Problem Set 6 - Waze Shiny Dashboard

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2024-11-24

1. **ps6:** Due Sat 23rd at 5:00PM Central. Worth 100 points + 10 extra credit.

We use (`*`) to indicate a problem that we think might be time consuming.

Steps to submit (10 points on PS6)

1. "This submission is my work alone and complies with the 30538 integrity policy." Add your initials to indicate your agreement: **___**
2. "I have uploaded the names of anyone I worked with on the problem set **here**" **___** (2 point)
3. Late coins used this pset: **___** Late coins left after submission: **___**
4. Knit your `ps6.qmd` as a pdf document and name it `ps6.pdf`.
5. Push `ps6.qmd`, `ps6.pdf`, and all created folders (we will create three Shiny apps so you will have at least three additional folders) to your Github repo. It is fine to use Github Desktop.
6. Submit `ps6.pdf` and also link your Github repo via Gradescope (8 points)

   - The PDF should not be more than 25 pages. Use `head()` and re-size figures when appropriate.

7. Tag your submission in Gradescope

Note: see the Quarto documentation (link) for directions on inserting images into your knitted document.

Import requisite packages.

```
RendererRegistry.enable('png')
```

Background

Data Download and Exploration

Prior to starting the problem set, you should have downloaded the required data for this problem from here. The data dictionary for this dataset is here.

1. Using the `zipfile` package, unzip the `waze_data.zip` file. You will find two files in the unzipped folder: `waze_data.csv` (the whole dataset) and `waze_data_sample.csv` (a sample of 1% of the data). Load the `waze_data_sample.csv` file into a pandas DataFrame. What are the variable names and what are their data types? When reporting data types, report using the Altair syntax (e.g., Quantitative, Nominal, etc.). When reporting data types, ignore the columns `ts`, `geo`, and `geoWKT`.

```
import zipfile
import pandas as pd

# Unzip the data file
# They could create a path, but anything should work

waze_data_path = "waze_data.zip"
with zipfile.ZipFile(waze_data_path, 'r') as zip_ref:
    zip_ref.extractall('data')

# Read the unzipped CSV into a pandas DataFrame
df_waze = pd.read_csv('data/waze_data.csv')
```

```
# Display basic info about the DataFrame
print("Number of rows:", len(df_waze))
print("\nDataFrame info:") # They should get 7_781
df_waze.info()
df_waze.head()
```

```
Number of rows: 778094

DataFrame info:
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 778094 entries, 0 to 778093
Data columns (total 15 columns):
 #   Column         Non-Null Count   Dtype
---  ------         --------------   -----
 0   city           778094 non-null  object
 1   confidence    778094 non-null  int64
 2   nThumbsUp     1371 non-null    float64
 3   street        764021 non-null  object
 4   uuid          778094 non-null  object
 5   country       778094 non-null  object
 6   type          778094 non-null  object
 7   subtype       682008 non-null  object
 8   roadType      778094 non-null  int64
 9   reliability   778094 non-null  int64
 10  magvar        778094 non-null  int64
 11  reportRating  778094 non-null  int64
 12  ts            778094 non-null  object
 13  geo           778094 non-null  object
 14  geoWKT        778094 non-null  object
dtypes: float64(1), int64(5), object(9)
memory usage: 89.0+ MB

E:\Anaconda\Lib\site-packages\IPython\core\formatters.py:344: FutureWarning:

In future versions `DataFrame.to_latex` is expected to utilise the base
implementation of `Styler.to_latex` for formatting and rendering. The
arguments signature may therefore change. It is recommended instead to use
`DataFrame.style.to_latex` which also contains additional functionality.
```

	city	confidence	nThumbsUp	street	uuid	country	type
0	Chicago, IL	0	NaN	NaN	004025a4-5f14-4cb7-9da6-2615daafbf37	US	JAM
1	Chicago, IL	1	NaN	NaN	ad7761f8-d3cb-4623-951d-dafb419a3ec3	US	ACC
2	Chicago, IL	0	NaN	NaN	0e5f14ae-7251-46af-a7f1-53a5272cd37d	US	ROA
3	Chicago, IL	0	NaN	Alley	654870a4-a71a-450b-9f22-bc52ae4f69a5	US	JAM
4	Chicago, IL	0	NaN	Alley	926ff228-7db9-4e0d-b6cf-6739211ffc8b	US	JAM

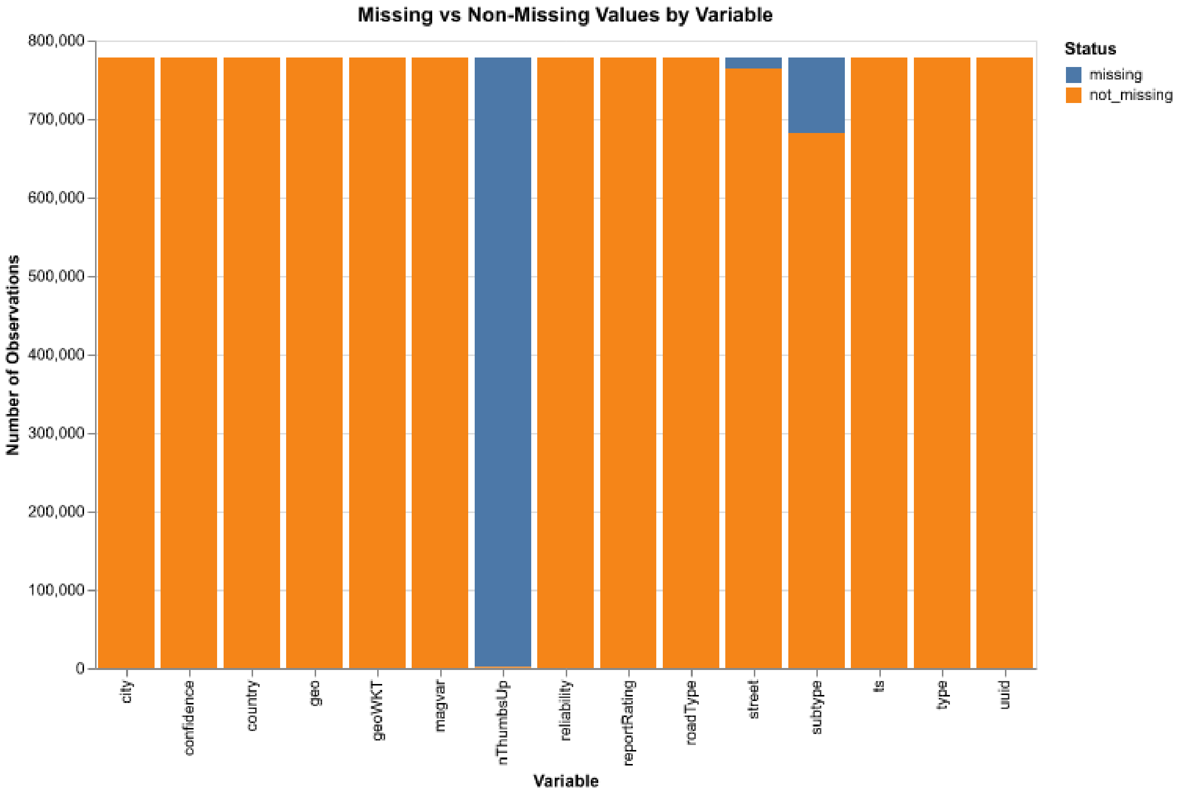
Solution: They should be getting 7,781 rows for the sample. The last three columns are not required to be reported in the solution

variable	type
city	Nominal
confidence	Quantitative
nThumbsUp	Quantative
street	Nominal
uuid	Nominal
country	Nominal
type	Nominal

variable	type
subtype	Nominal
roadType	Nominal
reliability	Ordinal
magvar	Ordinal
reportRating	Ordinal
ts	Temporal
geo	Quantitative
geoWKT	Quantitative

2. Now load the `waze_data.csv` file into a pandas DataFrame. With this file, Create a stacked bar chart where the x-axis is each variable and the stacked bar has two categories: the number of observations where that variable is `NULL` or missing, and the number of observations where they are not. Which variables have the `NULL` values? Which variable has the highest share of observations that are missing?

```
# Create a DataFrame with missing value counts for each column
missing_df_waze = pd.DataFrame({
    'variable': df_waze.columns,
    'missing': df_waze.isnull().sum(),
    'not_missing': df_waze.notnull().sum()
}).melt(id_vars=['variable'], var_name='status', value_name='count')

# Create stacked bar chart
chart = alt.Chart(missing_df_waze).mark_bar().encode(
    x=alt.X('variable:N', title='Variable'),
    y=alt.Y('count:Q', title='Number of Observations'),
    color=alt.Color('status:N', title='Status'),
    tooltip=['variable', 'status', 'count']
).properties(
    width=600,
    height=400,
    title='Missing vs Non-Missing Values by Variable'
)

chart
```



Solution: Three variables have missing values `nThumbsUp`, `subtype` and `street` have missing values. `nThumsUp` has the highest share of observations missing.

3. Take a look at the variables `type` and `subtype`. Even though they informative, some are not aesthetically pleasing, and others are difficult to read. Before going into the development of our Shiny Apps, we will create a **crosswalk** table to help us have cleaner data.

Print the unique values for the columns `type` and `subtype`. How many types have a subtype that is `NA`? Even though we print the combinations for two columns, can you identify which `type` has `subtypes` that have enough information to consider that they could have *sub-subtypes*?

Write out a bulleted listed with the values at each layer given this hierarchy. For this list, use names that are clean and readable. For example, using `ACCIDENT_MAJOR` in the dashboard is not as readable or user-friendly as one menu option that says `Accident` and then a subsequent one that says `Major`.

Finally, do you consider that we should keep the `NA` subtypes? Why? If you choose to keep the `NA` subtypes, code them as “Unclassified.”

Solution: All four types have a subtype that is `NA`. `HAZARD` has subtypes which could have sub-subtypes.

```
# Identify unique values for type and subtype

df_waze[['type', 'subtype']].drop_duplicates().sort_values(by = ['type',
 ↪  'subtype']).reset_index(drop = True)
```

```
E:\Anaconda\Lib\site-packages\IPython\core\formatters.py:344: FutureWarning:

In future versions `DataFrame.to_latex` is expected to utilise the base
implementation of `Styler.to_latex` for formatting and rendering. The
arguments signature may therefore change. It is recommended instead to use
`DataFrame.style.to_latex` which also contains additional functionality.
```

	type	subtype
0	ACCIDENT	ACCIDENT_MAJOR
1	ACCIDENT	ACCIDENT_MINOR
2	ACCIDENT	NaN
3	HAZARD	HAZARD_ON_ROAD
4	HAZARD	HAZARD_ON_ROAD_CAR_STOPPED
5	HAZARD	HAZARD_ON_ROAD_CONSTRUCTION
6	HAZARD	HAZARD_ON_ROAD_EMERGENCY_VEHICLE
7	HAZARD	HAZARD_ON_ROAD_ICE
8	HAZARD	HAZARD_ON_ROAD_LANE_CLOSED
9	HAZARD	HAZARD_ON_ROAD_OBJECT
10	HAZARD	HAZARD_ON_ROAD_POT_HOLE
11	HAZARD	HAZARD_ON_ROAD_ROAD_KILL
12	HAZARD	HAZARD_ON_ROAD_TRAFFIC_LIGHT_FAULT
13	HAZARD	HAZARD_ON_SHOULDER
14	HAZARD	HAZARD_ON_SHOULDER_ANIMALS
15	HAZARD	HAZARD_ON_SHOULDER_CAR_STOPPED
16	HAZARD	HAZARD_ON_SHOULDER_MISSING_SIGN
17	HAZARD	HAZARD_WEATHER
18	HAZARD	HAZARD_WEATHER_FLOOD
19	HAZARD	HAZARD_WEATHER_FOG
20	HAZARD	HAZARD_WEATHER_HAIL
21	HAZARD	HAZARD_WEATHER_HEAVY_SNOW
22	HAZARD	NaN
23	JAM	JAM_HEAVY_TRAFFIC
24	JAM	JAM_LIGHT_TRAFFIC
25	JAM	JAM_MODERATE_TRAFFIC
26	JAM	JAM_STAND_STILL_TRAFFIC
27	JAM	NaN
28	ROAD_CLOSED	ROAD_CLOSED_CONSTRUCTION
29	ROAD_CLOSED	ROAD_CLOSED_EVENT
30	ROAD_CLOSED	ROAD_CLOSED_HAZARD
31	ROAD_CLOSED	NaN

Types Jam, Accident, and Road Closed should have two layers. Type Hazard has three layers.

- Jam
  - Heavy traffic
  - Moderate traffic
  - Stand still traffic
  - Light traffic

    - Unclassified

- Accident
    - Major
    - Minor
    - Unspecified
- Road closed
    - Event
    - Construction
    - Hazard
    - Unclassified
- Hazard
    - On road
        - General (this is for subtype `HAZARD_ON_ROAD`)
        - Car stopped
        - Construction
        - Emergency
        - Ice
        - Object
        - Pot hole
        - Traffic light fault
        - Lane closed
    - On shoulder
        - General
        - Car stopped
        - Animals
        - Missing sign
        - Road kill
    - Weather
        - General
        - Flood
        - Fog
        - Heavy snow
        - Hail
    - Unclassified

4. We want to assign this newly created hierarchy to the original data. To do so, we will create the crosswalk DataFrame and then merge it with the rest of the data.

1. To create a crosswalk, define a pandas DataFrame which has five columns: `type` and `subtype` from the original dataset, and three new columns `updated_type`, `updated_subtype`, and `updated_subsubtype`.
2. Let each row of this DataFrame be a unique combination of `type` and `subtype`. Then, based on the hierarchy you proposed in Q3, fill in `updated_type`, `updated_subtype`, and `updated_subsubtype` accordingly. Remember to name the `NA` subtypes as "Unclassified". Hint: your crosswalk should have 32 observations.
3. Merge the crosswalk with the original data using `type` and `subtype`. How many rows are there for Accident - Unclassified?
4. **EXTRA CREDIT/OPTIONAL**: After merging the crosswalk,can you check that the crosswalk and the new merged dataset have the same values in `type` and `subtype`?

