Data Visualization (part 2)

Intermediate graphing techniques with ggplot2

by Martin Frigaard

Written: September 21 2021

Updated: November 30 2021

[Created using the "λέξις" theme]()

`ggplot2` = a grammar for data visualization

Load the packages

```r
install.packages("tidyverse")
library(tidyverse)
```

Outline

Recap `ggplot2`

Graphing preliminaries

- *Data Wrangling*
- *Tidying*

Variable Distributions

- *Histograms, density plots, violin plots*

Line Graphs

Adding Text

- *Annotations, labeling values*

Reference Lines

Advanced Faceting

- *facet_wrap(), facet_wrap_paginate(), facet_geo()*

Resources

Link to slides

https://mjfrigaard.github.io/csuc-data-journalism/slides.html

Link to exercises

https://mjfrigaard.github.io/csuc-data-journalism/lessons.html

Recap of `ggplot2`

Recap of `ggplot2`

In the previous lesson, we covered:

1) The grammar of graphics

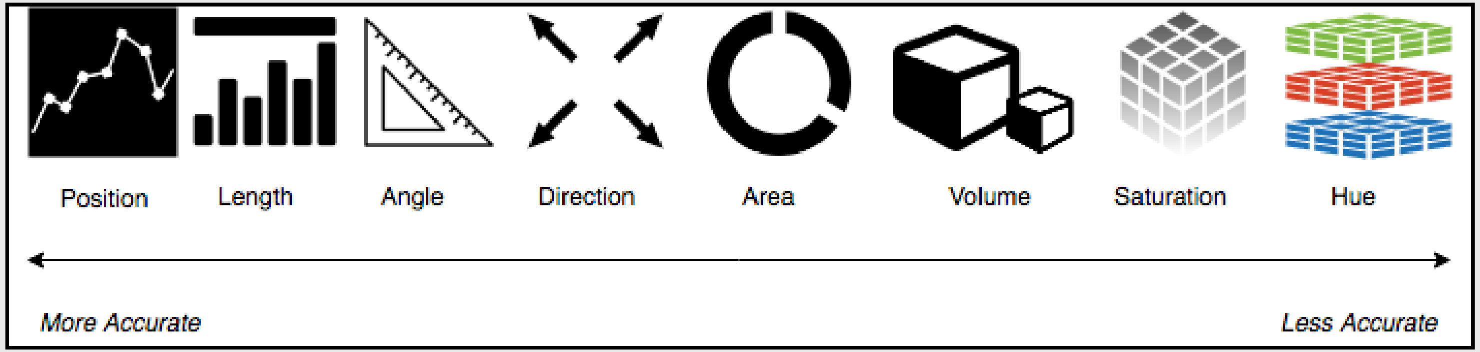
- `ggplot2` is a language of *layers*, organized linearly
- `ggplot2`'s layers give us a "*linear ordering of phrases*" to build an infinite number of graphs "*which convey a gnarly network of ideas.*"
- "**Infinitely extensible**"

Recap of `ggplot2` (cont)

In the previous lesson, we covered:

2) Identifying graph aesthetics

position (x and y), size, color, shape, etc.



Recap of `ggplot2` (cont)

In the previous lesson, we covered:

3) Recognizing and using `geoms`

- Scatter plot = `geom_point()`
- Box plot = `geom_boxplot()`
- Line graph = `geom_line()`
- Bar graph = `geom_histogram()`, `geom_bar()`, `geom_col()`

Recap of `ggplot2` (cont)

4) Labels and factes (exercises)

- **Build labels first!**
- Facet for subplots of levels in a grouping variable

Before we start...

Things to consider (1)

Recognize the needs of your audience

level of data literacy, subject matter expertise, etc.

Check and communicate data quality with stakeholders

let them know the good and the bad news

Identify the correct data visualization (based on the data)

single variable, bivariate, and multivariate graphs

Things to consider (2)

Incorporate feedback from stakeholders/audience into graphs

ask them to be part of the process

Design visualizations with the appropriate detail and annotations

inform (and do not mislead) the audience

Getting started

1) Clearly define the question or problem

- Start with a general goal, broad question, or novel problem
- Move towards specific tasks

2) Matching the measurements to metrics

- *'Measurements'* are what we care about
- *'Metrics'* are the available data

COVID and Transportation Habits

Example: How has COVID changed our modes of transportation?

What kind of measurements would these be?

how are people traveling (walk, drive, etc.)

What would these data look like?

what would the columns and rows look like?

Apple Mobility Data

Fortunately, these data exist!

Apple released mobility data:

https://covid19.apple.com/mobility

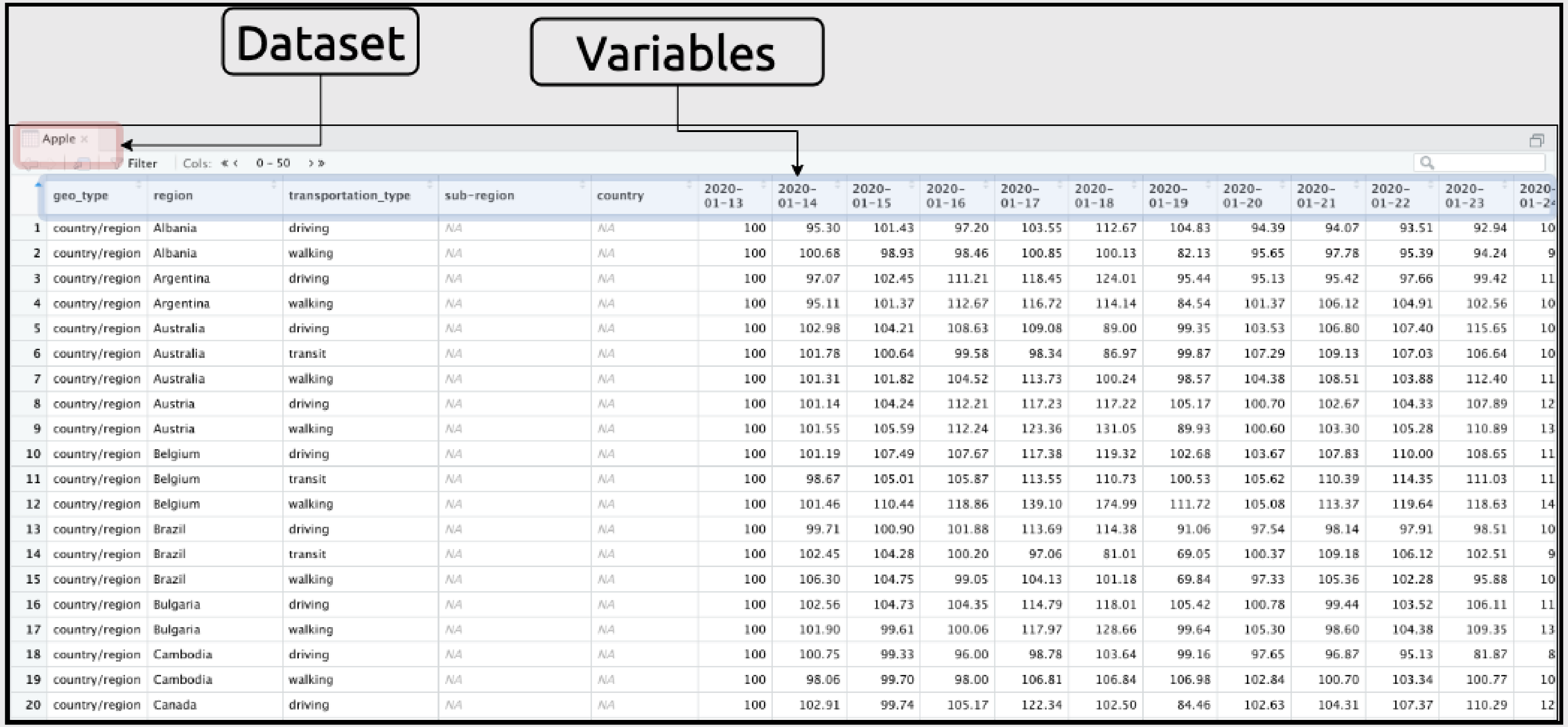
Import these data below:

```
AppleMobRaw <- readr::read_csv("https://bit.ly/36tTVpe")
```

