2nd at South Park
429
2nd at Townsend
784
5th at Howard
750
Adobe on Almaden
0
…
…
Temporary Transbay Terminal (Howard at Beale)
94
Townsend at 7th
825
University and Emerson
0
```

```
Washington at Kearny
90
Yerba Buena Center of the Arts (3rd @ Howard)
401

                                                                \
Start Station                                  Townsend at 7th
End Station
2nd at Folsom                                              342
2nd at South Park                                          143
2nd at Townsend                                            417
5th at Howard                                              199
Adobe on Almaden                                             0
…                                                          …
Temporary Transbay Terminal (Howard at Beale)              732
Townsend at 7th                                            132
University and Emerson                                       0
Washington at Kearny                                        29
Yerba Buena Center of the Arts (3rd @ Howard)              153

                                                                    \
Start Station                                  University and Emerson
End Station
2nd at Folsom                                                      0
2nd at South Park                                                  0
2nd at Townsend                                                    0
5th at Howard                                                      0
Adobe on Almaden                                                   0
…                                                                …
Temporary Transbay Terminal (Howard at Beale)                      0
Townsend at 7th                                                    0
University and Emerson                                            62
Washington at Kearny                                               0
Yerba Buena Center of the Arts (3rd @ Howard)                      0

                                                                     \
Start Station                                  Washington at Kearny
End Station
2nd at Folsom                                                     17
2nd at South Park                                                 63
2nd at Townsend                                                   57
5th at Howard                                                     43
Adobe on Almaden                                                   0
…                                                                …
Temporary Transbay Terminal (Howard at Beale)                     98
Townsend at 7th                                                   53
University and Emerson                                             0
```

```
Washington at Kearny                                          55
Yerba Buena Center of the Arts (3rd @ Howard)                 36


Start Station                                  Yerba Buena Center of the Arts
(3rd @ Howard)
End Station
2nd at Folsom
31
2nd at South Park
209
2nd at Townsend
166
5th at Howard
267
Adobe on Almaden
0
…
…
Temporary Transbay Terminal (Howard at Beale)
113
Townsend at 7th
261
University and Emerson
0
Washington at Kearny
66
Yerba Buena Center of the Arts (3rd @ Howard)
72

[70 rows x 630 columns]
```

[ ]:
```
pd.pivot_table(commute,
               columns='Start Station',
               index='End Station',
               values='Duration',
               aggfunc='min').fillna(0).apply(np.int64)
```

[ ]:
```
Start Station                                  2nd at Folsom  \
End Station
2nd at Folsom                                             61
2nd at South Park                                         61
2nd at Townsend                                          137
5th at Howard                                            215
Adobe on Almaden                                           0
…                                                        …
Temporary Transbay Terminal (Howard at Beale)            112
```

```
Townsend at 7th                                    399
University and Emerson                               0
Washington at Kearny                               266
Yerba Buena Center of the Arts (3rd @ Howard)      145

Start Station                                  2nd at South Park  \
End Station
2nd at Folsom                                                97
2nd at South Park                                            60
2nd at Townsend                                              67
5th at Howard                                               300
Adobe on Almaden                                              0
…                                                             …
Temporary Transbay Terminal (Howard at Beale)               195
Townsend at 7th                                             324
University and Emerson                                        0
Washington at Kearny                                        378
Yerba Buena Center of the Arts (3rd @ Howard)               212

Start Station                                  2nd at Townsend  5th at Howard  \
End Station
2nd at Folsom                                              164             268
2nd at South Park                                           77              86
2nd at Townsend                                             60             423
5th at Howard                                              384              68
Adobe on Almaden                                             0               0
…                                                            …               …
Temporary Transbay Terminal (Howard at Beale)              261             279
Townsend at 7th                                            319             330
University and Emerson                                       0               0
Washington at Kearny                                       464             269
Yerba Buena Center of the Arts (3rd @ Howard)              299             128

Start Station                                  Adobe on Almaden  \
End Station
2nd at Folsom                                                 0
2nd at South Park                                             0
2nd at Townsend                                               0
5th at Howard                                                 0
Adobe on Almaden                                             84
…                                                             …
Temporary Transbay Terminal (Howard at Beale)                 0
Townsend at 7th                                               0
University and Emerson                                        0
Washington at Kearny                                          0
Yerba Buena Center of the Arts (3rd @ Howard)                 0
```