Solution: For part 3, there are 24,359 rows for Accident - Unclassified. The goal of this part is for them to make sure that they merged correctly as they could have made a mistake in the NULL handling.

```
# Create crosswalk DataFrame with the hierarchy
crosswalk_data = [
    # Jam
    ['JAM', 'JAM_HEAVY_TRAFFIC', 'Jam', 'Heavy traffic', None],
    ['JAM', 'JAM_MODERATE_TRAFFIC', 'Jam', 'Moderate traffic', None],
    ['JAM', 'JAM_STAND_STILL_TRAFFIC', 'Jam', 'Stand still traffic', None],
    ['JAM', 'JAM_LIGHT_TRAFFIC', 'Jam', 'Light traffic', None],
    ['JAM', None, 'Jam', 'Unclassified', None],

    # Accident
    ['ACCIDENT', 'ACCIDENT_MAJOR', 'Accident', 'Major', None],
    ['ACCIDENT', 'ACCIDENT_MINOR', 'Accident', 'Minor', None],
    ['ACCIDENT', None, 'Accident', 'Unclassified', None],

    # Road Closed
    ['ROAD_CLOSED', 'ROAD_CLOSED_EVENT', 'Road closed', 'Event', None],
    ['ROAD_CLOSED', 'ROAD_CLOSED_CONSTRUCTION', 'Road closed',
↪   'Construction', None],
    ['ROAD_CLOSED', 'ROAD_CLOSED_HAZARD', 'Road closed', 'Hazard', None],
    ['ROAD_CLOSED', None, 'Road closed', 'Unclassified', None],

    # Hazard - On road
    ['HAZARD', 'HAZARD_ON_ROAD', 'Hazard', 'On road', 'General'],
    ['HAZARD', 'HAZARD_ON_ROAD_CAR_STOPPED', 'Hazard', 'On road', 'Car
↪   stopped'],
    ['HAZARD', 'HAZARD_ON_ROAD_CONSTRUCTION', 'Hazard', 'On road',
↪   'Construction'],
    ['HAZARD', 'HAZARD_ON_ROAD_EMERGENCY_VEHICLE', 'Hazard', 'On road',
 ↪  'Emergency'],
    ['HAZARD', 'HAZARD_ON_ROAD_ICE', 'Hazard', 'On road', 'Ice'],
    ['HAZARD', 'HAZARD_ON_ROAD_OBJECT', 'Hazard', 'On road', 'Object'],
    ['HAZARD', 'HAZARD_ON_ROAD_POT_HOLE', 'Hazard', 'On road', 'Pot hole'],
    ['HAZARD', 'HAZARD_ON_ROAD_TRAFFIC_LIGHT_FAULT', 'Hazard', 'On road',
 ↪  'Traffic light fault'],
    ['HAZARD', 'HAZARD_ON_ROAD_LANE_CLOSED', 'Hazard', 'On road', 'Lane
 ↪  closed'],
    ['HAZARD', 'HAZARD_ON_ROAD_ROAD_KILL', 'Hazard', 'On road', 'Road kill'],

    # Hazard - On shoulder
    ['HAZARD', 'HAZARD_ON_SHOULDER', 'Hazard', 'On shoulder', 'General'],
    ['HAZARD', 'HAZARD_ON_SHOULDER_CAR_STOPPED', 'Hazard', 'On shoulder',
 ↪  'Car stopped'],
    ['HAZARD', 'HAZARD_ON_SHOULDER_ANIMALS', 'Hazard', 'On shoulder',
 ↪  'Animals'],
    ['HAZARD', 'HAZARD_ON_SHOULDER_MISSING_SIGN', 'Hazard', 'On shoulder',
 ↪  'Missing sign'],

    # Hazard - Weather
    ['HAZARD', 'HAZARD_WEATHER', 'Hazard', 'Weather', 'General'],
    ['HAZARD', 'HAZARD_WEATHER_FLOOD', 'Hazard', 'Weather', 'Flood'],
    ['HAZARD', 'HAZARD_WEATHER_FOG', 'Hazard', 'Weather', 'Fog'],
    ['HAZARD', 'HAZARD_WEATHER_HEAVY_SNOW', 'Hazard', 'Weather', 'Heavy
 ↪  snow'],
    ['HAZARD', 'HAZARD_WEATHER_HAIL', 'Hazard', 'Weather', 'Hail'],

    # Hazard - Unclassified
    ['HAZARD', None, 'Hazard', 'Unclassified', None]
]

# Create DataFrame from the crosswalk data
crosswalk = pd.DataFrame(crosswalk_data,
                        columns=['type', 'subtype', 'updated_type',
                                'updated_subtype', 'updated_subsubtype'])
```

```
#OPTIONAL: check that our crosswalk and df_waze have the same values in type
 ↪  and sub_type

types_subtypes_crosswalk = crosswalk[['type',
 ↪  'subtype']].drop_duplicates().sort_values(by = ['type',
 ↪  'subtype']).reset_index(drop = True)
```

```
types_subtypes_df = df_waze[['type',
↪  'subtype']].drop_duplicates().sort_values(by = ['type',
↪  'subtype']).reset_index(drop = True)

types_subtypes_crosswalk.equals(types_subtypes_df)
```

```
True
```

```
# Merge crosswalk with original data
df_waze_crosswalk = df_waze.merge(crosswalk, on=['type', 'subtype'],
↪  how='left')

# Count rows for Accident - Unclassified
df_waze_crosswalk[(df_waze_crosswalk['updated_type'] == 'Accident') &
↪  (df_waze_crosswalk['updated_subtype'] == 'Unclassified')].shape[0]
```

```
24359
```

App #1: Top Location by Alert Type Dashboard

We will first make a spatial dashboard that displays the top 10 locations in Chicago with the highest number of alerts of a chosen type and subtype. Follow the lecture notes on how to create a Basic Shiny app and create it in a new folder called `top_alerts_map` (**Note**: remember to choose "No" when prompted to choose if you would like to use Shiny Express).

1. Let's begin by by developing our output outside of Shiny. We will first clean and collapse the data.

    a. The `geo` variable holds coordinates data, but they are stored in a string that represents the Well-Known Text representation of the point. Create two variables `latitude` and `longitude` after extracting the latitude and longitude from the string. *Hint: you will have to use regular expressions or* `regex` *to extract your text. You can look at the tutorial on regex here (here (link)) or prompt ChatGPT to put together a regular expression that extracts the coordinates. If you use ChatGPT, copy your prompt ChatGPT's response below.*

Solution: Expect a lot of chatgpt prompts…

```
def extract_lat_lon_series(geo_series):
    coords = geo_series.str.extract(r'POINT\(([-\d.]+) ([-\d.]+)\)')
    #coords.columns = ['latitude', 'longitude'] # Well, it seems this was
     ↪  incorrect
    coords.columns = ['longitude', 'latitude']
    return coords.astype(float)

df_waze_geo = pd.concat([df_waze_crosswalk,
 ↪  extract_lat_lon_series(df_waze_crosswalk['geo'])], axis=1)
```

b. Bin the latitude and longitude variables into bins of step size 0.01. That is, coordinats with values of `(-41.9232, -87.4251)` should become `(-41.92, -87.43)`. Which binned latitude-longitude combination has the greatest number of observations in the overall dataset?

Solution: The latitude-longitude combination with the greatest number of observations is (-87.75, 41.96)

```
# create 0.01-degree bins for latitude and longitude
df_waze_geo['latitude_bin'] = (df_waze_geo['latitude'] // 0.01) * 0.01
df_waze_geo['longitude_bin'] = (df_waze_geo['longitude'] // 0.01) * 0.01

# aggregate and find top values
tot_counts = df_waze_geo.groupby(['latitude_bin',
 ↪  'longitude_bin']).size().reset_index(name='totcount')
tot_counts = tot_counts.sort_values(by='totcount', ascending=False)
print(tot_counts.head())
```

```
     latitude_bin  longitude_bin  totcount
589         41.96         -87.75     26537
421         41.88         -87.65     22934
437         41.89         -87.66     16703
404         41.87         -87.65     15032
339         41.83         -87.64     13280
```

c. Collapse the data down to the level of aggregation needed to plot the top 10 latitude-longitude bins with the highest number of alerts for a chosen *type and subtype* (Note: no sub-subtype). Save DataFrame as `top_alerts_map.csv` file in the `top_alerts_map` folder you created. What is the level of aggregation in this case? How many rows does this DataFrame have?

Solution:It should be collapsed down to the type x subtype x latitude bin x longitude bin level and it should have 6,764 rows.

```
collapsed_df_waze_geo = df_waze_geo.groupby(['latitude_bin', 'longitude_bin',
 ↪  'updated_type', 'updated_subtype']).size().reset_index(name='totcount')

collapsed_df_waze_geo.to_csv("./top_alerts_map/top_alerts_map.csv",
 ↪  index=False)

len(collapsed_df_waze_geo)
collapsed_df_waze_geo.head()
```

```
E:\Anaconda\Lib\site-packages\IPython\core\formatters.py:344: FutureWarning:

In future versions `DataFrame.to_latex` is expected to utilise the base
implementation of `Styler.to_latex` for formatting and rendering. The
arguments signature may therefore change. It is recommended instead to use
`DataFrame.style.to_latex` which also contains additional functionality.
```

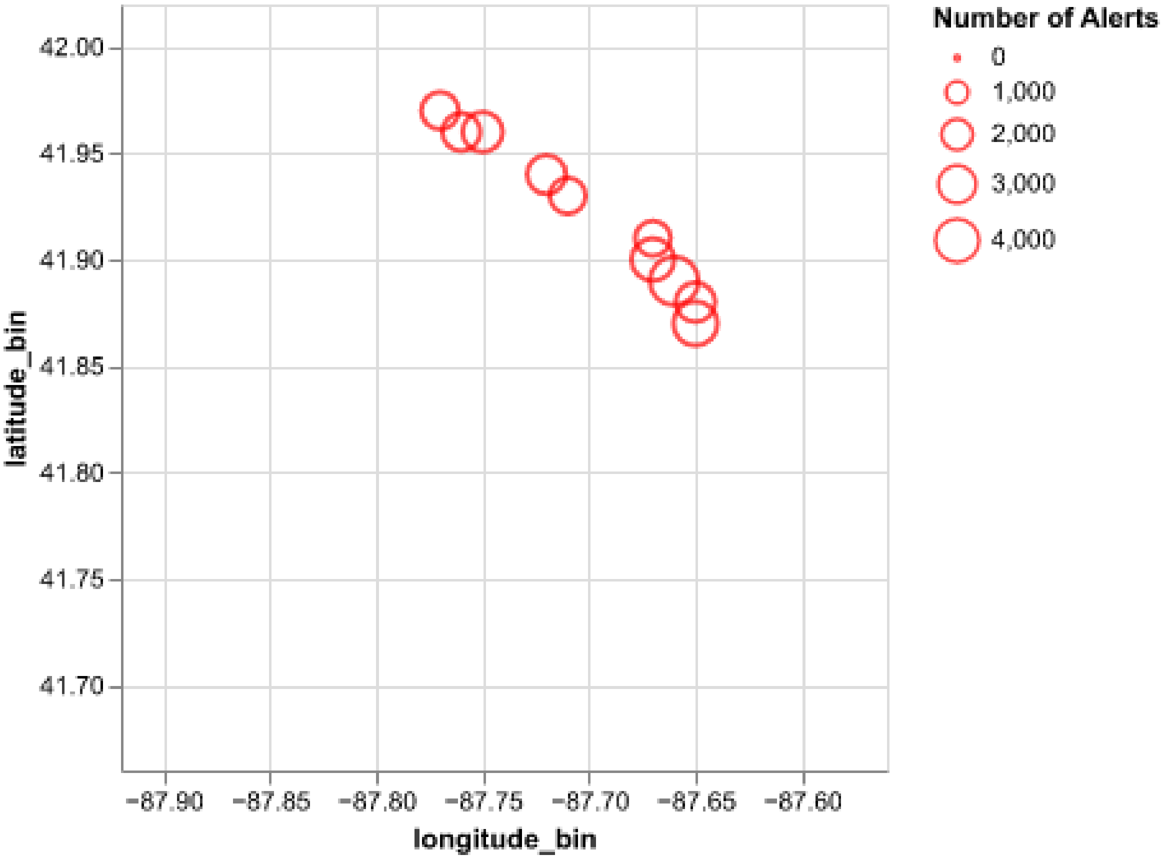
	latitude_bin	longitude_bin	updated_type	updated_subtype	totcount
0	41.64	-87.62	Hazard	On road	14
1	41.64	-87.59	Accident	Major	1
2	41.64	-87.59	Accident	Unclassified	4
3	41.64	-87.59	Hazard	On road	24
4	41.64	-87.59	Hazard	On shoulder	89

2. Using `altair`, plot a scatter plot where the x-axis is longitude and y-axis is latitude, and the points represent the latitude-longitude bins with the 10 highest number of “Jam - Heavy Traffic” alerts. Encode the size of the mark to represent the number of alerts. Hint: for a better presentation of the plot, you should set the domain of the x and y axis to be between some minimum and maximum values for the latitude and longitude.

Solution:

```
# We get the filtered data
top_10 = collapsed_df_waze_geo[(collapsed_df_waze_geo['updated_type'] ==
 ↪  'Jam') & (collapsed_df_waze_geo['updated_subtype'] == "Heavy traffic")]

# We filter just the top 10
top_10 = top_10.sort_values(by='totcount', ascending=False)
top_10 = top_10.head(10)
```

```
# We define the ranges for the plot
latitude_range = [41.66, 42.02]  # Adjust longitude for zoom
longitude_range = [-87.92, -87.56]  # Adjust latitude for zoom

# We plot the data
top10_chart = alt.Chart(top_10).mark_point(color='red').encode(
    x=alt.X('longitude_bin:Q', scale=alt.Scale(domain=longitude_range)),
    y=alt.Y('latitude_bin:Q', scale=alt.Scale(domain=latitude_range)),
    # This is the important part
    size=alt.Size(
        'totcount:Q',
        legend=alt.Legend(title='Number of Alerts')
    )
)
top10_chart
```



3. Next, we will layer the scatter plot on top of a map of Chicago.

a. Download the neighborhood boundaries as a GeoJSON from the Chicago Data Portal (link). Extra credit: can you download the file directly with Python using the `requests` package?