Use Raw as a prefix or suffix for data in it's most 'raw' state

Raw Apple Mobility Data

```
AppleMobRaw %>% View("Apple")
```



	geo_type	region	transportation_type	sub-region	country	2020-01-13	2020-01-14	2020-01-15	2020-01-16	2020-01-17	2020-01-18	2020-01-19	2020-01-20	2020-01-21	2020-01-22	2020-01-23	2020-01-2
1	country/region	Albania	driving	NA	NA	100	95.30	101.43	97.20	103.55	112.67	104.83	94.39	94.07	93.51	92.94	10
2	country/region	Albania	walking	NA	NA	100	100.68	98.93	98.46	100.85	100.13	82.13	95.65	97.78	95.39	94.24	9
3	country/region	Argentina	driving	NA	NA	100	97.07	102.45	111.21	118.45	124.01	95.44	95.13	95.42	97.66	99.42	11
4	country/region	Argentina	walking	NA	NA	100	95.11	101.37	112.67	116.72	114.14	84.54	101.37	106.12	104.91	102.56	10
5	country/region	Australia	driving	NA	NA	100	102.98	104.21	108.63	109.08	89.00	99.35	103.53	106.80	107.40	115.65	10
6	country/region	Australia	transit	NA	NA	100	101.78	100.64	99.58	98.34	86.97	99.87	107.29	109.13	107.03	106.64	10
7	country/region	Australia	walking	NA	NA	100	101.31	101.82	104.52	113.73	100.24	98.57	104.38	108.51	103.88	112.40	11
8	country/region	Austria	driving	NA	NA	100	101.14	104.24	112.21	117.23	117.22	105.17	100.70	102.67	104.33	107.89	12
9	country/region	Austria	walking	NA	NA	100	101.55	105.59	112.24	123.36	131.05	89.93	100.60	103.30	105.28	110.89	13
10	country/region	Belgium	driving	NA	NA	100	101.19	107.49	107.67	117.38	119.32	102.68	103.67	107.83	110.00	108.65	11
11	country/region	Belgium	transit	NA	NA	100	98.67	105.01	105.87	113.55	110.73	100.53	105.62	110.39	114.35	111.03	11
12	country/region	Belgium	walking	NA	NA	100	101.46	110.44	118.86	139.10	174.99	111.72	105.08	113.37	119.64	118.63	14
13	country/region	Brazil	driving	NA	NA	100	99.71	100.90	101.88	113.69	114.38	91.06	97.54	98.14	97.91	98.51	10
14	country/region	Brazil	transit	NA	NA	100	102.45	104.28	100.20	97.06	81.01	69.05	100.37	109.18	106.12	102.51	9
15	country/region	Brazil	walking	NA	NA	100	106.30	104.75	99.05	104.13	101.18	69.84	97.33	105.36	102.28	95.88	10
16	country/region	Bulgaria	driving	NA	NA	100	102.56	104.73	104.35	114.79	118.01	105.42	100.78	99.44	103.52	106.11	11
17	country/region	Bulgaria	walking	NA	NA	100	101.90	99.61	100.06	117.97	128.66	99.64	105.30	98.60	104.38	109.35	13
18	country/region	Cambodia	driving	NA	NA	100	100.75	99.33	96.00	98.78	103.64	99.16	97.65	96.87	95.13	81.87	8
19	country/region	Cambodia	walking	NA	NA	100	98.06	99.70	98.00	106.81	106.84	106.98	102.84	100.70	103.34	100.77	10
20	country/region	Canada	driving	NA	NA	100	102.91	99.74	105.17	122.34	102.50	84.46	102.63	104.31	107.37	110.29	12

Wrangling Apple Mobility Data

Wrangling Apple Mobility Data

What variables do we have?

How are these variables formatted?

How do we need to change them?

...with a focus on answering our question

View Apple Mobility Data (head)

```
AppleMobRaw %>% head()
```

geo_type	region	transportation_type	sub-region	country
<chr>	<chr>	<chr>	<chr>	<chr>
country/region	Albania	driving	*NA*	*NA*
country/region	Albania	walking	*NA*	*NA*
country/region	Argentina	driving	*NA*	*NA*
country/region	Argentina	walking	*NA*	*NA*
country/region	Australia	driving	*NA*	*NA*
country/region	Australia	transit	*NA*	*NA*

6 rows | 1-5 of 322 columns

View Apple Mobility Data (tail)

```
AppleMobRaw %>% tail()
```

geo_type <chr>	region <chr>	transportation_type <chr>	sub-region <chr>
county	York County	walking	South Carolina
county	York County	walking	Pennsylvania
county	Young County	driving	Texas
county	Yuba County	driving	California
county	Yuma County	driving	Arizona
county	Yuma County	walking	Arizona

6 rows | 1-4 of 322 columns

Tidying Apple Mobility Data

Tidy dates and mobility into `date` and `dir_request` ('relative usage of directions')

```
AppleMobRaw %>% tidyr::pivot_longer(cols = -c(geo_type:country),
    names_to = "date", values_to = "dir_request") %>%
    head(5)
```

geo_type	region	transportation_type	sub-region	country
<chr>	<chr>	<chr>	<chr>	<chr>
country/region	Albania	driving	*NA*	*NA*
country/region	Albania	driving	*NA*	*NA*
country/region	Albania	driving	*NA*	*NA*
country/region	Albania	driving	*NA*	*NA*
country/region	Albania	driving	*NA*	*NA*

5 rows | 1-5 of 7 columns

Manipulate Apple Mobility Data

Remove missing values in `country` and `sub-region` and `clean_names()`

```r
AppleMobRaw %>%
  tidyr::pivot_longer(cols = -c(geo_type:country),
    names_to = "date", values_to = "dir_request") %>%
  # remove missing country data
  dplyr::filter(!is.na(country) & !is.na(`sub-region`)) %>%
  # clean names
  janitor::clean_names() %>% View("TidyApple")
```

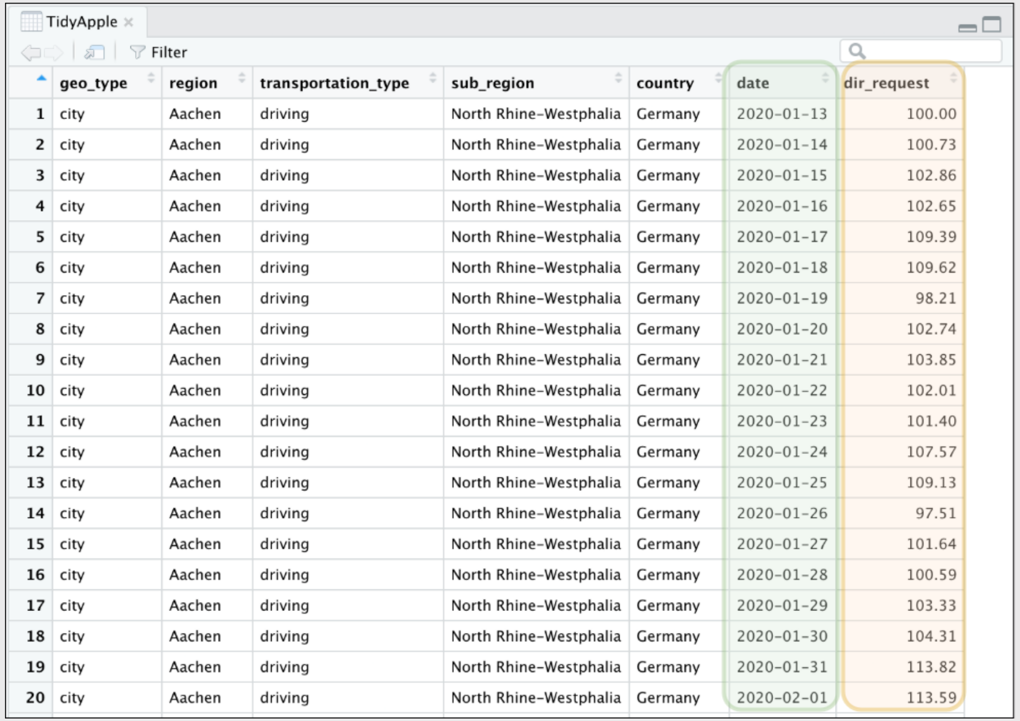
Create a 'TidyApple' Mobility Dataset!

Assign the output from pivot_longer(), filter(), and clean_names() to TidyApple

```
TidyApple <- AppleMobRaw %>%
  tidyr::pivot_longer(
      cols = -c(geo_type:country),
        names_to = "date",
        values_to = "dir_request") %>%
        # remove missing country data
        dplyr::filter(!is.na(country) &
            !is.na(`sub-region`)) %>%
        # clean names
        janitor::clean_names()
TidyApple
```

names_to =

values_to =



	geo_type	region	transportation_type	sub_region	country	date	dir_request
1	city	Aachen	driving	North Rhine-Westphalia	Germany	2020-01-13	100.00
2	city	Aachen	driving	North Rhine-Westphalia	Germany	2020-01-14	100.73
3	city	Aachen	driving	North Rhine-Westphalia	Germany	2020-01-15	102.86
4	city	Aachen	driving	North Rhine-Westphalia	Germany	2020-01-16	102.65
5	city	Aachen	driving	North Rhine-Westphalia	Germany	2020-01-17	109.39
6	city	Aachen	driving	North Rhine-Westphalia	Germany	2020-01-18	109.62
7	city	Aachen	driving	North Rhine-Westphalia	Germany	2020-01-19	98.21
8	city	Aachen	driving	North Rhine-Westphalia	Germany	2020-01-20	102.74
9	city	Aachen	driving	North Rhine-Westphalia	Germany	2020-01-21	103.85
10	city	Aachen	driving	North Rhine-Westphalia	Germany	2020-01-22	102.01
11	city	Aachen	driving	North Rhine-Westphalia	Germany	2020-01-23	101.40
12	city	Aachen	driving	North Rhine-Westphalia	Germany	2020-01-24	107.57
13	city	Aachen	driving	North Rhine-Westphalia	Germany	2020-01-25	109.13
14	city	Aachen	driving	North Rhine-Westphalia	Germany	2020-01-26	97.51
15	city	Aachen	driving	North Rhine-Westphalia	Germany	2020-01-27	101.64
16	city	Aachen	driving	North Rhine-Westphalia	Germany	2020-01-28	100.59
17	city	Aachen	driving	North Rhine-Westphalia	Germany	2020-01-29	103.33
18	city	Aachen	driving	North Rhine-Westphalia	Germany	2020-01-30	104.31
19	city	Aachen	driving	North Rhine-Westphalia	Germany	2020-01-31	113.82
20	city	Aachen	driving	North Rhine-Westphalia	Germany	2020-02-01	113.59