```
Start Station                                 Arena Green / SAP Center  \
End Station
2nd at Folsom                                                        0
2nd at South Park                                                    0
2nd at Townsend                                                      0
5th at Howard                                                        0
Adobe on Almaden                                                   275
…                                                                    …
Temporary Transbay Terminal (Howard at Beale)                        0
Townsend at 7th                                                      0
University and Emerson                                               0
Washington at Kearny                                                 0
Yerba Buena Center of the Arts (3rd @ Howard)                        0

Start Station                                 Beale at Market  \
End Station
2nd at Folsom                                              271
2nd at South Park                                           78
2nd at Townsend                                            311
5th at Howard                                              357
Adobe on Almaden                                             0
…                                                            …
Temporary Transbay Terminal (Howard at Beale)               68
Townsend at 7th                                            614
University and Emerson                                       0
Washington at Kearny                                       142
Yerba Buena Center of the Arts (3rd @ Howard)              262

Start Station                                 Broadway St at Battery St  \
End Station
2nd at Folsom                                                      407
2nd at South Park                                                  345
2nd at Townsend                                                    469
5th at Howard                                                      530
Adobe on Almaden                                                     0
…                                                                    …
Temporary Transbay Terminal (Howard at Beale)                      261
Townsend at 7th                                                    822
University and Emerson                                               0
Washington at Kearny                                                69
Yerba Buena Center of the Arts (3rd @ Howard)                      420

Start Station                                 California Ave Caltrain Station
\
End Station
2nd at Folsom                                                                0
2nd at South Park                                                            0
```

```
2nd at Townsend                                                    0
5th at Howard                                                      0
Adobe on Almaden                                                   0
…                                                                …
Temporary Transbay Terminal (Howard at Beale)                      0
Townsend at 7th                                                    0
University and Emerson                                           592
Washington at Kearny                                               0
Yerba Buena Center of the Arts (3rd @ Howard)                      0

Start Station                                 Castro Street and El Camino Real
\
End Station
2nd at Folsom                                                      0
2nd at South Park                                                  0
2nd at Townsend                                                    0
5th at Howard                                                      0
Adobe on Almaden                                                   0
…                                                                …
Temporary Transbay Terminal (Howard at Beale)                      0
Townsend at 7th                                                    0
University and Emerson                                             0
Washington at Kearny                                               0
Yerba Buena Center of the Arts (3rd @ Howard)                      0

Start Station                                 …  South Van Ness at Market  \
End Station                                   …
2nd at Folsom                                 …                      590
2nd at South Park                             …                      399
2nd at Townsend                               …                      777
5th at Howard                                 …                      375
Adobe on Almaden                              …                        0
…                                           …                        …
Temporary Transbay Terminal (Howard at Beale) …                      647
Townsend at 7th                               …                      351
University and Emerson                        …                        0
Washington at Kearny                          …                      514
Yerba Buena Center of the Arts (3rd @ Howard) …                      464

Start Station                                 Spear at Folsom  St James Park  \
End Station
2nd at Folsom                                             208              0
2nd at South Park                                          63              0
2nd at Townsend                                           241              0
5th at Howard                                             402              0
Adobe on Almaden                                            0            369
…                                                         …              …
```

```
Temporary Transbay Terminal (Howard at Beale)              137              0
Townsend at 7th                                            514              0
University and Emerson                                       0              0
Washington at Kearny                                       341              0
Yerba Buena Center of the Arts (3rd @ Howard)              287              0

Start Station                                 Stanford in Redwood City  \
End Station
2nd at Folsom                                                        0
2nd at South Park                                                    0
2nd at Townsend                                                      0
5th at Howard                                                        0
Adobe on Almaden                                                     0
…                                                                  …
Temporary Transbay Terminal (Howard at Beale)                        0
Townsend at 7th                                                      0
University and Emerson                                               0
Washington at Kearny                                                 0
Yerba Buena Center of the Arts (3rd @ Howard)                        0