Solution: Bonus points if they download the file using Python which is just using ChatGPT to do it.

```
import requests

# Download the GeoJSON file
url =
 ↪  "https://data.cityofchicago.org/api/geospatial/bbvz-uum9?method=export&format=GeoJSON"
response = requests.get(url)

# Save to file
with open("./top_alerts_map/chicago-boundaries.geojson", "wb") as f:
    f.write(response.content)
```

```
b. Load it into Python using the `json` package and prepare it for Altair
using the following code:
```

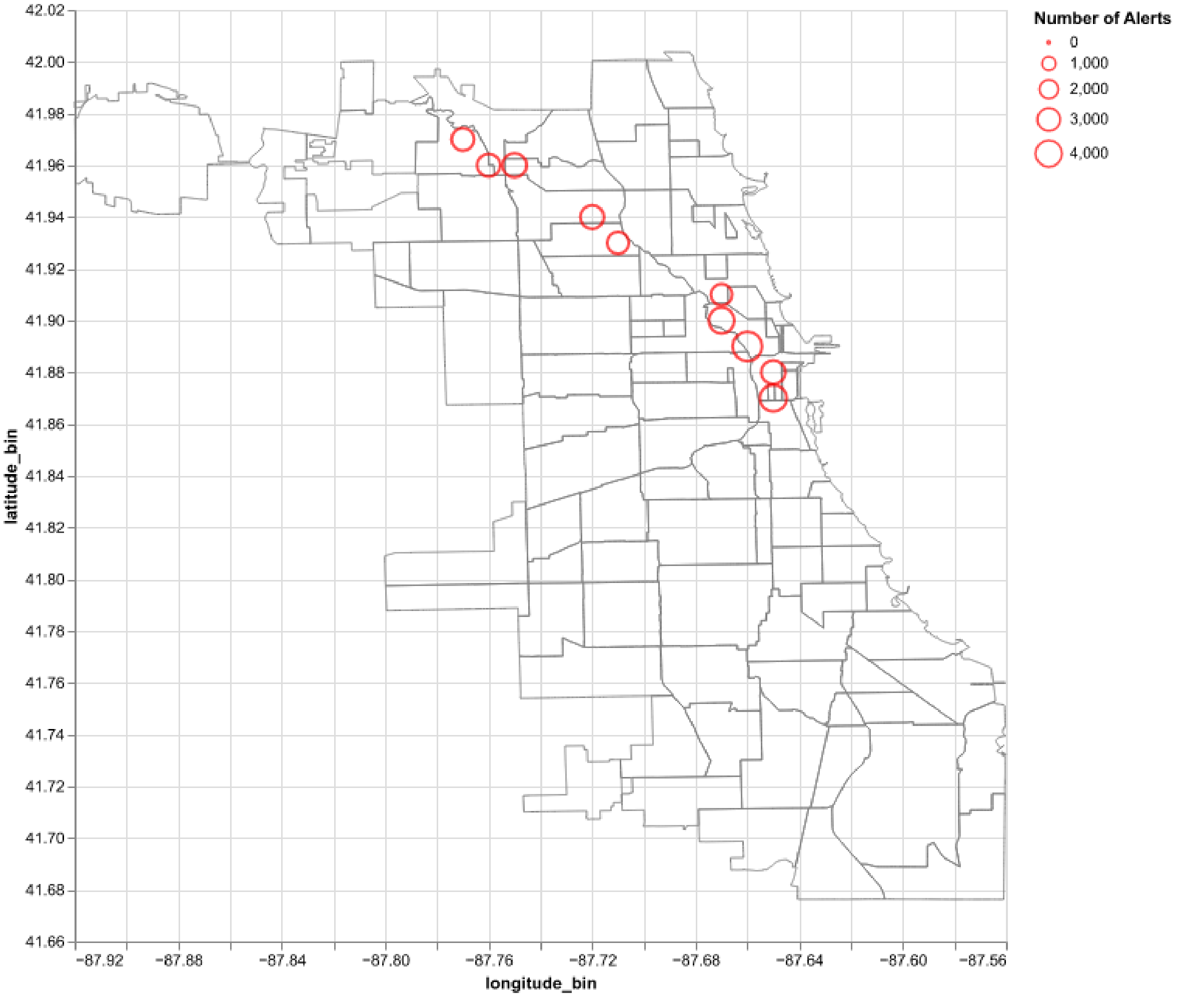
```
# MODIFY ACCORDINGLY
file_path = "./top_alerts_map/chicago-boundaries.geojson"
#----

with open(file_path) as f:
    chicago_geojson = json.load(f)

geo_data = alt.Data(values=chicago_geojson["features"])
```

For now on, follow the Altair documentation Altair geographic plots documentation (link) to plot `geo_data` in Altair.

4. Layer the scatter plot from step 3 on top of the map you loaded in step 1. Adjust the x and y axis domains so that the two layer correctly on top of each other. You may need to change the layering order of the map and the scatter plot or make the map fill transparent in order to properly see both plots.

Solution:

```
map_layer = alt.Chart(geo_data).mark_geoshape(
    fill='none',
    stroke='gray'
).project('equirectangular') # Use the same projection


combined_chart = map_layer + top10_chart
combined_chart.properties(
    width=600,
    height=600
).display()
```

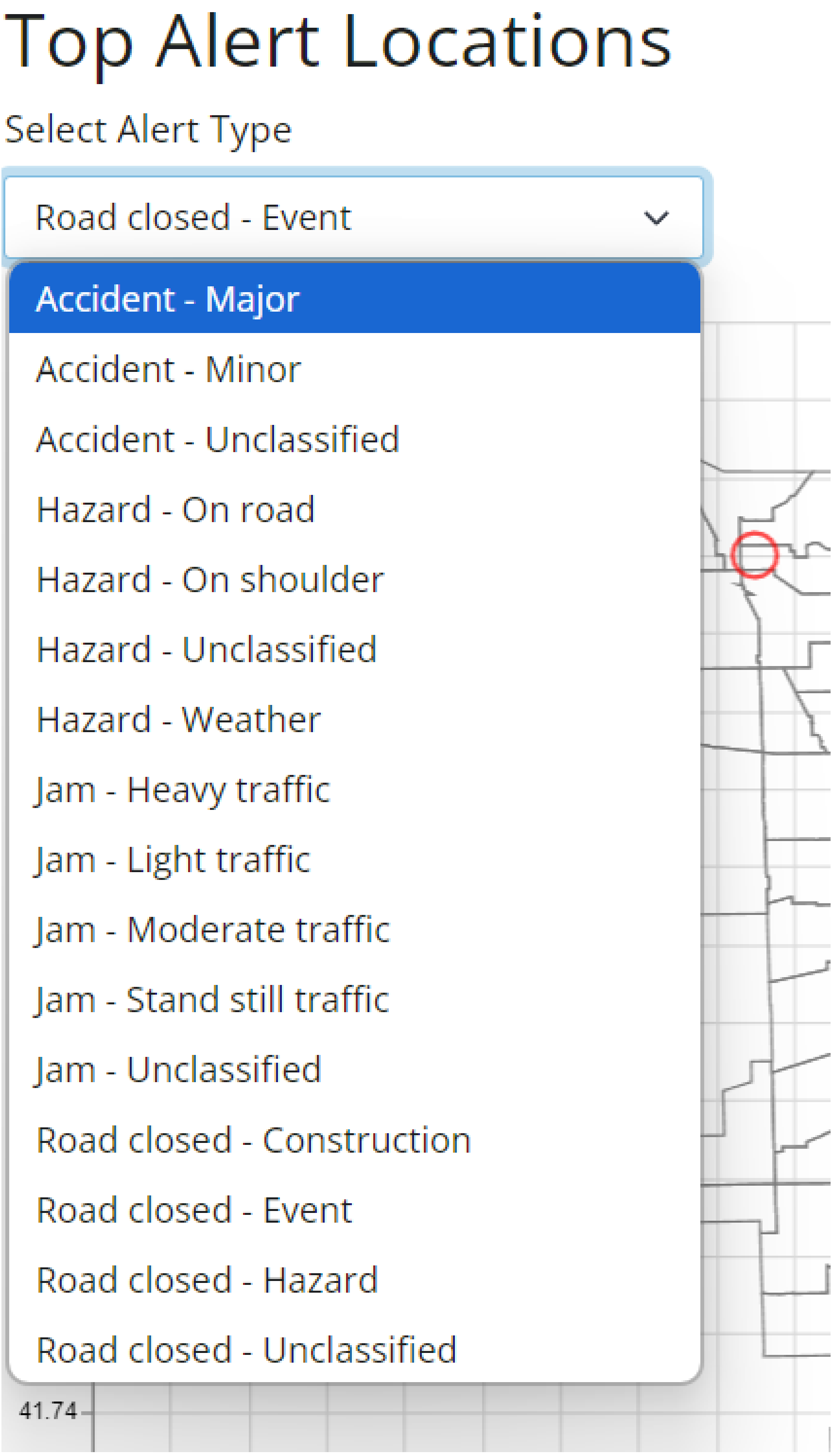


5. Now, we are ready to make our data and plot into the Shiny dashboard. In particular,

we're going to make a dashboard that lets users select in a single dropdown menu which combination of type and subtype they want to display. Once the user has made their selection, the app will show the 10 locations with the highest counts of those alerts.

a. For the UI component, create a **single dropdown menu** for type and subtype. Insert a screenshot of the dropdown menu below. How many total type x subtype combinations are there in your dropdown menu?

Solution: Expected behaviour. They don't need to have a functional dashboard to answer this, but the total combinations are 16.



Top Alert Locations

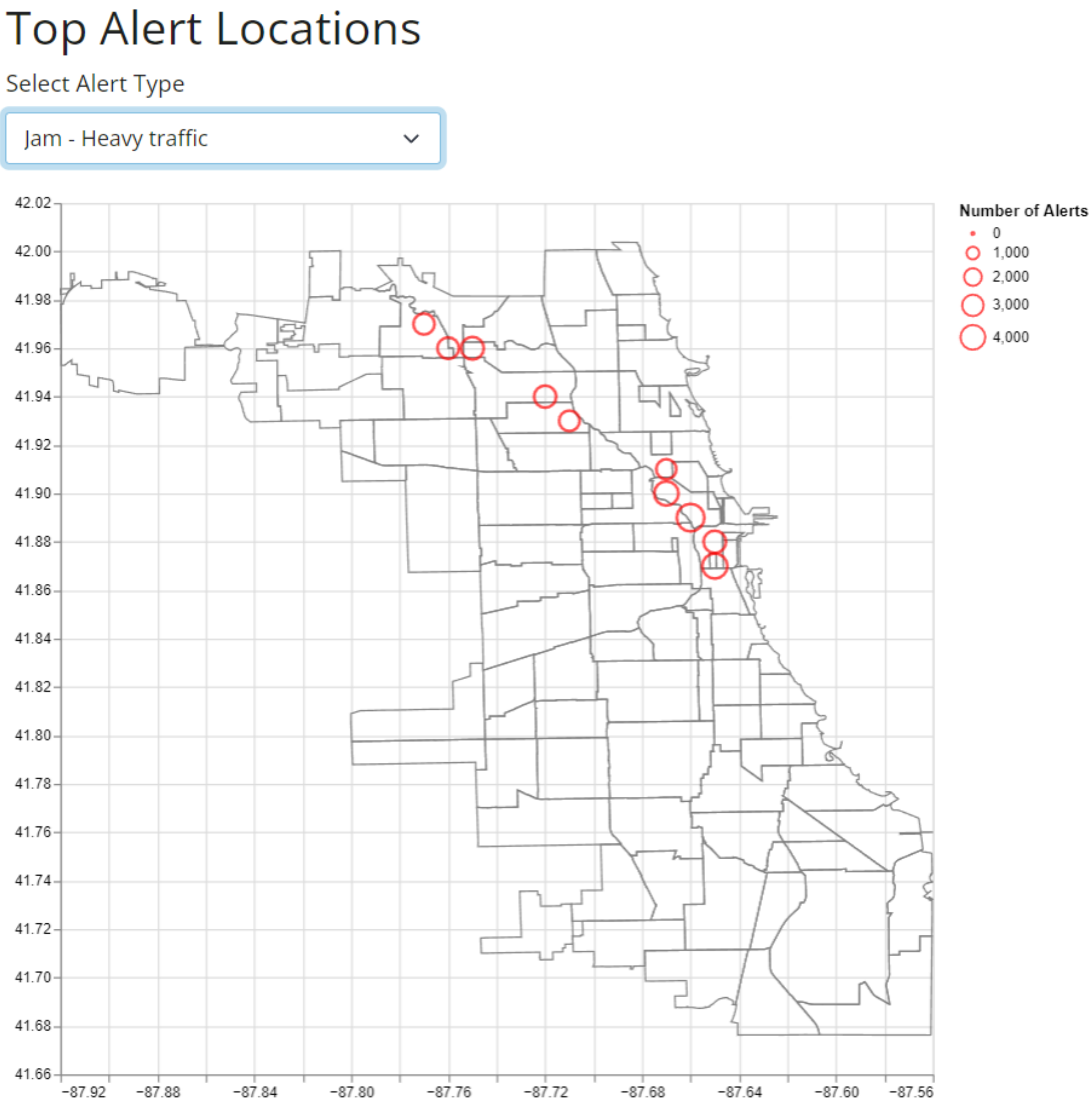
Select Alert Type

Road closed - Event

Figure 1: Dropdown menu

b. Recreate the “Jam - Heavy Traffic” plot from above by using the dropdown menu and insert a screenshot of the graph below. (*)