TidyApple: Format Variables

+ date needs to be formatted as a date

+ rename transportation_type to trans_type

```
TidyApple <- TidyApple %>%
  mutate(date = lubridate::ymd(date)) %>%
  rename(trans_type = transportation_type)
```

TidyApple: Check Formatted Variables

Re-check TidyApple data.

```
glimpse(TidyApple)
```

```
Rows: 1,055,293
Columns: 7
$ geo_type    <chr> "city", "city", "city", "city", "city", "city", "city", "c…
$ region      <chr> "Aachen", "Aachen", "Aachen", "Aachen", "Aachen", "Aachen"…
$ trans_type  <chr> "driving", "driving", "driving", "driving", "driving", "dr…
$ sub_region  <chr> "North Rhine-Westphalia", "North Rhine-Westphalia", "North…
$ country     <chr> "Germany", "Germany", "Germany", "Germany", "Germany", "Ge…
$ date        <date> 2020-01-13, 2020-01-14, 2020-01-15, 2020-01-16, 2020-01-1…
$ dir_request <dbl> 100.00, 100.73, 102.86, 102.65, 109.39, 109.62, 98.21, 102…
```

Now we can see trans_type and date are formatted correctly

TidyApple: Counting

> *"data science is mostly counting things"* - tabyl vignette

Count the trans_type variable with dplyr::count()

```
TidyApple %>%
    count(trans_type)
```

trans_type <chr>	n <int>
driving	743682
transit	106512
walking	205099

3 rows

Add the sort = TRUE argument to arrange the counts descending

```
TidyApple %>%
  count(trans_type, sort = TRUE)
```

trans_type <chr>	n <int>
driving	743682
walking	205099
transit	106512

3 rows

Visualizing Variable Distributions

What kinds of question(s) do graphs like these answer?

What does the distribution of direction requests look like?

What is the distribution of `dir_request`? We will explore this with a histogram.

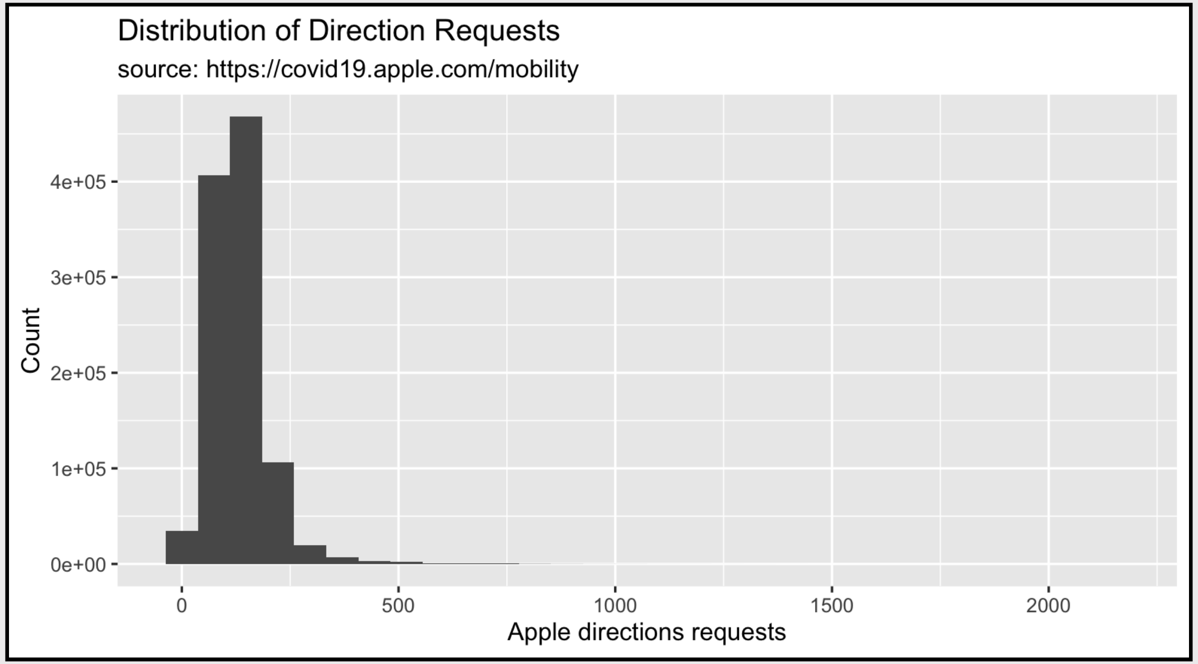
Labels!!

```r
lab_hist <- labs(x = "Apple directions requests",
                 y = "Count",
     title = "Distribution of Direction Requests",
     subtitle = "source: https://covid19.apple.com/mobility")
```

Histogram = single variable distributions

Create a histogram of `dir_request` with the code below:

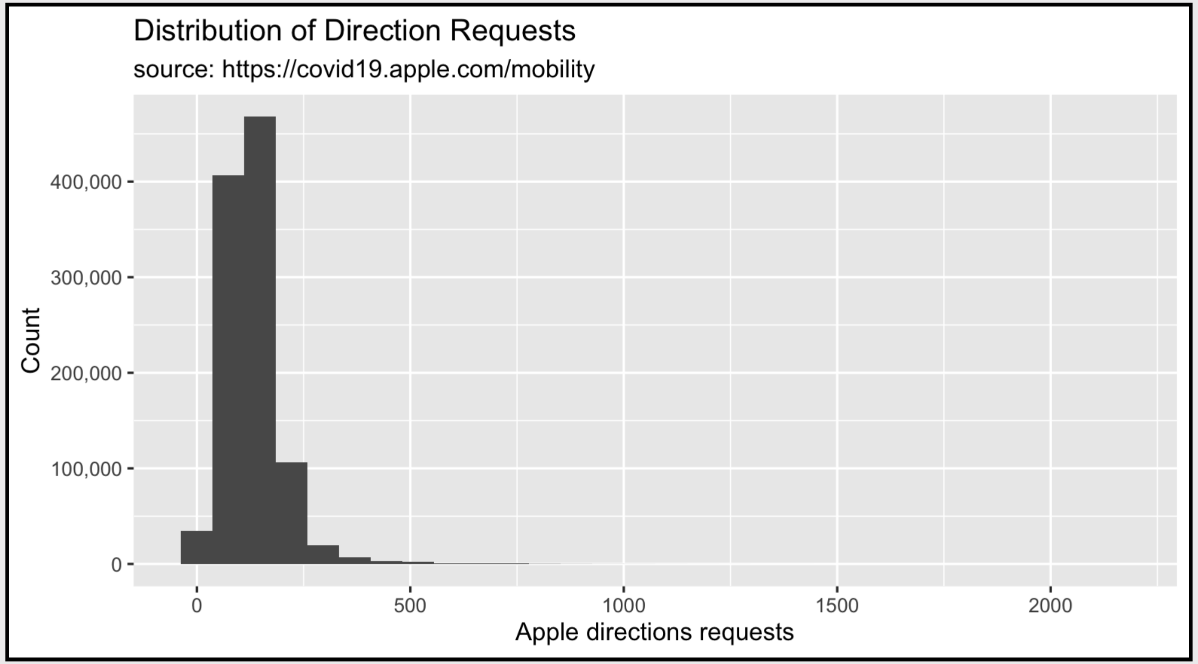
```
TidyApple %>% ggplot() +
  geom_histogram(aes(x = dir_request)) +
  lab_hist
```



Histograms: Changing the Y Axis

Fix the y axis numbers with help from the scales package

```
library(scales)
TidyApple %>% ggplot() +
  geom_histogram(aes(x = dir_request)) +
  scale_y_continuous(
      labels = scales::comma) +
  lab_hist
```