Start Station                                 Steuart at Market  \
End Station
2nd at Folsom                                                  318
2nd at South Park                                               79
2nd at Townsend                                                291
5th at Howard                                                  455
Adobe on Almaden                                                 0
…                                                              …
Temporary Transbay Terminal (Howard at Beale)                  139
Townsend at 7th                                                624
University and Emerson                                           0
Washington at Kearny                                           165
Yerba Buena Center of the Arts (3rd @ Howard)                  320

Start Station                                 Temporary Transbay Terminal
(Howard at Beale)  \
End Station
2nd at Folsom
149
2nd at South Park
61
2nd at Townsend
249
5th at Howard
265
Adobe on Almaden
0
```

```
…
…
Temporary Transbay Terminal (Howard at Beale)
60
Townsend at 7th
534
University and Emerson
0
Washington at Kearny
248
Yerba Buena Center of the Arts (3rd @ Howard)
190

Start Station                                    Townsend at 7th  \
End Station
2nd at Folsom                                                448
2nd at South Park                                             78
2nd at Townsend                                              259
5th at Howard                                                357
Adobe on Almaden                                               0
…                                                              …
Temporary Transbay Terminal (Howard at Beale)                542
Townsend at 7th                                               61
University and Emerson                                         0
Washington at Kearny                                         642
Yerba Buena Center of the Arts (3rd @ Howard)                479

Start Station                                    University and Emerson  \
End Station
2nd at Folsom                                                          0
2nd at South Park                                                      0
2nd at Townsend                                                        0
5th at Howard                                                          0
Adobe on Almaden                                                       0
…                                                                      …
Temporary Transbay Terminal (Howard at Beale)                          0
Townsend at 7th                                                        0
University and Emerson                                                93
Washington at Kearny                                                   0
Yerba Buena Center of the Arts (3rd @ Howard)                          0

Start Station                                    Washington at Kearny  \
End Station
2nd at Folsom                                                      429
2nd at South Park                                                  270
2nd at Townsend                                                    610
5th at Howard                                                      553
```

```
Adobe on Almaden                                                    0
…                                                                   …
Temporary Transbay Terminal (Howard at Beale)                     311
Townsend at 7th                                                   817
University and Emerson                                              0
Washington at Kearny                                               65
Yerba Buena Center of the Arts (3rd @ Howard)                     360

Start Station                                    Yerba Buena Center of the Arts
(3rd @ Howard)
End Station
2nd at Folsom
165
2nd at South Park
96
2nd at Townsend
284
5th at Howard
109
Adobe on Almaden
0
…
…
Temporary Transbay Terminal (Howard at Beale)
226
Townsend at 7th
432
University and Emerson
0
Washington at Kearny
190
Yerba Buena Center of the Arts (3rd @ Howard)
60

[70 rows x 70 columns]
```

2.2 Drawing Maps

[ ]:
```
url = "https://raw.githubusercontent.com/data-8/textbook/main/assets/data/
 ↪station.csv"
stations = pd.read_csv(url)
stations
```

[ ]:
```
    station_id                              name        lat        long  \
0            2  San Jose Diridon Caltrain Station  37.329732 -121.901782
1            3              San Jose Civic Center  37.330698 -121.888979
2            4             Santa Clara at Almaden  37.333988 -121.894902
```

```
3            5                    Adobe on Almaden  37.331415 -121.893200
4            6                    San Pedro Square  37.336721 -121.894074
..         …                                    …       …         …
65          77                  Market at Sansome  37.789625 -122.400811
66          80   Santa Clara County Civic Center  37.352601 -121.905733
67          82         Broadway St at Battery St  37.798541 -122.400862
68          83                        Mezes Park  37.491269 -122.236234
69          84                       Ryland Park  37.342725 -121.895617

    dockcount       landmark installation
0          27       San Jose     8/6/2013
1          15       San Jose     8/5/2013
2          11       San Jose     8/6/2013
3          19       San Jose     8/5/2013
4          15       San Jose     8/7/2013
..        …            …          …
65         27  San Francisco    8/25/2013
66         15       San Jose   12/31/2013
67         15  San Francisco    1/22/2014
68         15   Redwood City    2/20/2014
69         15       San Jose     4/9/2014