Solution: Expected behaviour



Top Alert Locations

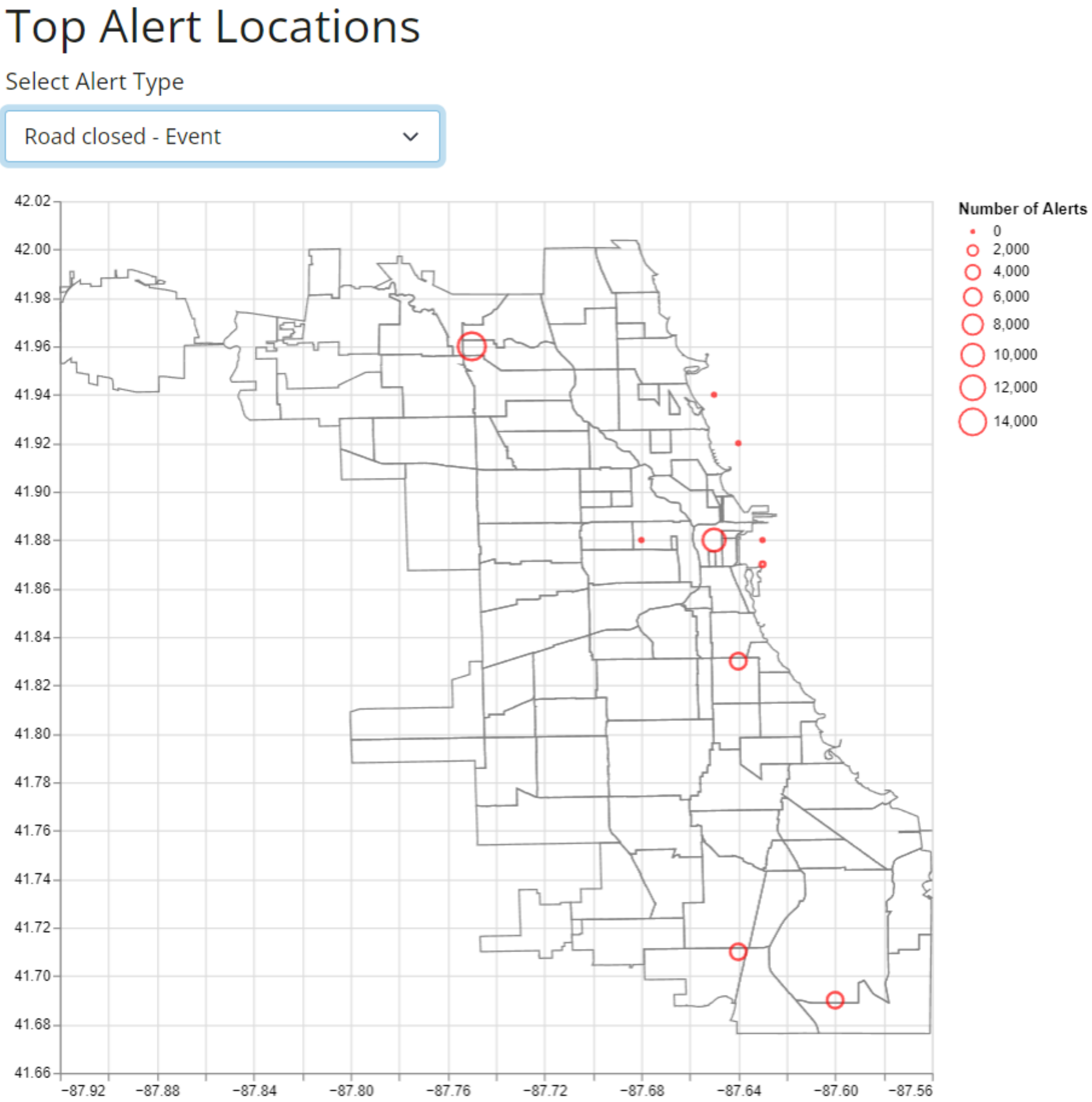
Select Alert Type

Jam - Heavy traffic

Figure 2: Jam - Heavy Traffic

c. Use your dashboard to answer the following question: where are alerts for road closures due to events most common? Insert a screenshot as your answer below.

Solution: They should filter for the Road closed type and then pick the Event subsubtype. I am sure they should not identify the neighbourhood, should be enough with the screenshot.



Top Alert Locations

Select Alert Type

Road closed - Event

Figure 3: Road closed - Event

d. Other than the examples above, give an example of a question this dashboard could be used to answer. Formulate the question, take a screenshot of the selection and resulting plot in the dashboard, and then provide the answer.

Solution: This part the solution is open to interpretation. We should expect a lot of different answers here.

Just as an example: I would love to use this dashboard to answer stuff about traffic jams. Almost all of the Jam subtypes are centered around the same areas (which are the highways). I am not saying this is the best answer, but this is what I would pick (and it's a great segway to the next app)

e. Can you suggest adding another column to the dashboard to enhance our analysis?

Solution: We could use the hour column to show the top 10 locations by hour. Segway into the next app.

App #2: Top Location by Alert Type and Hour Dashboard

1. We will now create a new App folder called `top_alerts_map_byhour`. This new app will modify your first app to add a **slider** to `topalerts_map` that lets users **pick an hour of the day**, and show the top 10 locations at that time of day. But, again, we will first work on the data outside of Shiny before we make the app.

   a. Take a look at the whole dataset we are working with. Given the information present in the `ts` column, would you think that it would be a good idea to collapse the dataset by this column? Why or why not?

   Solution: The proposed solution would be to not do it because we have a lot of detail in the `ts` column, it would be impractical to collapse the dataset by this column.

```
len(df_waze_crosswalk['ts'].unique())
```

```
738674
```

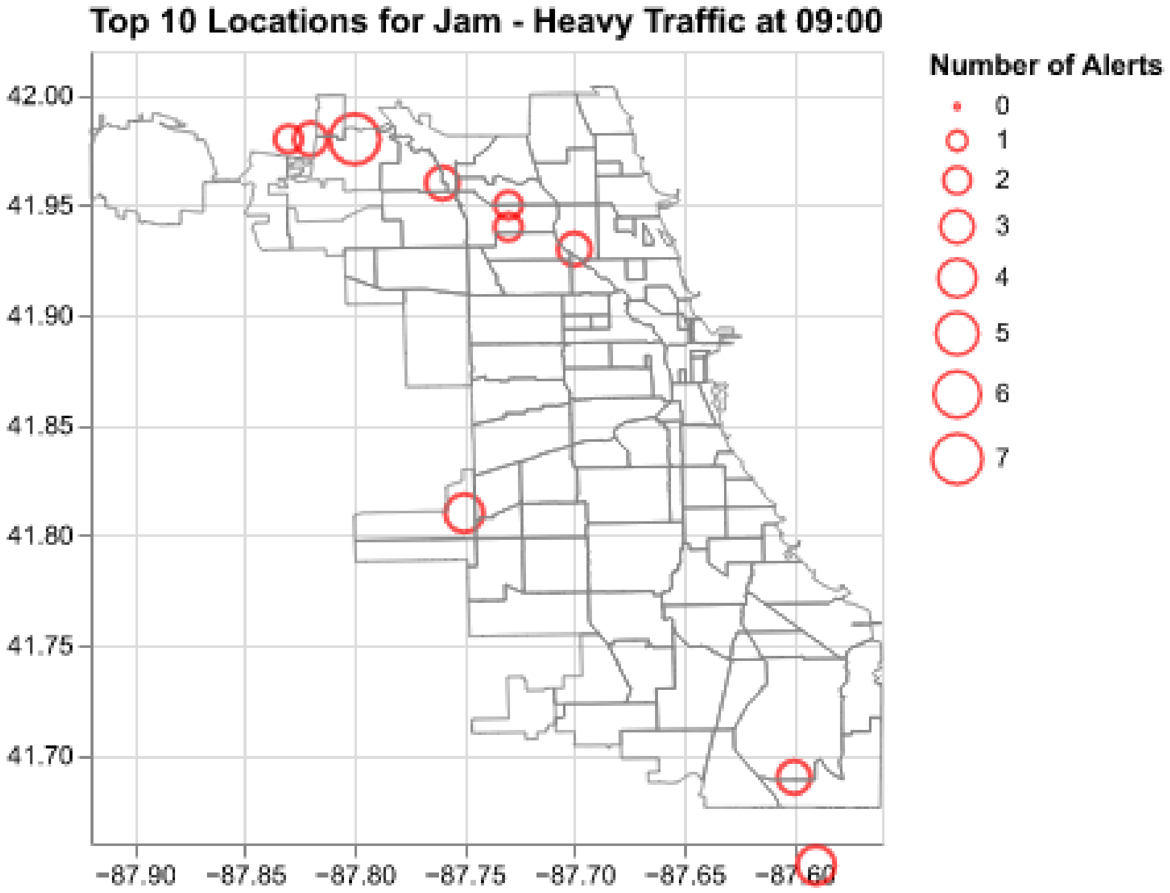
```
a. Create a new variable called `hour` that extracts the hour from the `ts`
column (i.e. if the timestamp is 2024-01-01 **01**:34:32, the `hour` column
should be 01:00). Then, generate a new collapsed dataset that has the
required columns for us to plot the top 10 locations by hour. How many rows
does this dataset have? Beware that this might take some time to run. Save
this collapsed dataset as `top_alerts_map_byhour.csv` in the
`top_alerts_map_byhour` folder.

*Beware: this might take some time to run but shouldn't take more than 5
minutes*

**Solution**: The dataset should have 63,110 rows.
```

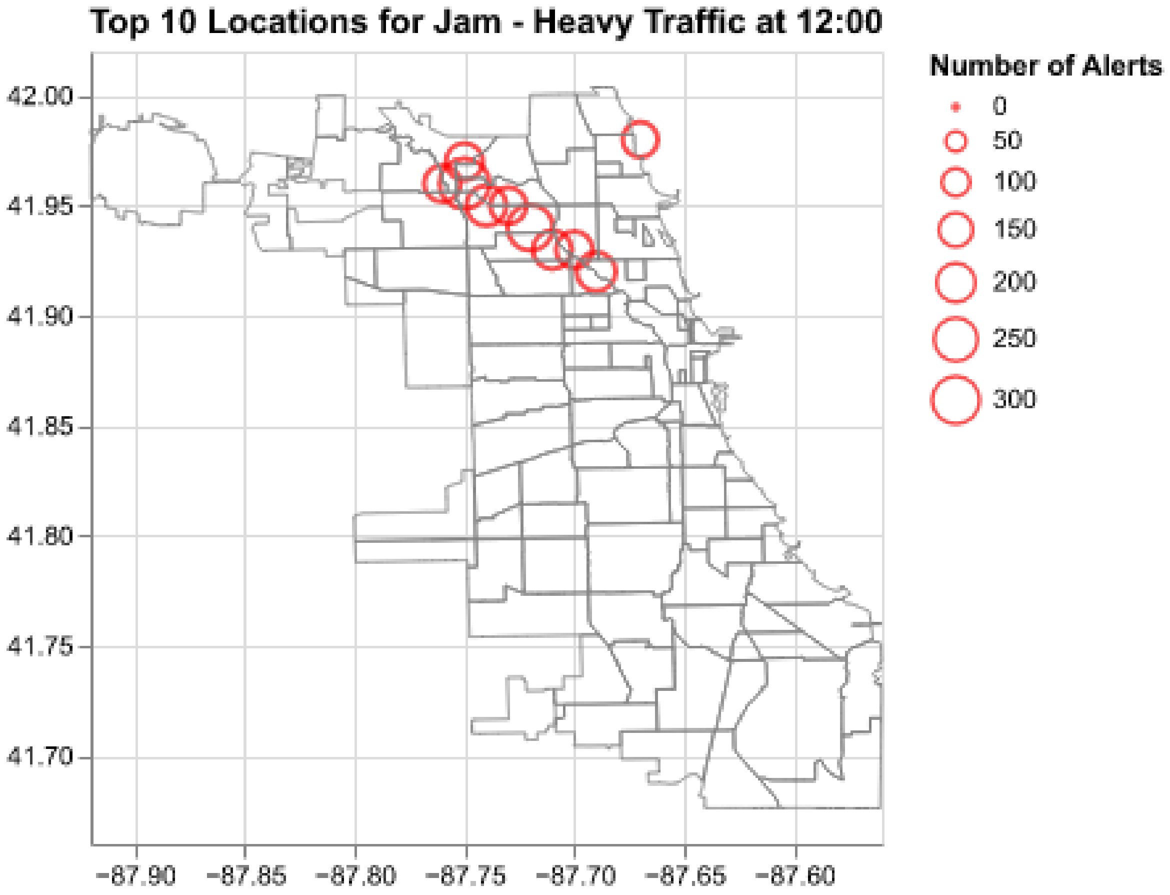
```
# Extract hour from ts column
df_waze_geo['hour'] = pd.to_datetime(df_waze_geo['ts']).dt.strftime('%H:00')

# Group by location bins, type-subtype, and hour to get counts
collapsed_df_waze_geo_byhour = df_waze_geo.groupby([
    'latitude_bin',
    'longitude_bin',
    'updated_type',
    'updated_subtype',
    'hour'
]).size().reset_index(name='totcount')

len(collapsed_df_waze_geo_byhour)

# Save collapsed dataset
collapsed_df_waze_geo_byhour.to_csv("./top_alerts_map_byhour/top_alerts_map_byhour.csv",
 ↪  index=False)
```

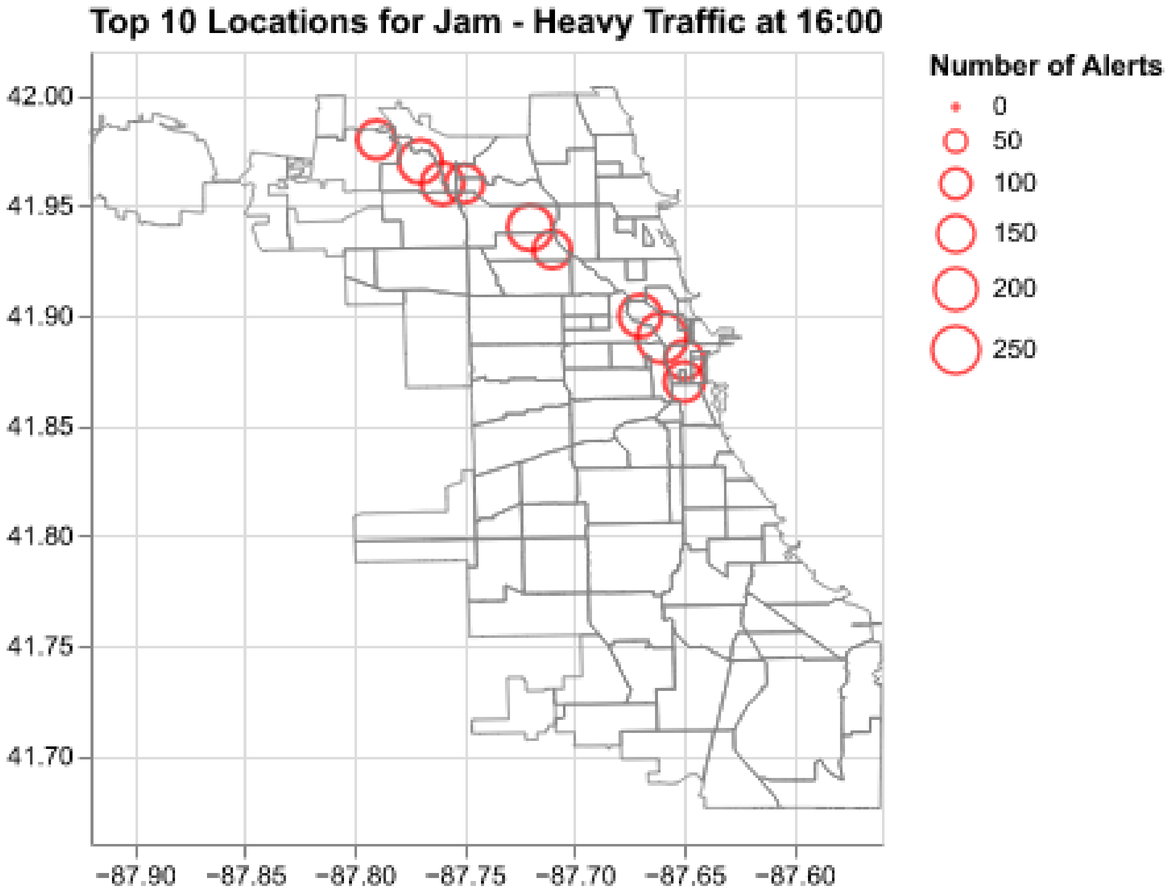
b. Generate an individual plot of the top 10 locations by hour for 'Jam - Heavy Traffic' for three different times within a day. Don't forget to use the map layer you created while working for the first app and use the same longitude and latitude ranges.