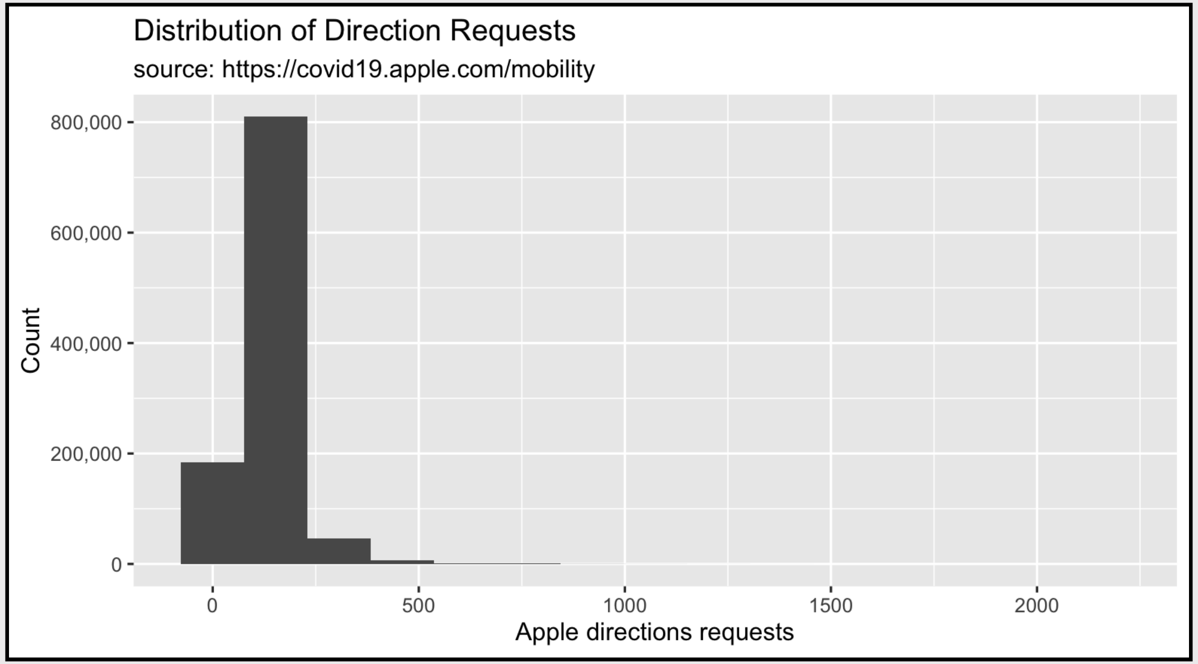
Distribution of Direction Requests

source: https://covid19.apple.com/mobility

Changing Histogram Shape

Adjust the shape of the histogram with the `bins` argument

```
TidyApple %>% ggplot() +
  geom_histogram(aes(x = dir_request),
                 bins = 15) +
  scale_y_continuous(
      labels = scales::comma) +
  lab_hist
```



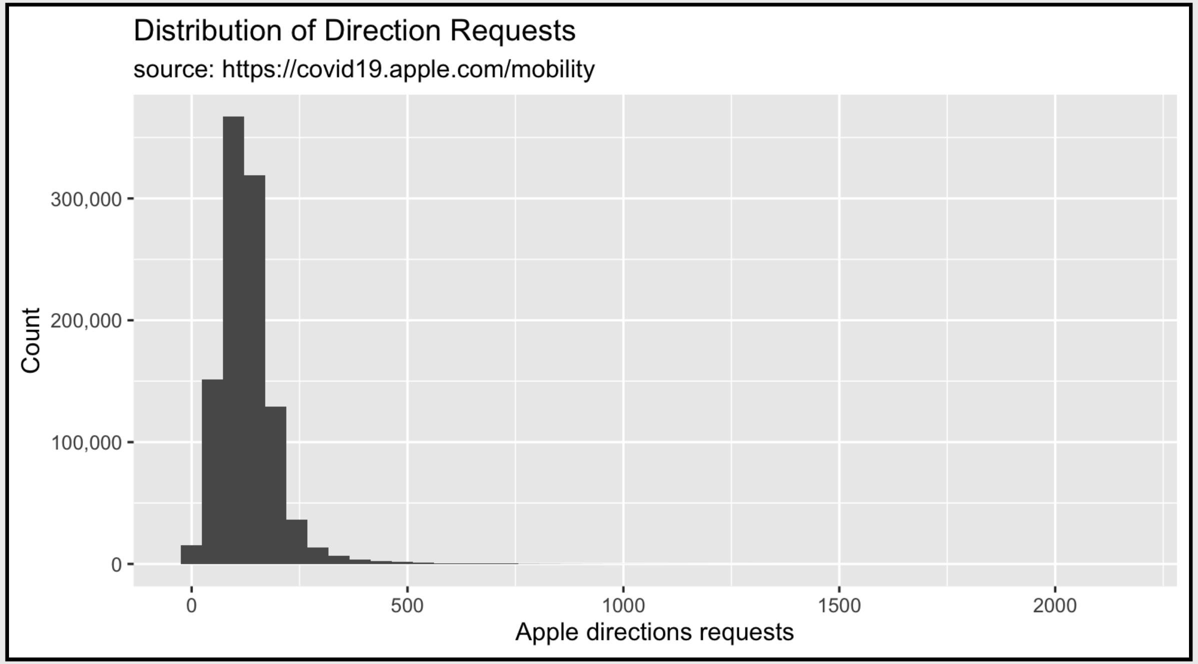
Distribution of Direction Requests

source: https://covid19.apple.com/mobility

Changing Histogram Shape

Adjust the shape of the histogram with the bins argument

```
TidyApple %>% ggplot() +
  geom_histogram(aes(x = dir_request),
                 bins = 45) +
  scale_y_continuous(
      labels = scales::comma) +
  lab_hist
```



Distribution of Direction Requests

source: https://covid19.apple.com/mobility

Visualizing variable distributions across groups

What questions do these graphs answer?

How does the distribution of `dir_request` across `trans_type`?

We can view this with a density plot, violin plot, or ridgeline plot

Density Plots

CREATE LABELS FIRST!!

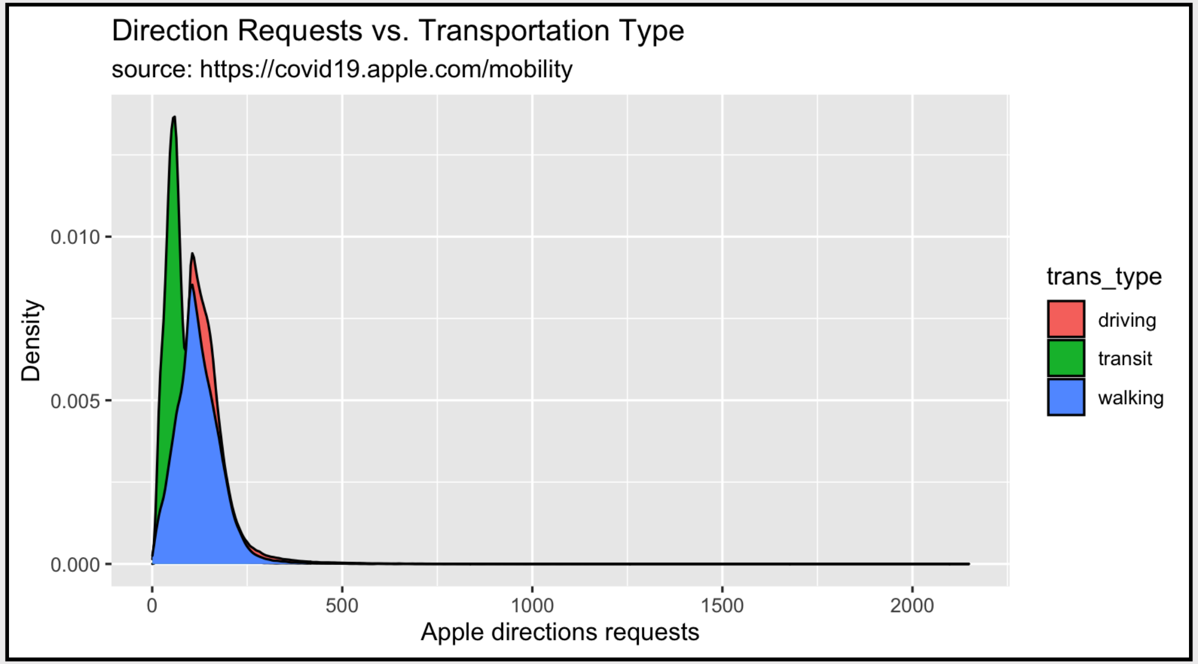
We need a new set of labels

```
lab_density <- labs(x = "Apple directions requests",
                    y = "Density",
     title = "Direction Requests vs. Transportation Type",
     subtitle = "source: https://covid19.apple.com/mobility")
```

Density Plots

Visualize the distribution of `dir_request` across `trans_type` with a `geom_density()`

```
TidyApple %>%
  ggplot() +
  geom_density(aes(x = dir_request,
                   fill = trans_type)) +
   lab_density
```