[70 rows x 7 columns]
```

[ ]:
```
import folium

fig = Figure(width=800, height=600)
cityMap = folium.Map(location = [stations['lat'].mean(axis='rows'),␣
 ↪stations['long'].mean(axis='rows')],
              zoom_start = 10)
makerPositions = stations[['lat', 'long']].values.tolist()
for markerPosition in makerPositions:
    folium.Marker(markerPosition).add_to(cityMap)
fig.add_child(cityMap)
```

[ ]:
```
<branca.element.Figure at 0x17894c5d810>
```

[ ]:
```
fig = Figure(width=600, height=400)
sf = stations[stations['landmark'] == 'San Francisco']
sf_map_data = folium.Map(location = [sf['lat'].mean(axis='rows'), sf['long'].
 ↪mean(axis='rows')],
              zoom_start = 12)
makerPositions = stations[['lat', 'long']].values.tolist()
for markerPosition in makerPositions:
    folium.CircleMarker(markerPosition,
                        fill = True,
                        color = 'green').add_to(sf_map_data)
```

```
fig.add_child(sf_map_data)
```

[ ]:
```
<branca.element.Figure at 0x1789e8e2510>
```

2.3 More Informative Maps: An Application of `join`

[ ]:
```
cities = stations.groupby('landmark')['landmark'].count()
cities
```

[ ]:
```
landmark
Mountain View     7
Palo Alto         5
Redwood City      7
San Francisco    35
San Jose         16
Name: landmark, dtype: int64
```

[ ]:
```
cities = stations.groupby('landmark')['landmark'].count().
 ↪reset_index(name='count').rename(columns={'landmark': 'city'})
cities
```

[ ]:

	city	count
0	Mountain View	7
1	Palo Alto	5
2	Redwood City	7
3	San Francisco	35
4	San Jose	16

[ ]:
```
colors = cities.copy()
colors['color'] = np.array(['blue', 'red', 'green', 'orange', 'purple'])
colors
```

[ ]:

	city	count	color
0	Mountain View	7	blue
1	Palo Alto	5	red
2	Redwood City	7	green
3	San Francisco	35	orange
4	San Jose	16	purple

[ ]:
```
# JOIN table stations and colors
joined = stations.join(colors.set_index('city'),
                       on='landmark',
                       how='inner')
colored = joined.loc[:, ['lat', 'long', 'name', 'color']]
colored
```

[ ]:
```
          lat        long                                name   color
0   37.329732 -121.901782   San Jose Diridon Caltrain Station  purple
1   37.330698 -121.888979               San Jose Civic Center  purple
2   37.333988 -121.894902             Santa Clara at Almaden  purple
3   37.331415 -121.893200                  Adobe on Almaden  purple
4   37.336721 -121.894074                  San Pedro Square  purple
..        …         …                                   …     …
62  37.794139 -122.394434                 Steuart at Market  orange
63  37.791300 -122.399051  Mechanics Plaza (Market at Battery)  orange
64  37.786305 -122.404966                      Market at 4th  orange
65  37.789625 -122.400811                 Market at Sansome  orange
67  37.798541 -122.400862          Broadway St at Battery St  orange

[70 rows x 4 columns]
```

[ ]:
```
fig = Figure(width=800, height=600)

colored_map = folium.Map(location = [colored['lat'].mean(axis='rows'),␣
 ↪colored['long'].mean(axis='rows')],
             zoom_start = 10)

for markerData in colored.values:
    folium.Marker([markerData[0],markerData[1]] ,
      icon=folium.Icon(color=markerData[3],icon_color='blue'),
      popup=markerData[2]
      ).add_to(colored_map)
fig.add_child(colored_map)
```

[ ]:
```
<branca.element.Figure at 0x1789f5aa210>
```

[ ]:
```
starts = commute.groupby('Start Station')['Start Station'].count()
starts
```

[ ]:
```
Start Station
2nd at Folsom                                  7841
2nd at South Park                              9274
2nd at Townsend                               13674
5th at Howard                                  7394
Adobe on Almaden                                522
                                               …
Temporary Transbay Terminal (Howard at Beale)  14298
Townsend at 7th                                13579
University and Emerson                           248
Washington at Kearny                            2395
Yerba Buena Center of the Arts (3rd @ Howard)   5249
Name: Start Station, Length: 70, dtype: int64
```

[ ]:
```
starts = commute.groupby('Start Station')['Start Station'].count().
  ↪reset_index(name='count').sort_values(by='count', ascending=False)
starts
```

[ ]:
```
                                  Start Station  count
49       San Francisco Caltrain (Townsend at 4th)  25858
50        San Francisco Caltrain 2 (330 Townsend)  21523
23           Harry Bridges Plaza (Ferry Building)  15543
65  Temporary Transbay Terminal (Howard at Beale)  14298
2                                 2nd at Townsend  13674
..                                            …    …
31                                   Mezes Park    189
41                   Redwood City Medical Center    139
55                       San Mateo County Center    108
42                   Redwood City Public Library    101
20                             Franklin at Maple     62