Solution:

```
# Define hours to plot
hours_to_plot = ['09:00', '12:00', '16:00']

for hour in hours_to_plot:
    # Filter for Jam - Heavy Traffic at specific hour
    plot_data = collapsed_df_waze_geo_byhour[
        (collapsed_df_waze_geo_byhour['updated_type'] == 'Jam') &
        (collapsed_df_waze_geo_byhour['updated_subtype'] == 'Heavy traffic')
 ↪  &
        (collapsed_df_waze_geo_byhour['hour'] == hour)
    ]

    # Get top 10 locations for this hour
    plot_data = plot_data.sort_values('totcount', ascending=False).head(10)

    # Create scatter plot
    chart = alt.Chart(plot_data).mark_point(color='red').encode(
        x=alt.X('longitude_bin:Q', title='',
↪   scale=alt.Scale(domain=longitude_range)),
        y=alt.Y('latitude_bin:Q', title='',
↪   scale=alt.Scale(domain=latitude_range)),
        # This is the important part
        size=alt.Size(
            'totcount:Q',
            legend=alt.Legend(title='Number of Alerts')
        )
    ).properties(
        title=f'Top 10 Locations for Jam - Heavy Traffic at {hour}'
    )

    display(chart + map_layer)
```



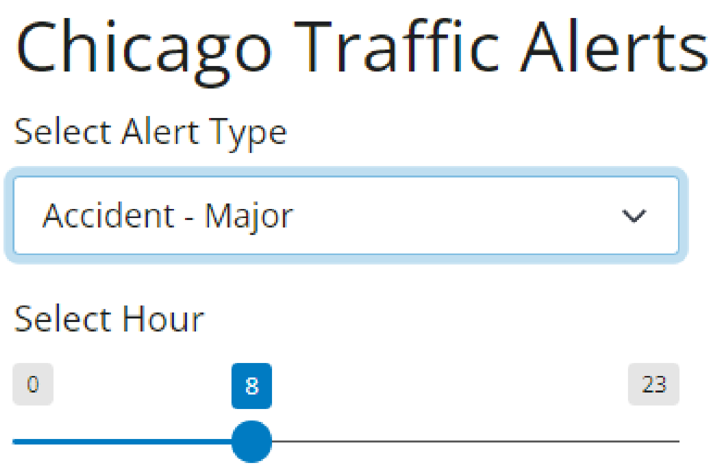

Top 10 Locations for Jam - Heavy Traffic at 12:00
Number of Alerts
0
50
100
150
200
250
300
42.00
41.95
41.90
41.85
41.80
41.75
41.70
-87.90
-87.85
-87.80
-87.75
-87.70
-87.65
-87.60



2. We will now turn into creating the Shiny app. As mentioned, for this app we will have a single dropdown menu (similar to the one from App 1) and add a slider to pick the hour. Remember to not use the whole dataset for this app, but the collapsed dataset you created in the previous part.

    a. Create the UI for the app, which should have the dropdown menu to choose a combination of type and subtype, and a slider to pick the hour. Insert a screenshot of the UI below.

    Solution: Expected behaviour



Chicago Traffic Alerts Map

Select Alert Type

Accident - Major

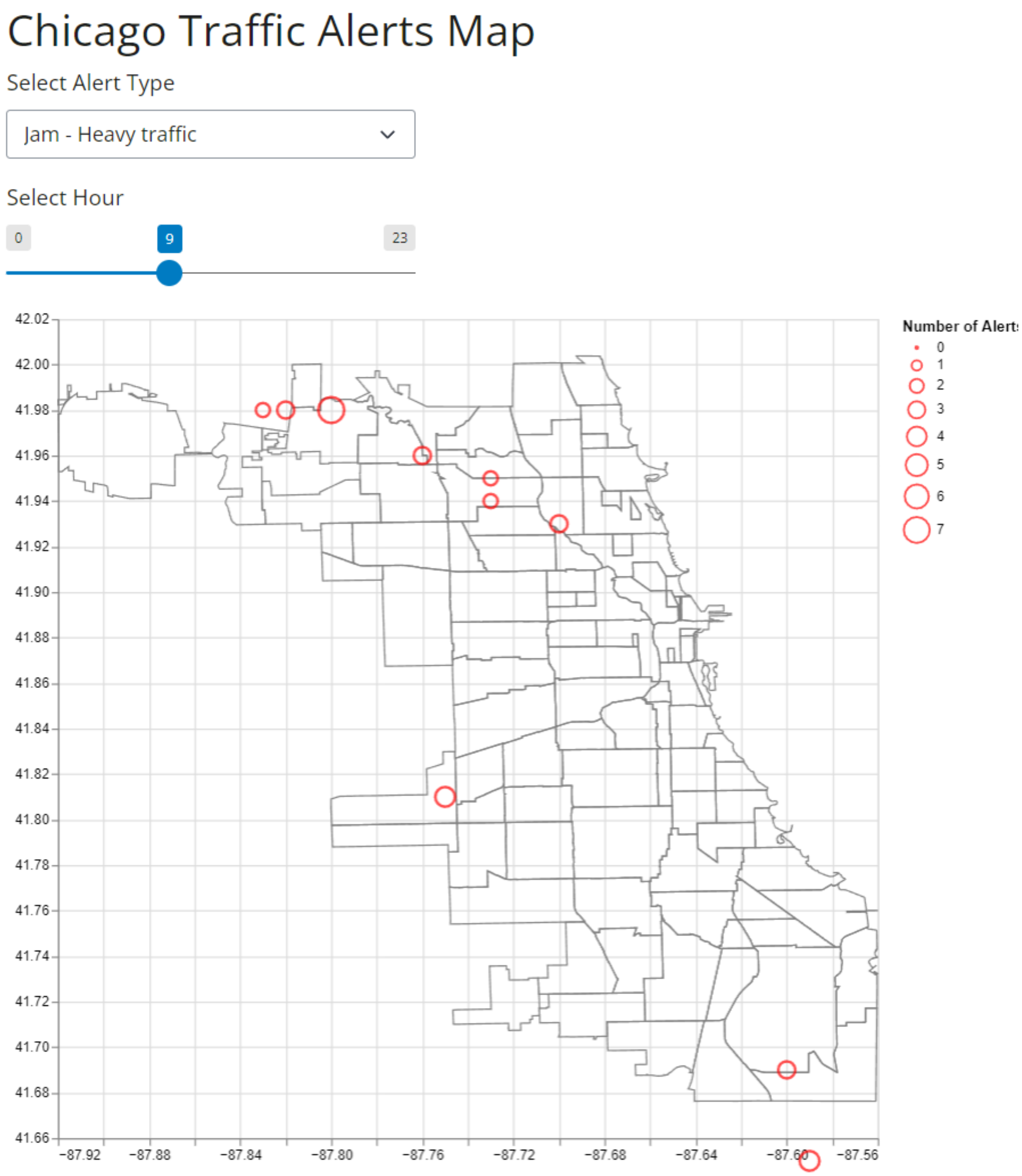
Select Hour

8

Figure 4: Hour slider

b. Recreate the “Jam - Heavy Traffic” plot from above by using the dropdown menu and slider and insert a screenshot of each plot below.

Solution:



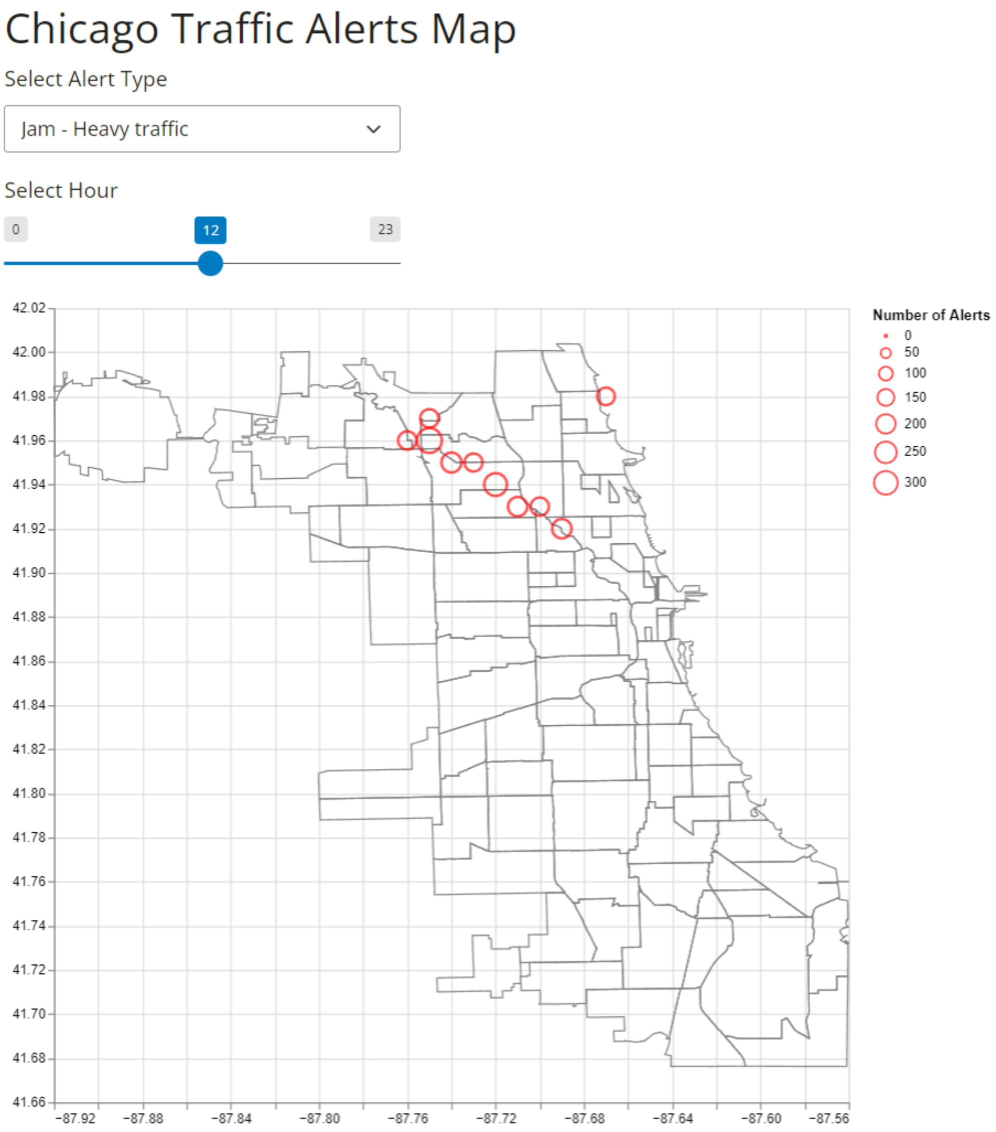
Chicago Traffic Alerts Map

Select Alert Type

Jam - Heavy traffic

Select Hour

0 9 23



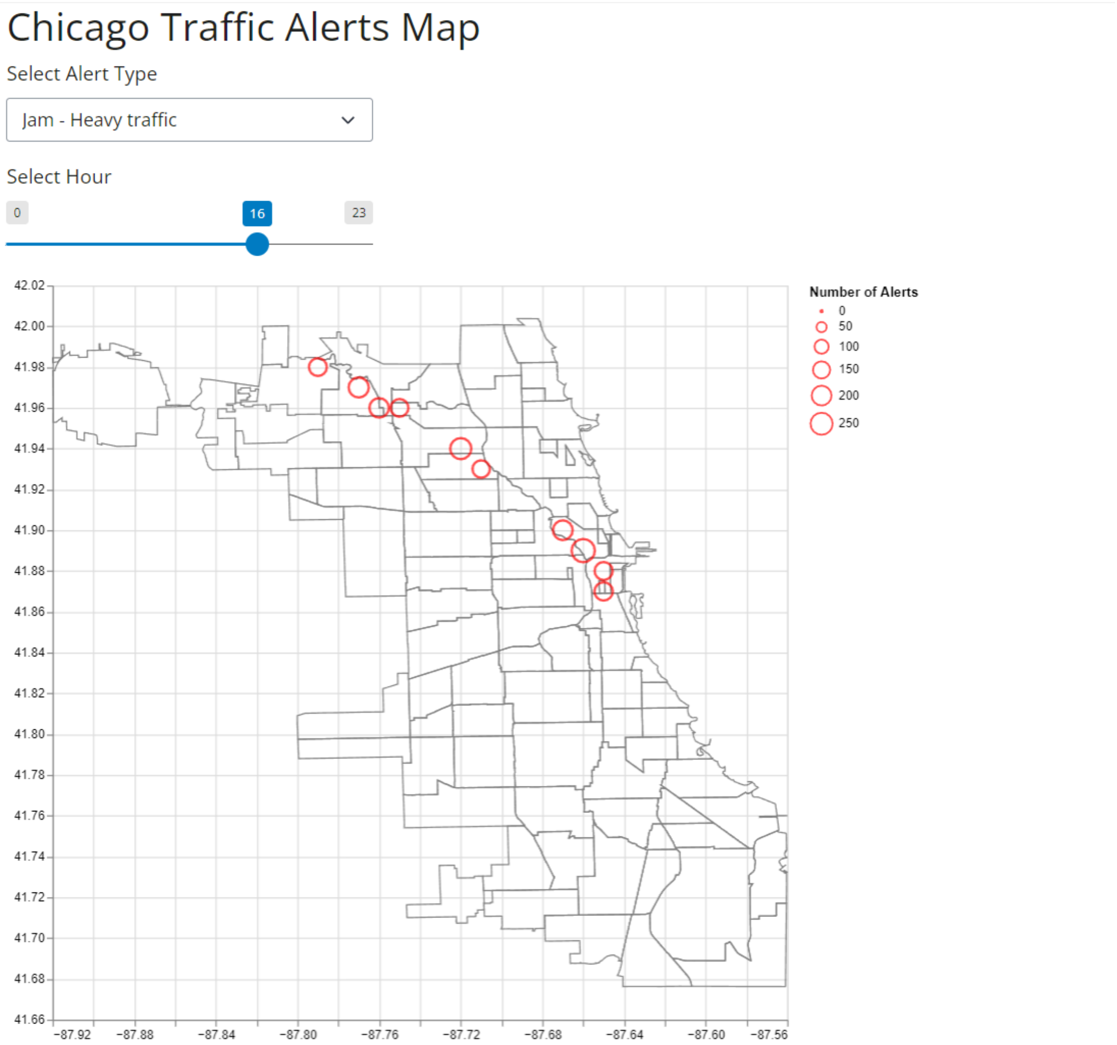
Chicago Traffic Alerts Map

Select Alert Type

Jam - Heavy traffic

Select Hour

12



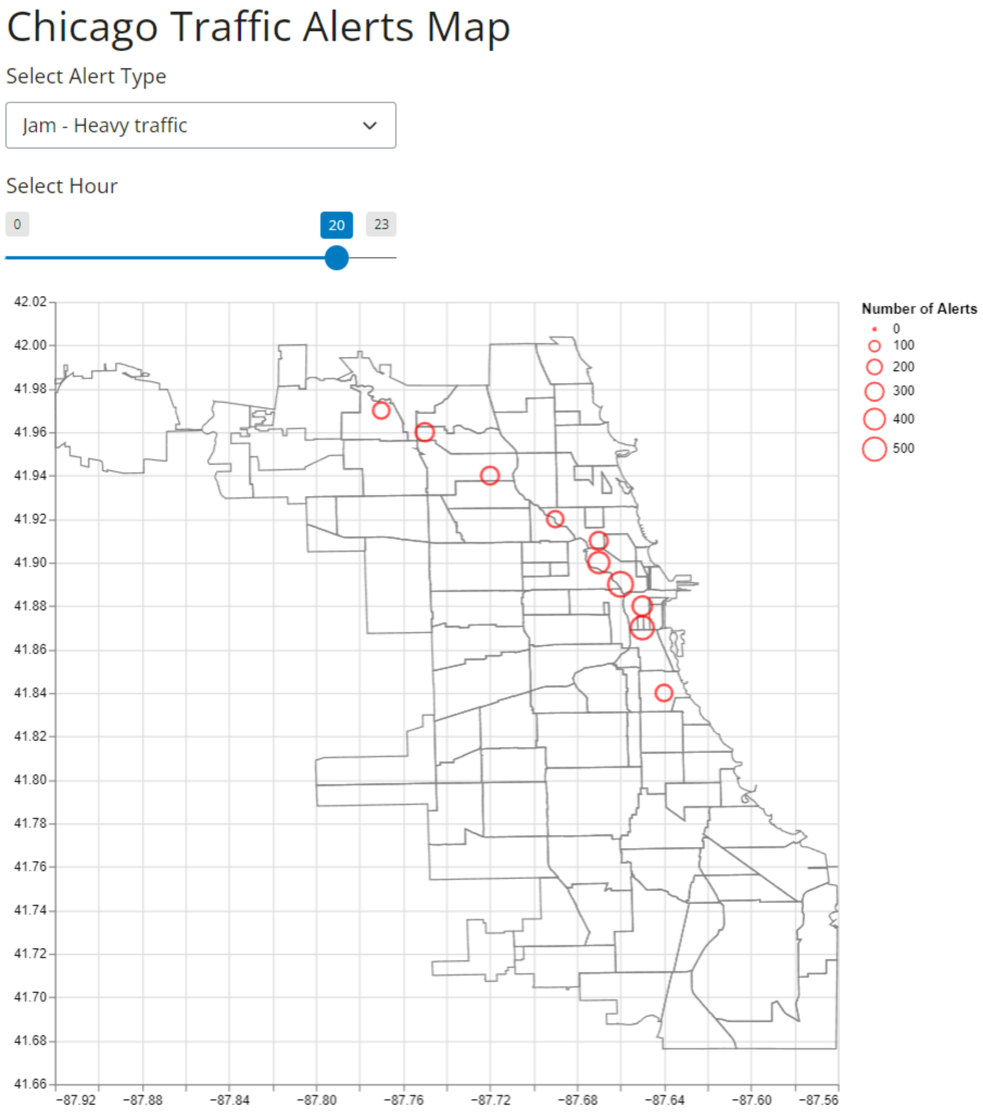
Chicago Traffic Alerts Map

Select Alert Type

Jam - Heavy traffic

Select Hour

16



Chicago Traffic Alerts Map

Select Alert Type

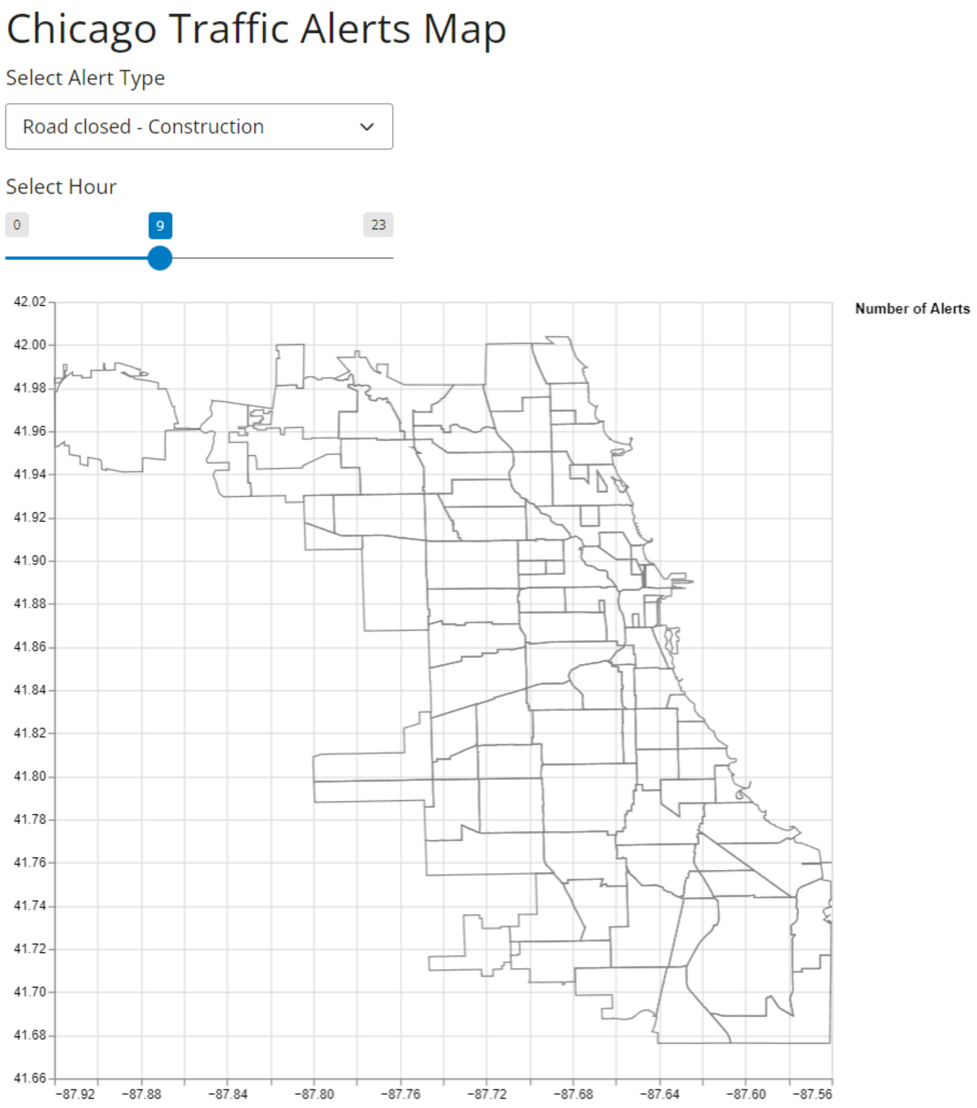
Jam - Heavy traffic

Select Hour

0 20 23

c. Use your dashboard to answer the following question: does it seem like road construction is done more during morning hours or night hours? No need to insert more than two screenshots of the dashboard to support your answer.

Solution: There seems to be more road constructions during the night than during the day.



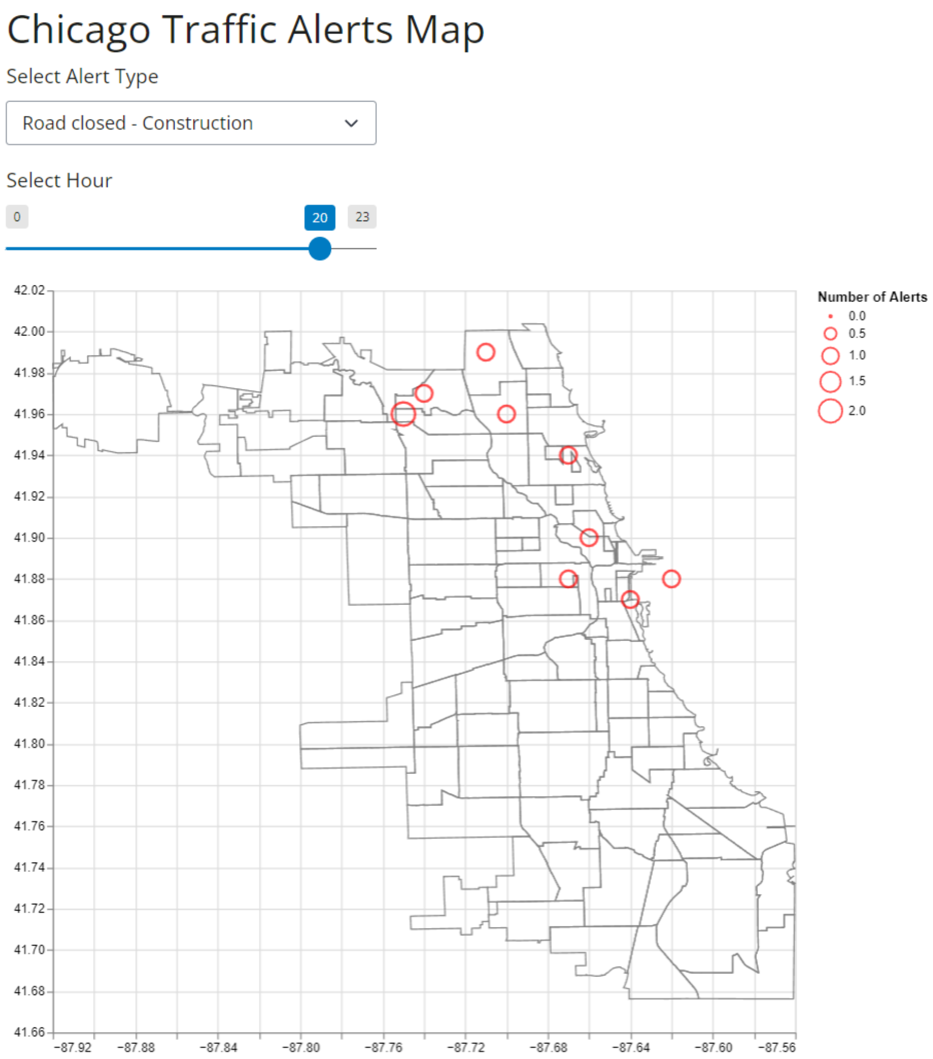
Chicago Traffic Alerts Map

Select Alert Type

Road closed - Construction

Select Hour

0 9 23



Chicago Traffic Alerts Map

Select Alert Type

Road closed - Construction

Select Hour

0 20 23

App #3: Top Location by Alert Type and Hour Dashboard

1. As choosing a single hour might not the best way to look at this data, we will now create a new app that builds upon App 2. For this app, we will add a component that allows the user to pick a **range of hours**. For this new app, create a new folder called `top_alerts_map_byhour_sliderrange`. We will modify the app from the previous part to allow the user to go from a slider to a *slider range* – that is, it will allow the user to pick a *range* of hours like 6AM-10AM, rather than a single hour.