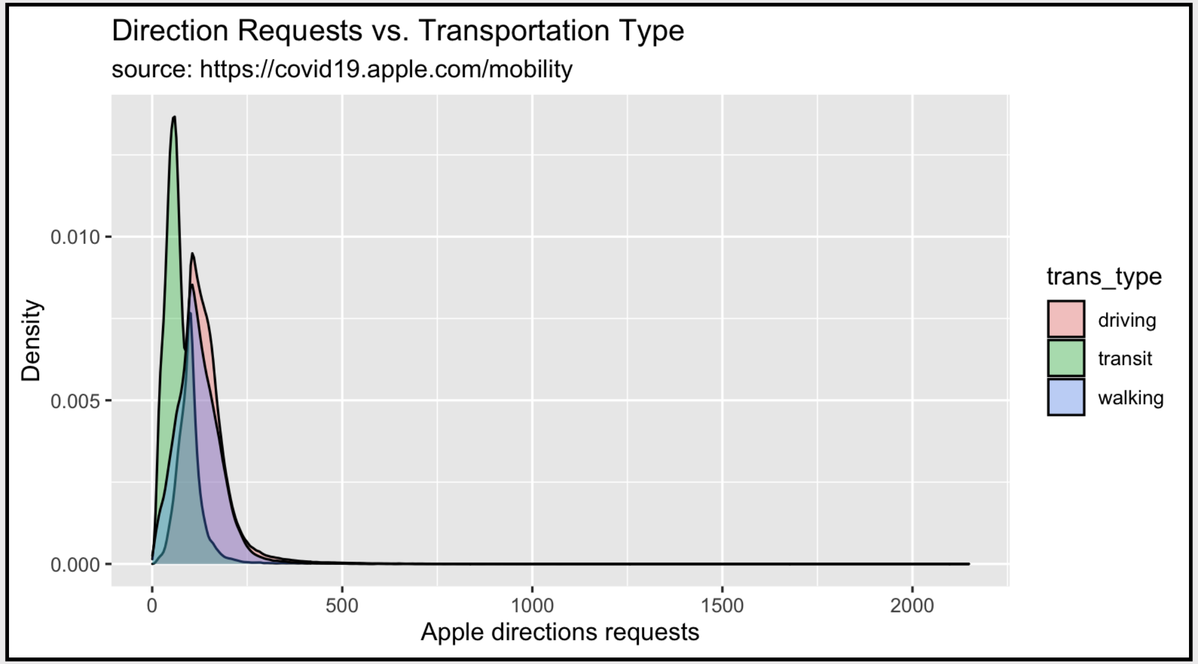
Direction Requests vs. Transportation Type

source: https://covid19.apple.com/mobility

Density Plots (alpha)

Adjust the alpha so we can see the overlap

```
TidyApple %>%
  ggplot() +
  geom_density(aes(x = dir_request,
                   fill = trans_type),
               alpha = 1/3) +
  lab_density
```



Direction Requests vs. Transportation Type

source: https://covid19.apple.com/mobility

Violin Plots

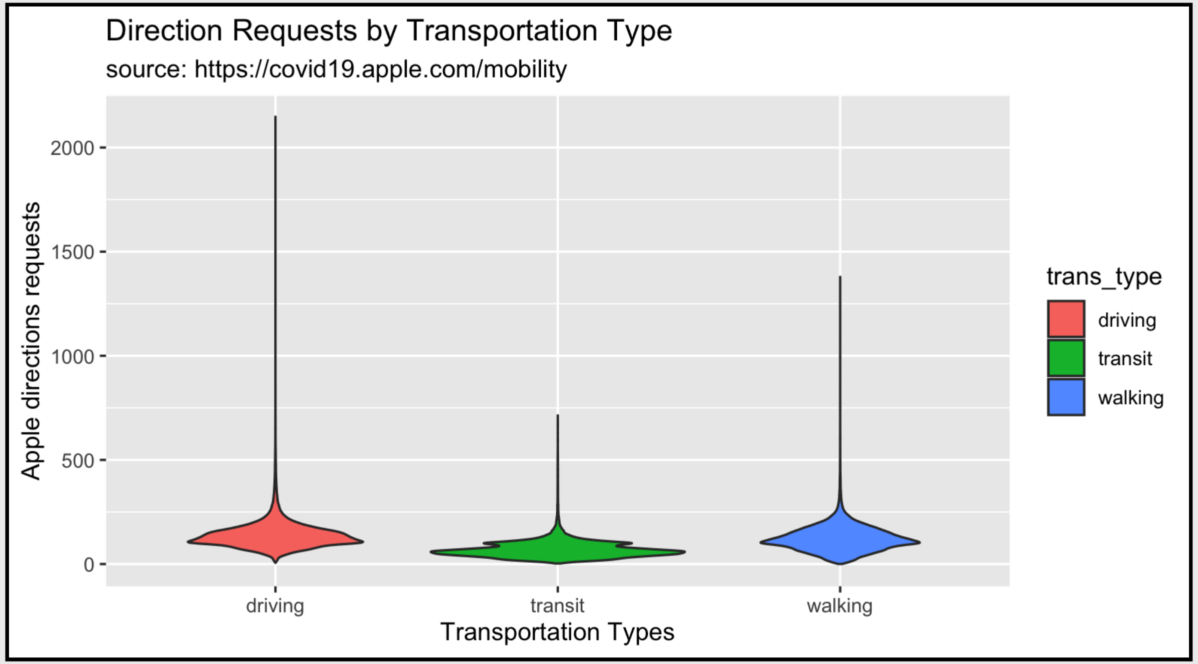
Violin plots are alternatives to box-plots.

```
lab_violin <- labs(y = "Apple directions requests",
                   x = "Transportation Types",
     title = "Direction Requests by Transportation Type",
     subtitle = "source: https://covid19.apple.com/mobility")
```

Violin Plots

Violin plots allow us to add a categorical variable to the x axis.

```
TidyApple %>%
  ggplot() +
  geom_violin(aes(y = dir_request,
                  x = trans_type,
                  fill = trans_type)) +
  lab_violin
```



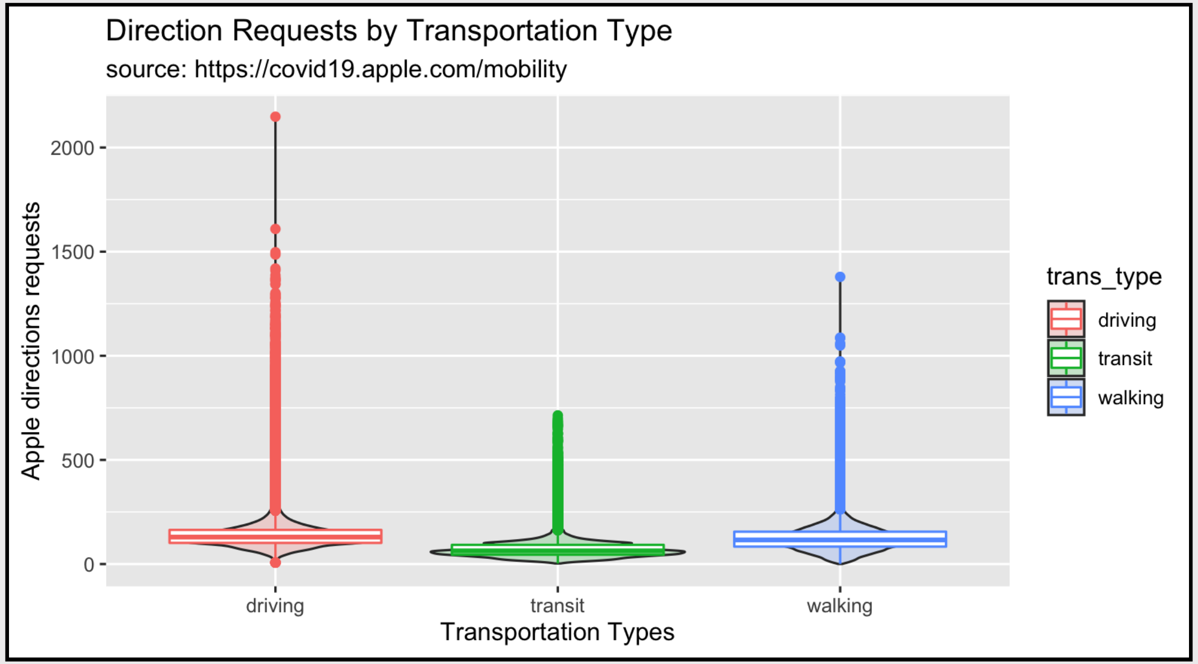
Direction Requests by Transportation Type

source: https://covid19.apple.com/mobility

Violin Plots: *confused?*

Add a boxplot layer!