[70 rows x 2 columns]
```

[ ]:
```
station_starts = stations.join(starts.set_index('Start Station'),
                               on='name',
                               how='inner')
station_starts
```

[ ]:
```
    station_id                             name        lat        long  \
0            2  San Jose Diridon Caltrain Station  37.329732 -121.901782
1            3              San Jose Civic Center  37.330698 -121.888979
2            4             Santa Clara at Almaden  37.333988 -121.894902
3            5                  Adobe on Almaden  37.331415 -121.893200
4            6                  San Pedro Square  37.336721 -121.894074
..         …                                 …       …         …
65          77                 Market at Sansome  37.789625 -122.400811
66          80   Santa Clara County Civic Center  37.352601 -121.905733
67          82         Broadway St at Battery St  37.798541 -122.400862
68          83                       Mezes Park  37.491269 -122.236234
69          84                      Ryland Park  37.342725 -121.895617

    dockcount       landmark installation  count
0          27       San Jose     8/6/2013   4899
1          15       San Jose     8/5/2013    574
2          11       San Jose     8/6/2013   1888
3          19       San Jose     8/5/2013    522
4          15       San Jose     8/7/2013   1321
..        …            …          …    …
65         27  San Francisco    8/25/2013  11023
66         15       San Jose   12/31/2013    510
67         15  San Francisco    1/22/2014   7460
```

```
68          15   Redwood City    2/20/2014    189
69          15       San Jose     4/9/2014   1077

[68 rows x 8 columns]
```

[ ]:
```
# Extract columns 'lat', 'long', 'name' from station_starts to starts_map_data
starts_map_data = station_starts.loc[:, ['lat', 'long', 'name']].copy()

# Set color
starts_map_data['colors'] = ['blue'] * 68 # 68 rows

# Set size
starts_map_data['areas'] = station_starts['count'] * 0.3

starts_map_data
```

[ ]:
```
          lat        long                                name colors   areas
0   37.329732 -121.901782  San Jose Diridon Caltrain Station   blue  1469.7
1   37.330698 -121.888979              San Jose Civic Center   blue   172.2
2   37.333988 -121.894902            Santa Clara at Almaden   blue   566.4
3   37.331415 -121.893200                 Adobe on Almaden   blue   156.6
4   37.336721 -121.894074                 San Pedro Square   blue   396.3
..        …         …                                   …    …     …
65  37.789625 -122.400811                Market at Sansome   blue  3306.9
66  37.352601 -121.905733   Santa Clara County Civic Center   blue   153.0
67  37.798541 -122.400862         Broadway St at Battery St   blue  2238.0
68  37.491269 -122.236234                      Mezes Park   blue    56.7
69  37.342725 -121.895617                     Ryland Park   blue   323.1

[68 rows x 5 columns]
```

[ ]:
```
def color_select(areas):
    if areas > 3000:
        return 'red'
    elif areas > 2000:
        return  'yellow'
    elif areas > 1000:
        return 'green'
    else:
        return 'dodgerblue'
```

[ ]:
```
fig = Figure(width=800, height=600)

stataion_starts_map = folium.Map(location = [starts_map_data['lat'].
 ↪mean(axis='rows'), starts_map_data['long'].mean(axis='rows')],
             zoom_start = 10)
```

```
for markerData in starts_map_data.values:
    folium.CircleMarker([markerData[0],markerData[1]],
                        fill = True,
                        color = color_select(markerData[4]),
                        radius = (markerData[4]**(1/2))/2).
 ↪add_to(stataion_starts_map)

fig.add_child(stataion_starts_map)
```

[ ]: <branca.element.Figure at 0x1789e9b7a10>