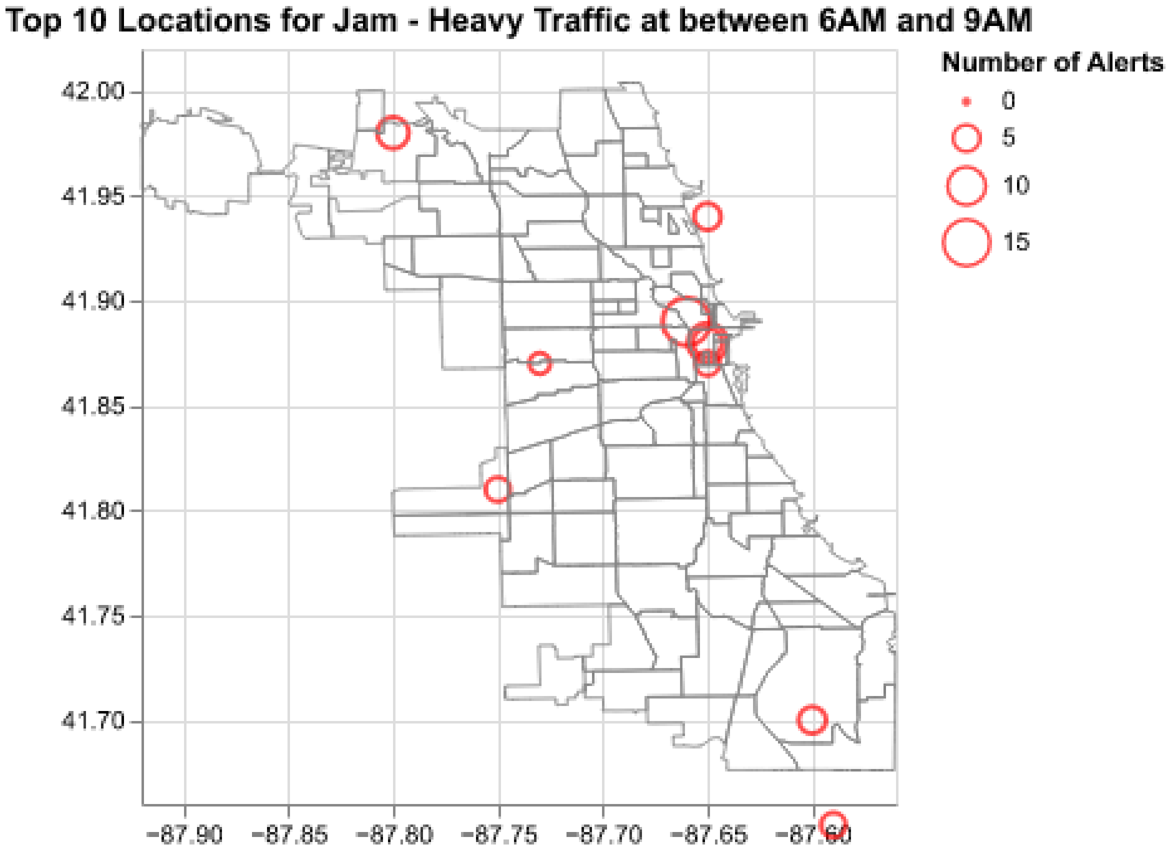
    a. Think about what we did in App 1 and 2 regarding collapsing our dataset to make it easier for the Shiny app to handle the data. Given our goal of plotting the top

10 locations by alert type and range of hours, would it be a good idea to collapse the dataset by range of hours? Why or why not?

Solution: it would not be a good idea to collapse it by range of hours because of various reasons. Just stating no because it makes no sense should be enough but the reasoning behind this is that because each hour bin is mutually exclusive, we can reuse the dataset from App 2 and just collapse it by range of hours according to the user's choice.

b. Before going into the Shiny app, create a plot of the top 10 locations by alert type and range of hours for Jam - Heavy Traffic between 6AM and 9AM.

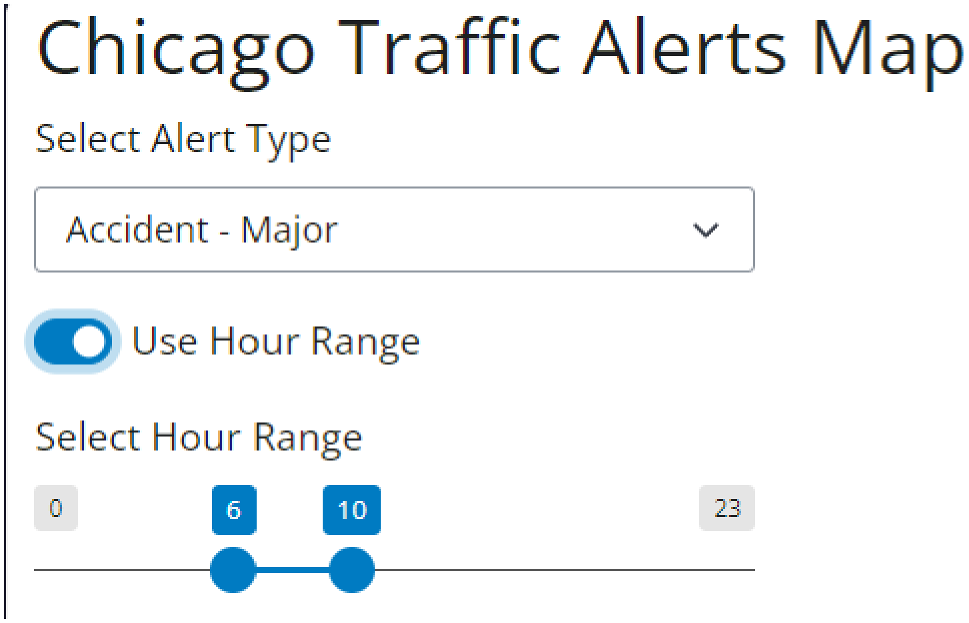
```
plot_data = collapsed_df_waze_geo_byhour[
    (collapsed_df_waze_geo_byhour['updated_type'] == 'Jam') &
    (collapsed_df_waze_geo_byhour['updated_subtype'] == 'Heavy traffic') &
    (collapsed_df_waze_geo_byhour['hour'].isin(['06:00', '07:00', '08:00',
 ↪  '09:00']))
]


plot_data = plot_data.sort_values('totcount', ascending=False).head(10)

chart = alt.Chart(plot_data).mark_point(color='red').encode(
        x=alt.X('longitude_bin:Q', title='',
 ↪  scale=alt.Scale(domain=longitude_range)),
        y=alt.Y('latitude_bin:Q', title='',
 ↪  scale=alt.Scale(domain=latitude_range)),
        # This is the important part
        size=alt.Size(
            'totcount:Q',
            legend=alt.Legend(title='Number of Alerts')
        )
    ).properties(
        title=f'Top 10 Locations for Jam - Heavy Traffic at between 6AM and
 ↪  9AM'
    )


display(chart + map_layer)
```



2. We will now create our new Shiny app adding the slider for the range of hours.

    a. Create the required UI for the App, which should have the dropdown menu to choose a combination of type and subtype, and a slider to pick the hour **range**. Insert a screenshot of the UI below and the plot.

Solution: Expected behaviour



Chicago Traffic Alerts Map

Select Alert Type

Accident - Major

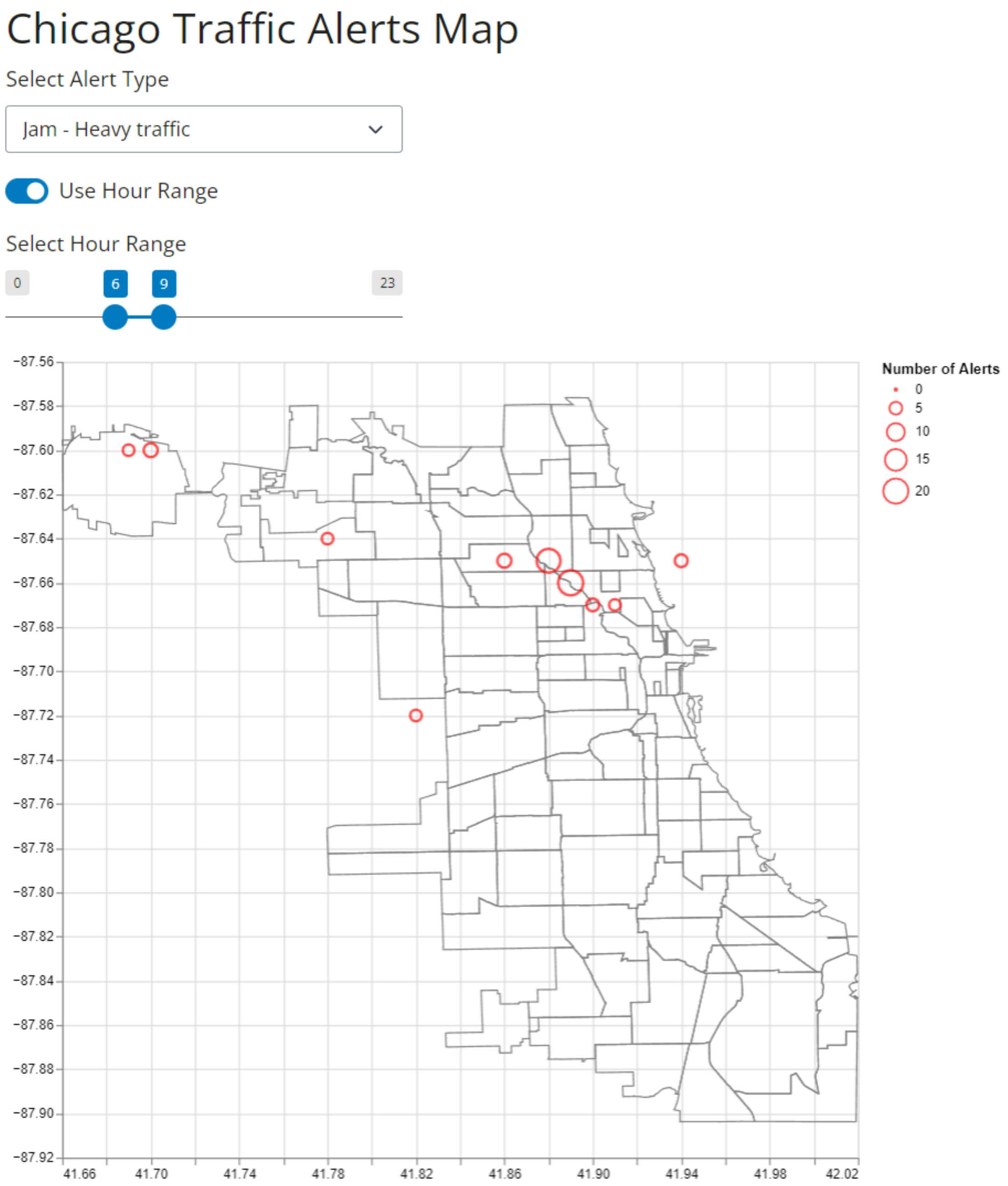
Use Hour Range

Select Hour Range

Figure 5: UI

b. Recreate the “Jam - Heavy Traffic” plot from above by using the dropdown menu and slider range. Insert a screenshot of your App below

Solution: Expected behaviour



Chicago Traffic Alerts Map

Select Alert Type

Jam - Heavy traffic

Use Hour Range

Select Hour Range

0 6 9 23

Figure 6: Jam - Heavy Traffic at 6AM-9AM

3. We will now add a conditional panel to the app to allow the user to toggle between the choice between a slide for a single hour or a slider for a range of hours. For this, we will

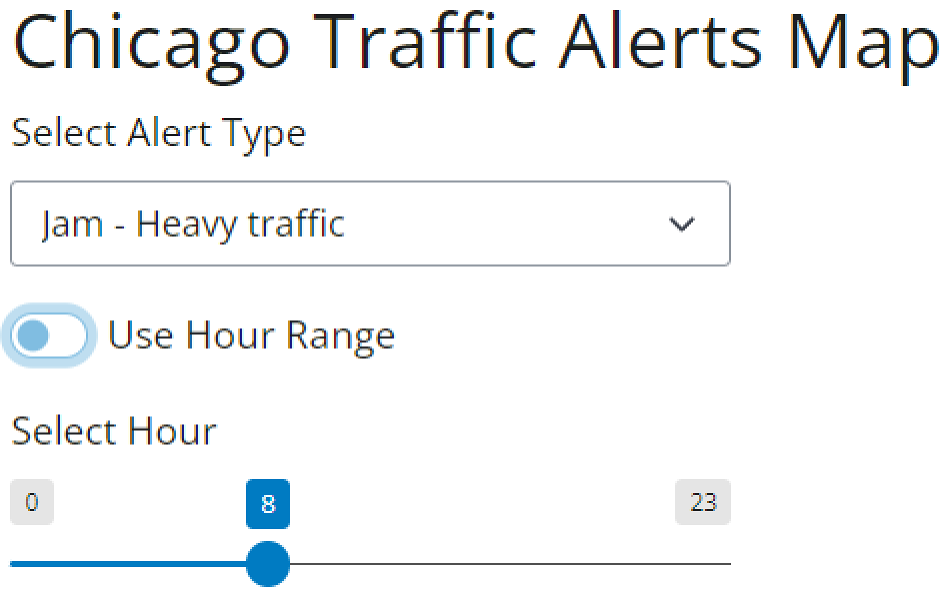
use a switch button component.

a. Read the documentation on switch buttons and then add the switch button with the label “Toggle to switch to range of hours” to the app. Insert a screenshot of your App with the addition of the switch button (it doesn’t need to be functional yet) and answer the following question: what are the possible *values* (understood as the possible values for `input.switch_button` if the switch button is named `switch_button`) for this switch button?

Solution: The two possible values for this switch button are `TRUE` and `FALSE`.

b. Modify the UI to add a conditional panel that shows a slider for a single hour when the switch button is toggled. Insert two screenshots of your App with the addition of the conditional panel, demonstrating that when the switch button is toggled, the slider for a single hour is shown and when it is not toggled, the slider for a range of hours is shown.

Solution: Expected behaviour.