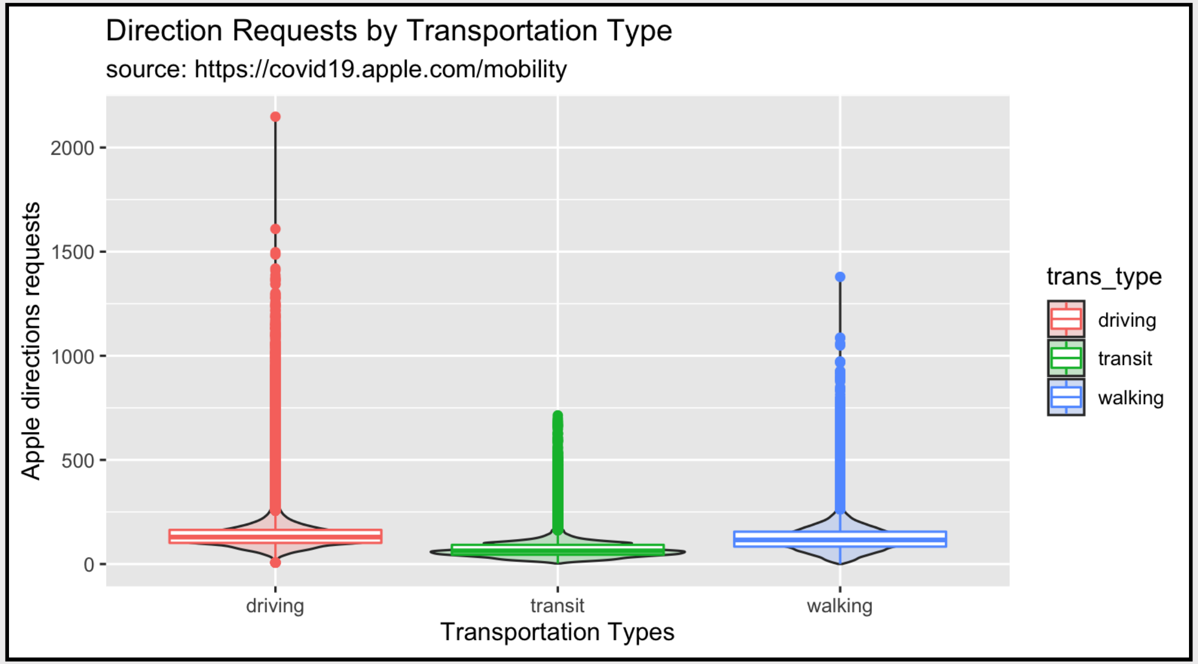
```
TidyApple %>%
  ggplot() +
  geom_violin(aes(y = dir_request,
                  x = trans_type,
                  fill = trans_type),
                  alpha = 1/5) +
  geom_boxplot(aes(y = dir_request,
                   x = trans_type,
                   color = trans_type)) +
  lab_violin
```



Violin Plots *and* Boxpots

We map the same variables to the x and y, but swap fill for color in the geom_boxplot().

```
TidyApple %>%
  ggplot() +
  geom_violin(aes(y = dir_request,
                  x = trans_type,
                  fill = trans_type),
                  alpha = 1/5) +
  geom_boxplot(aes(y = dir_request,
                   x = trans_type,
                   color = trans_type)) +
  lab_violin
```



Direction Requests by Transportation Type

source: https://covid19.apple.com/mobility

Rideline Plots

Another option is a ridgeline plot (from the `ggridges` package). These display multiple densities.

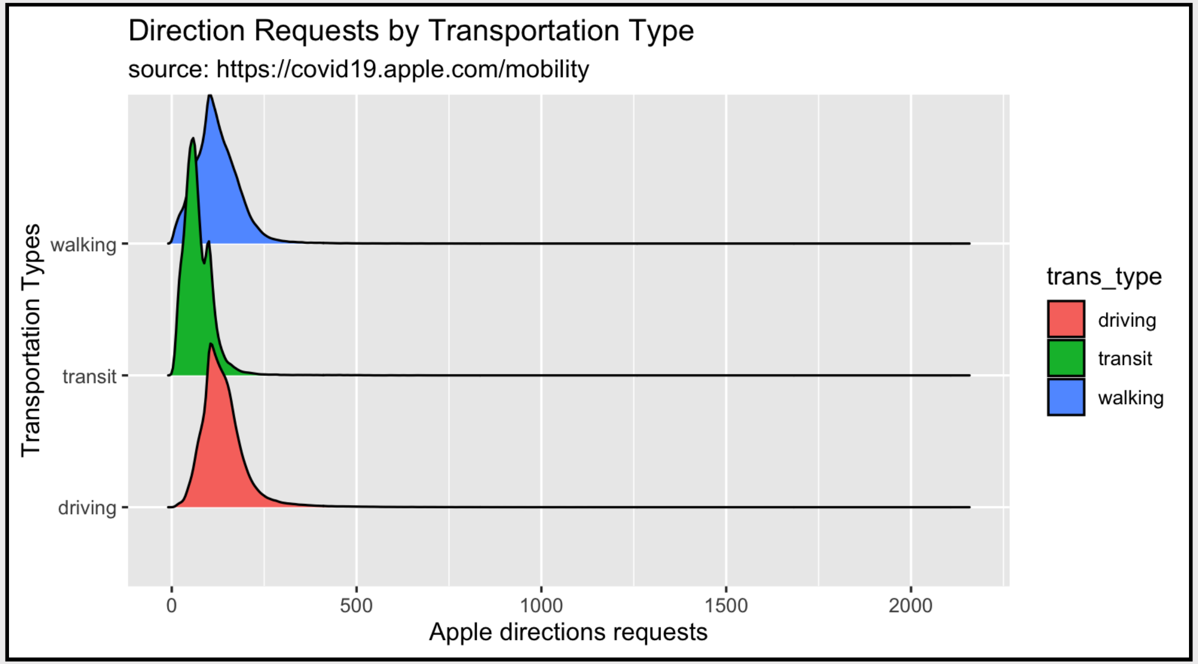
Labs first!

```
lab_ridges <- labs(x = "Apple directions requests",
                   y = "Transportation Types",
     title = "Direction Requests by Transportation Type",
     subtitle = "source: https://covid19.apple.com/mobility")
```

Rideline Plots

The `geom_density_ridges()` function works just like the `geom_density()`, except we can supply a `y` variable.

```
library(ggridges)
TidyApple %>%
  ggplot() +
  geom_density_ridges(
      aes(x = dir_request,
          y = trans_type,
          fill = trans_type)) +
  lab_ridges
```



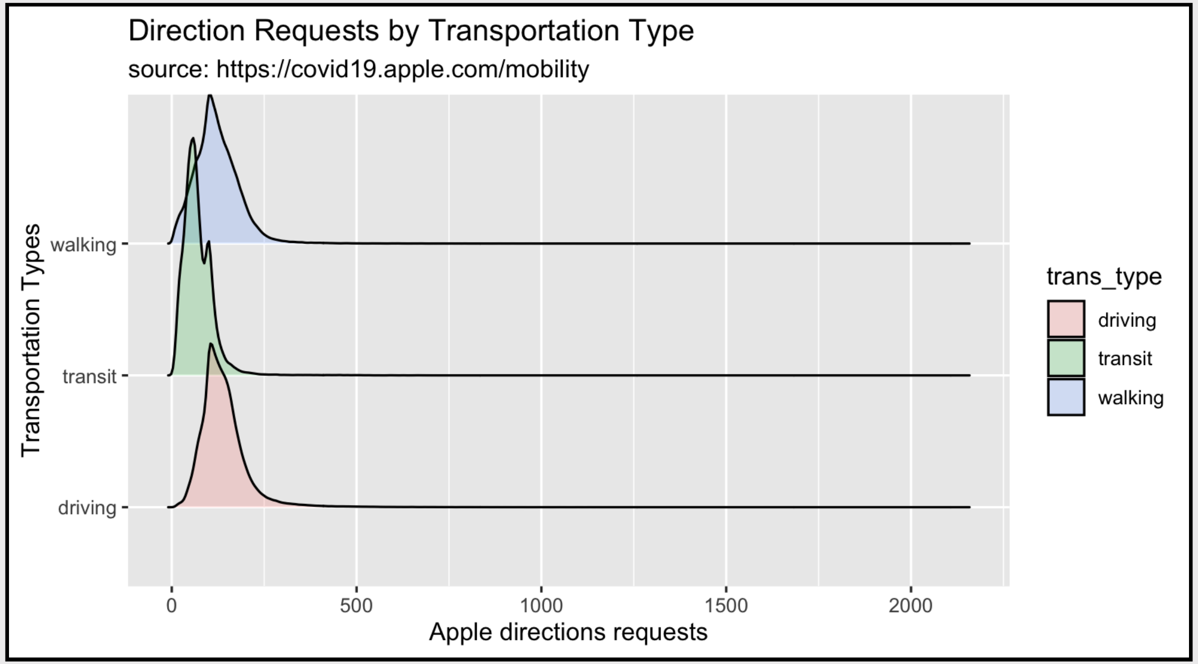
Direction Requests by Transportation Type

source: https://covid19.apple.com/mobility

Rideline Plots

We can adjust the `alpha` on these just like the density plots.

```
library(ggridges)
TidyApple %>%
  ggplot() +
  geom_density_ridges(
      aes(x = dir_request,
          y = trans_type,
          fill = trans_type),
      alpha = 1/5) +
   lab_ridges
```