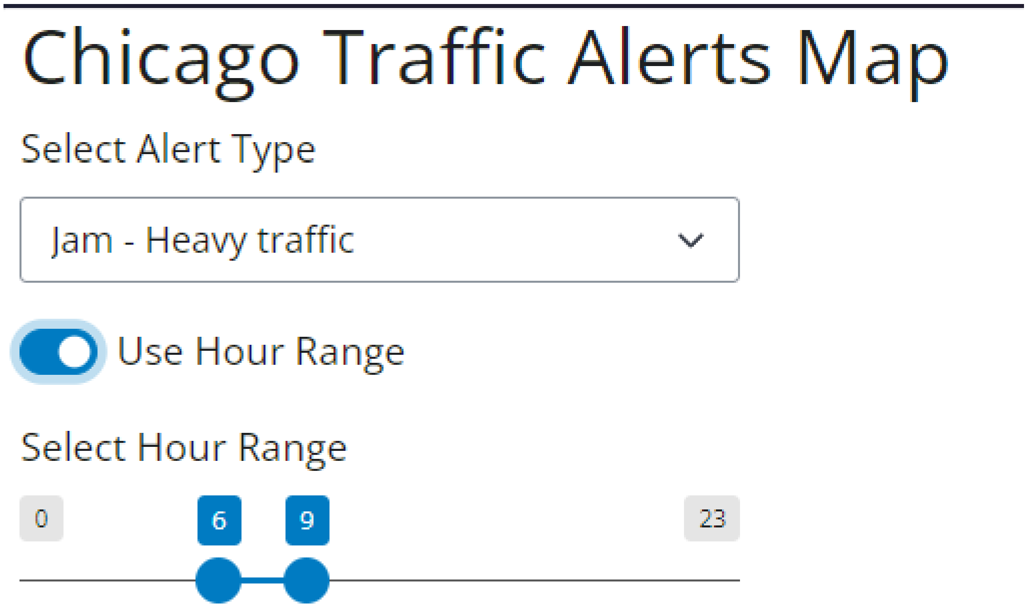
Chicago Traffic Alerts Map

Select Alert Type

Jam - Heavy traffic

Use Hour Range

Select Hour



Chicago Traffic Alerts Map

Select Alert Type

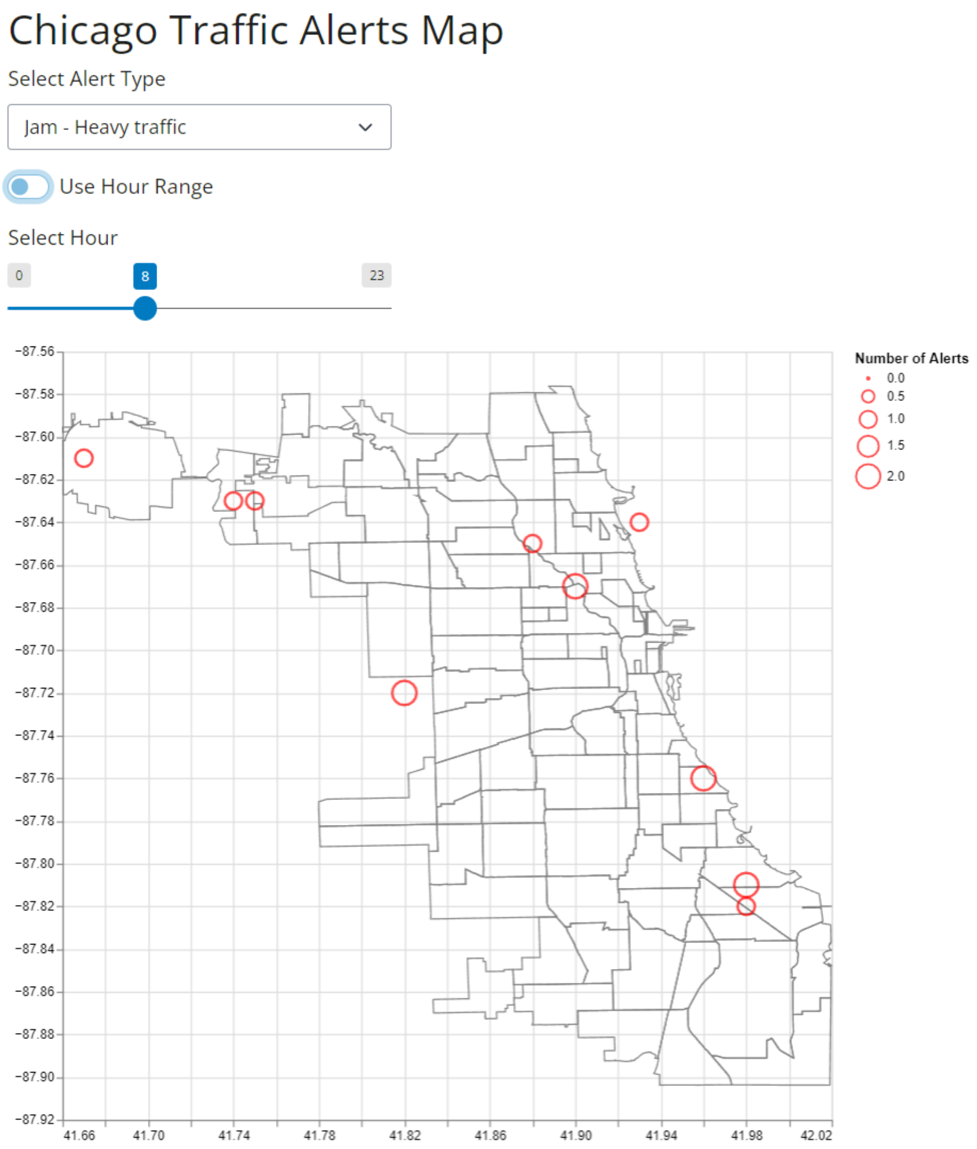
Jam - Heavy traffic

Use Hour Range

Select Hour Range

c. Lastly, modify the UI and server logic to add the functionality to the App so that when the switch button is toggled, the plot we show is the corresponding one according to our choice between hours (single hour or range of hours). Insert two screenshots showing this functionality: a plot generated with the slider for a single hour and a plot generated with the slider for a range of hours using the conditional panel functionality.

Solution: Expected behaviour, I mean is almost the same as part D



Chicago Traffic Alerts Map

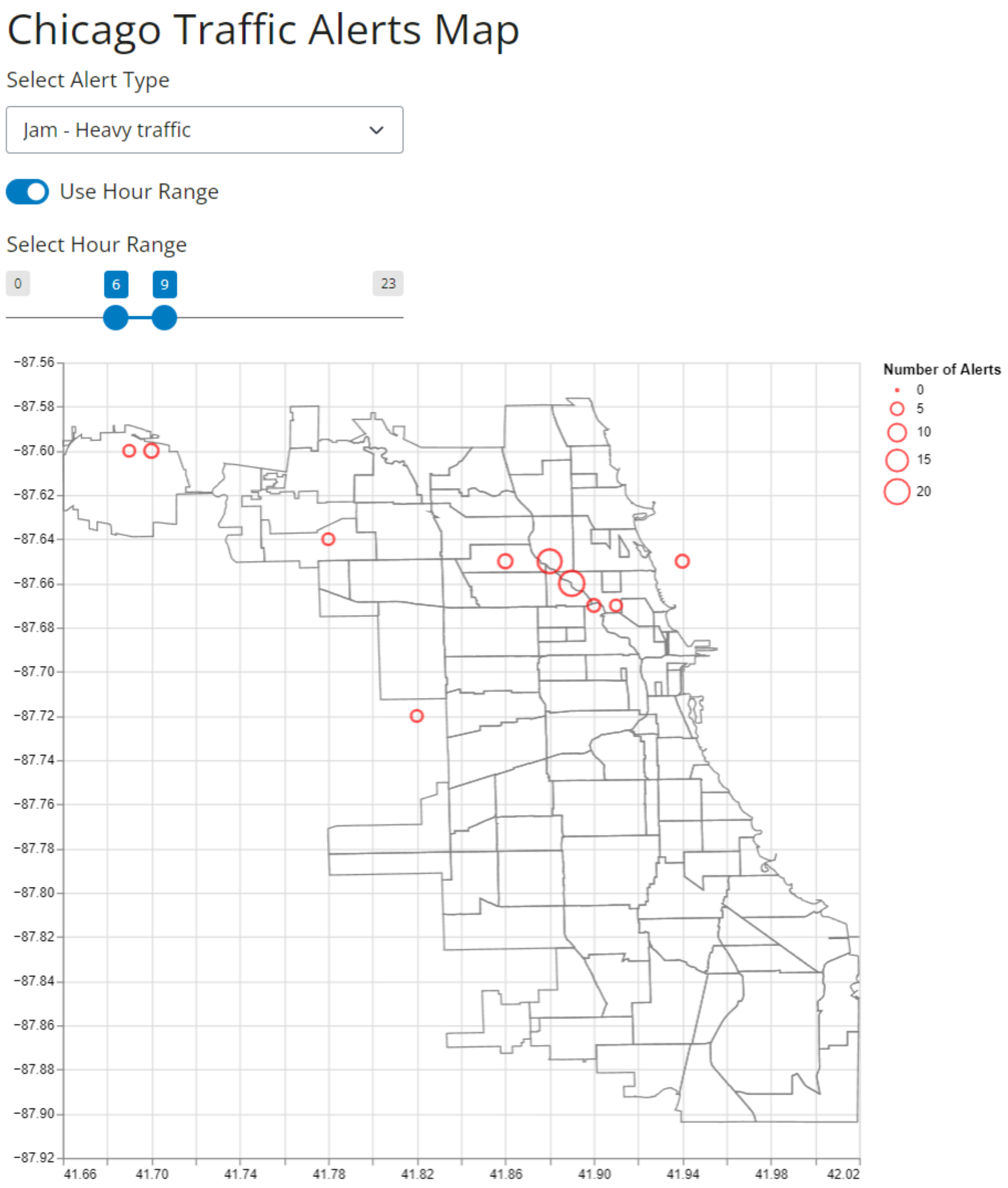
Select Alert Type

Jam - Heavy traffic

Use Hour Range

Select Hour

0 8 23



Chicago Traffic Alerts Map

Select Alert Type

Jam - Heavy traffic

Use Hour Range

Select Hour Range

0 6 9 23

d. EXTRA CREDIT: No need to code this part. What kind of changes would you make to the app in order for you to achieve a plot similar to the one below?

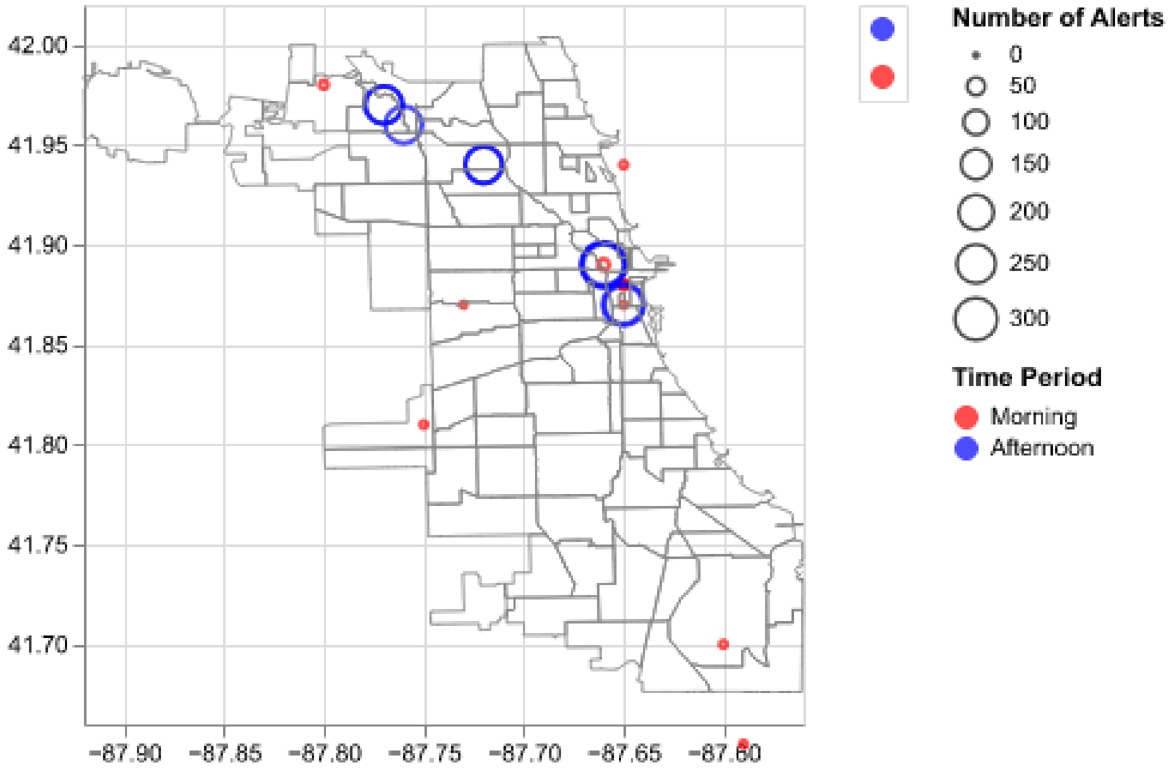
Solution: I just wanted to give them a challenge. For them to have full marks they should mention

- Having two different alert sliders

- Updating the graph to layer more than one altair chart at the same time

Everything else is just extra

```
plot_data_1 = collapsed_df_waze_geo_byhour[
    (collapsed_df_waze_geo_byhour['updated_type'] == 'Jam') &
    (collapsed_df_waze_geo_byhour['updated_subtype'] == 'Heavy traffic') &
    (collapsed_df_waze_geo_byhour['hour'].isin(['06:00', '07:00', '08:00',
 ↪  '09:00']))
]


plot_data_1 = plot_data.sort_values('totcount', ascending=False).head(10)

plot_data_2 = collapsed_df_waze_geo_byhour[
    (collapsed_df_waze_geo_byhour['updated_type'] == 'Jam') &
    (collapsed_df_waze_geo_byhour['updated_subtype'] == 'Heavy traffic') &
    (collapsed_df_waze_geo_byhour['hour'].isin(['15:00', '16:00', '17:00',
 ↪  '18:00']))
]


plot_data_2 = plot_data_2.sort_values('totcount', ascending=False).head(10)

chart_1 = alt.Chart(plot_data_1).mark_point(color='red').encode(
    x=alt.X('longitude_bin:Q', title='',
 ↪  scale=alt.Scale(domain=longitude_range)),
    y=alt.Y('latitude_bin:Q', title='',
 ↪  scale=alt.Scale(domain=latitude_range)),
    size=alt.Size(
        'totcount:Q',
        legend=alt.Legend(
            title='Number of Alerts',
            symbolFillColor='black',  # Make legend symbols black
            symbolStrokeColor='black'  # Make legend symbol outlines black
        )
    )
)

chart_2 = alt.Chart(plot_data_2).mark_point(color='blue').encode(
    x=alt.X('longitude_bin:Q', title='',
 ↪  scale=alt.Scale(domain=longitude_range)),
    y=alt.Y('latitude_bin:Q', title='',
 ↪  scale=alt.Scale(domain=latitude_range)),
    size=alt.Size(
        'totcount:Q',
        legend=None  # Remove duplicate size legend
    )
)
# Create a separate legend for time periods
time_legend = pd.DataFrame({'Time': ['Morning', 'Afternoon']})
legend = alt.Chart(time_legend).mark_circle(size=100).encode(
    y=alt.Y('Time:N', axis=None),
    color=alt.Color('Time:N',
        scale=alt.Scale(domain=['Morning', 'Afternoon'], range=['red',
 ↪  'blue']),
        legend=alt.Legend(title='Time Period')
    )
)
# Combine the charts
(chart_1 + chart_2 + map_layer) | legend
```



42.00
41.95
41.90
41.85
41.80
41.75
41.70
-87.90
-87.85
-87.80
-87.75
-87.70
-87.65
-87.60
Number of Alerts
0
50
100
150
200
250
300
Time Period
Morning
Afternoon