Direction Requests by Transportation Type

source: https://covid19.apple.com/mobility

Line Graphs

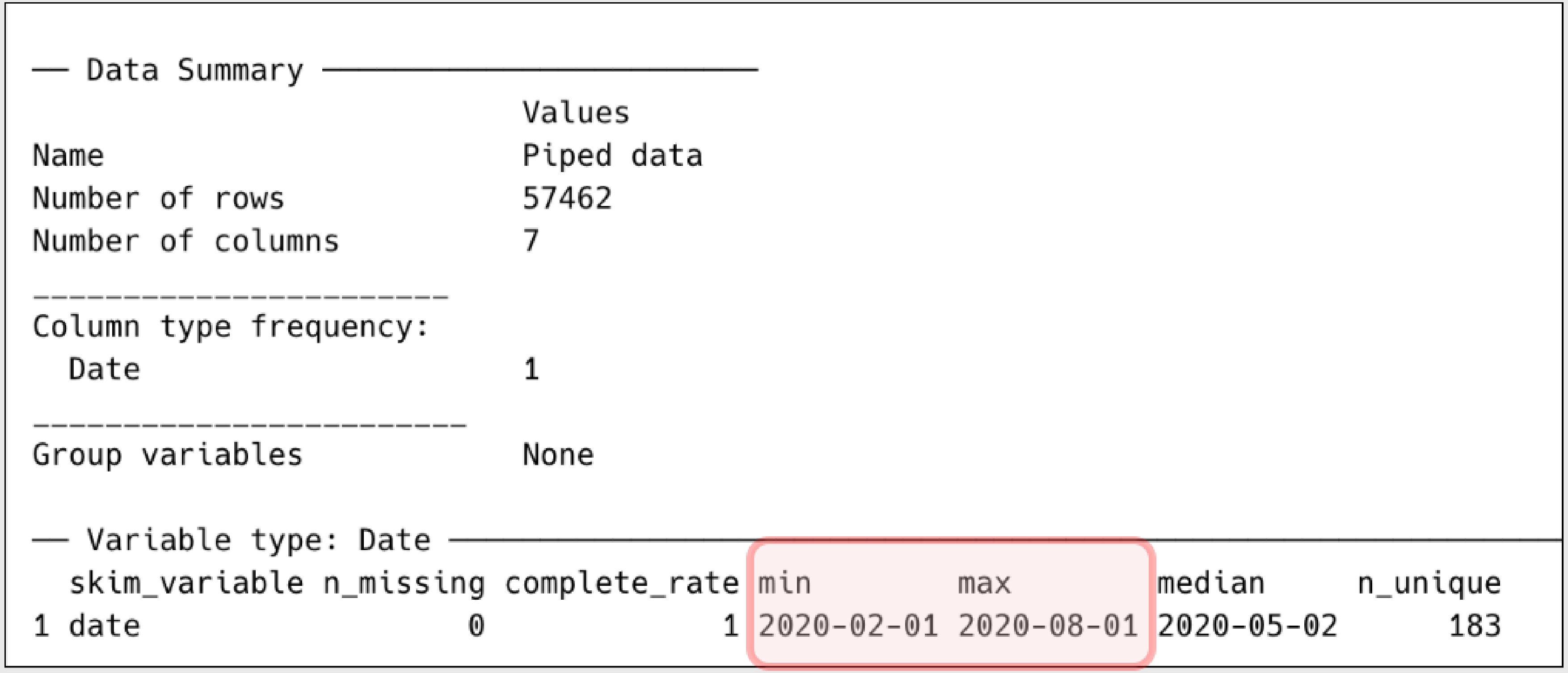
Narrowing date ranges

Filter the data to only us cities between `2020-02-01` and `2020-08-01`. Use `skimr::skim()` to make sure it works!

```
TidyApple %>%
  # us cities
  filter(geo_type == "city" &
         country == "United States",
         # feb - aug
         date >= lubridate::as_date("2020-02-01") &
         date <= lubridate::as_date("2020-08-01")) %>%
         # check work!
         skimr::skim(date)
```

Check with `skimr` output

These are helpful if we're checking a filter on a numerical certain condition (`min`, `max`, `mean`, etc.)



```
── Data Summary ────────────────────────
                           Values
Name                       Piped data
Number of rows             57462
Number of columns          7
_______________________
Column type frequency:
  Date                     1
________________________
Group variables            None

── Variable type: Date ──────────────────────────────────────────────────────────
  skim_variable n_missing complete_rate min        max        median     n_unique
1 date                  0             1 2020-02-01 2020-08-01 2020-05-02      183
```

Narrow to US Cities (Feb-Jul)

Create `USCitiesFebJul` data by filtering to US cities between Feb 1, 2020 and July 31, 2020.

```r
TidyApple %>%
  filter(geo_type == "city" &
         country == "United States",
         date >= lubridate::as_date("2020-02-01") &
         date <= lubridate::as_date("2020-08-01")) -> USCitiesFebJul
```

Line Graph: Labels (1)

Ideally, our labels update whenever the data changes.

```
paste0(min(USCitiesFebJul$date),
       " through ",
       max(USCitiesFebJul$date))
```

```
  [1] "2020-02-01 through 2020-08-01"
```

We can do this by using `paste0()` in our `subtitle`:

```
 subtitle =
    paste0(min(USCitiesFebJul$date), # first date
          " through ", # plain text
          max(USCitiesFebJul$date)),  # last date
```

Line Graph: Labels (2)

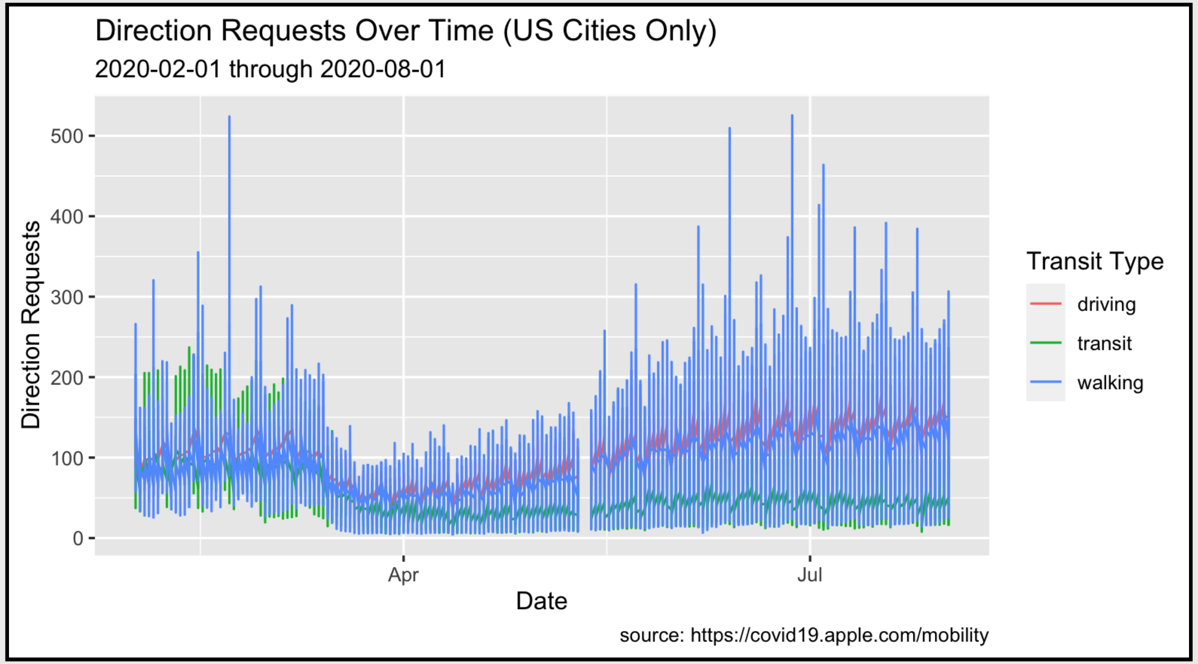
We can then supply the `subtitle` to `labs`

```
labs(x = "Date",
     y = "Direction Requests",
     title = "Direction Requests Over Time (US Cities Only)",
     subtitle = paste0(min(USCitiesFebJul$date),
                       " through ",
                       max(USCitiesFebJul$date)),
     caption = "source: https://covid19.apple.com/mobility",
     color = "Transit Type") -> lab_line_graph
```

Line Graph: Labels (3)

We will add group and color aesthetics to our graph of dir_request over time (date).

```
USCitiesFebJul %>%
  ggplot() +
  geom_line(aes(x = date,
                y = dir_request,
            group = trans_type,
            color = trans_type)) +
    lab_line_graph
```



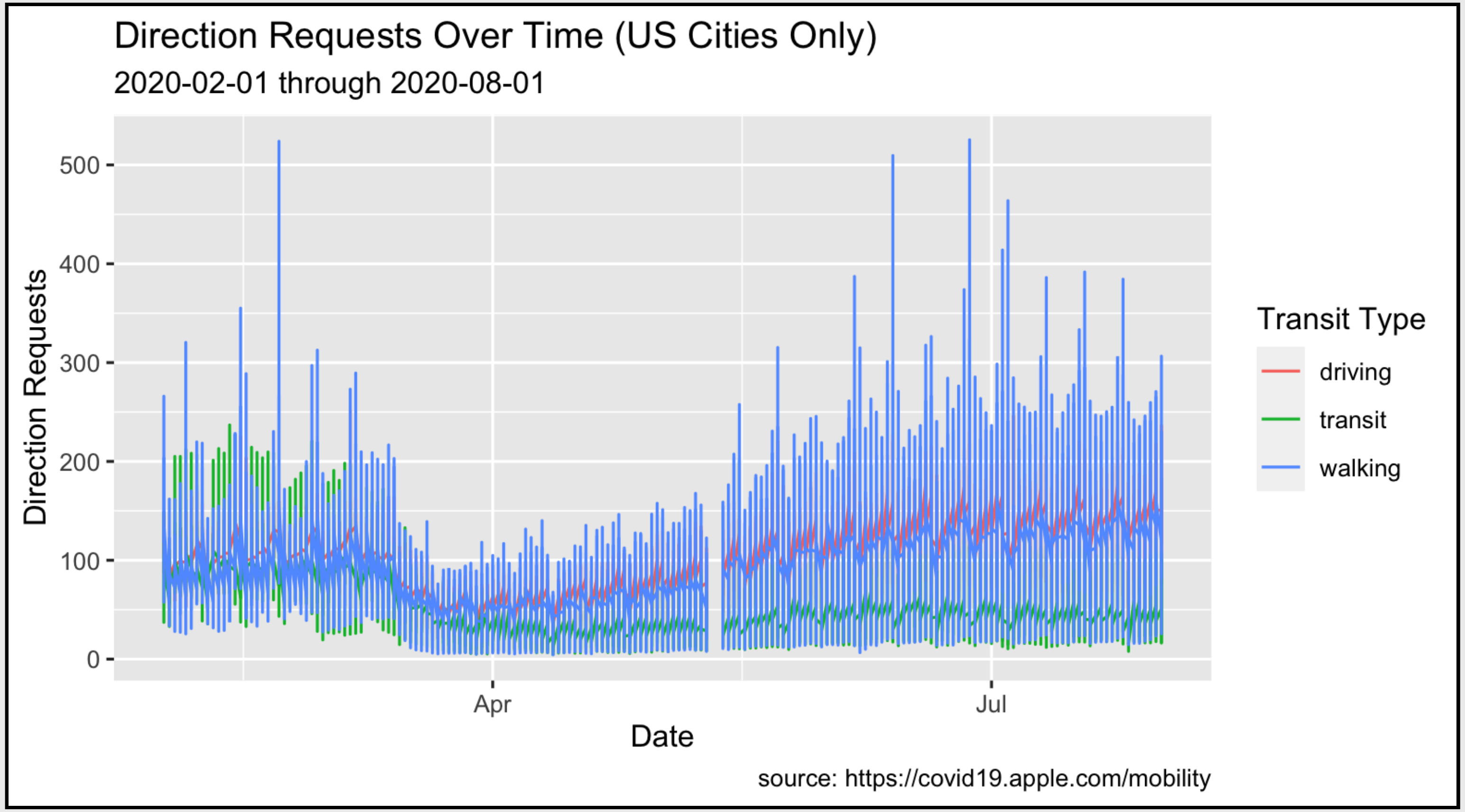
Direction Requests Over Time (US Cities Only)

2020-02-01 through 2020-08-01

source: https://covid19.apple.com/mobility

Line Graphs: Overlapping Lines

Consider our previous line graph--the lines overlap a bit.

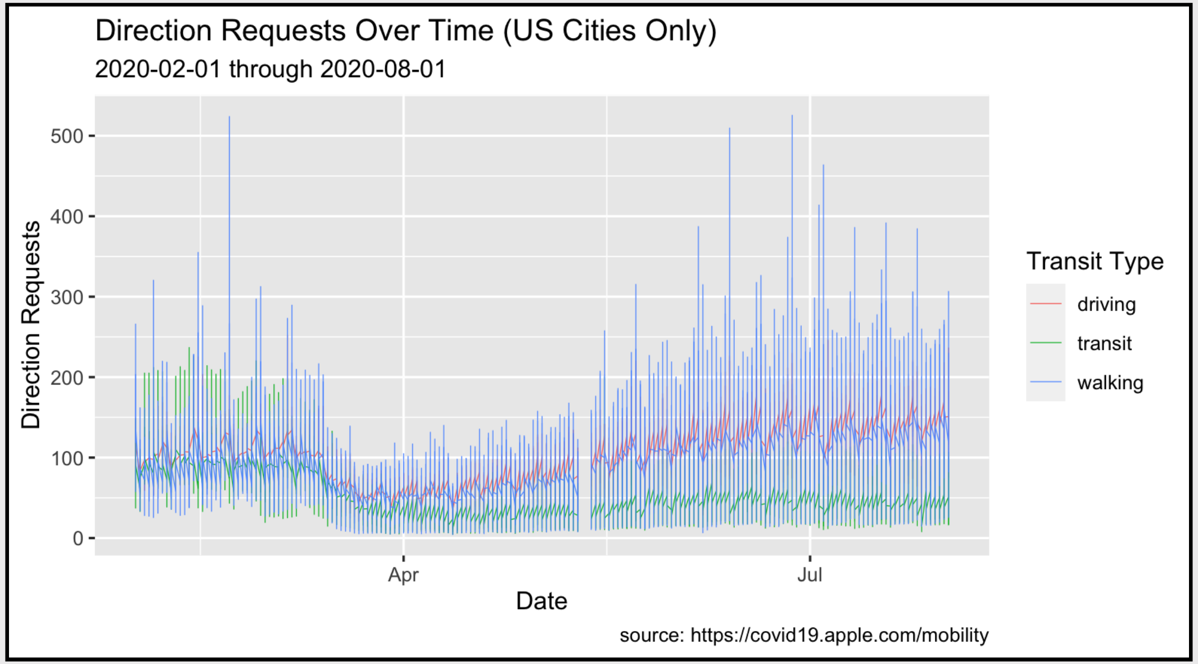


Line Graph: Line Size

We can minimize the size of the line with the `size` aesthetic.

```
USCitiesFebJul %>%
  ggplot() +
  geom_line(aes(x = date,
                y = dir_request,
             group = trans_type,
             color = trans_type),
    # make these slightly smaller
            size = 0.20) +
   lab_line_graph
```

This makes the trends easier to see.



Direction Requests Over Time (US Cities Only)

2020-02-01 through 2020-08-01

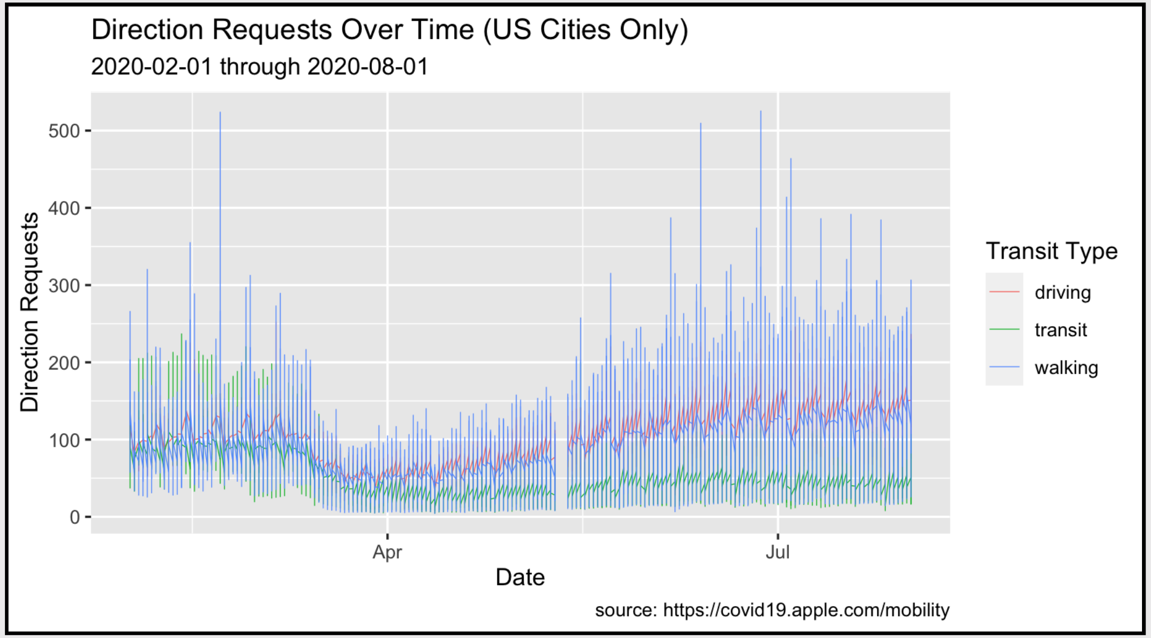
source: https://covid19.apple.com/mobility

Adding Text

Labeling Missing Data

There is a gap in the direct request data (this is documented in the data source).

> *"Data for May 11-12 is not available and will appear as blank columns in the data set."*



Create Annotate Data

These data are `filter`ed to US cities between March 1, 2020 to June 30, 2020.

```
USCitiesMarJun <-  TidyApple %>%
  filter(geo_type == "city" & country == "United States",
         date >= lubridate::as_date("2020-03-01") &
         date <= lubridate::as_date("2020-07-01"))
```

Create Annotate Data

```
USCitiesMarJun
```

geo_type <chr>	region <chr>	trans_type <chr>	sub_region <chr>	country <chr>	date <date>	dir_request <dbl>
city	Akron	driving	Ohio	United States	2020-03-01	91.46
city	Akron	driving	Ohio	United States	2020-03-02	107.46
city	Akron	driving	Ohio	United States	2020-03-03	111.38
city	Akron	driving	Ohio	United States	2020-03-04	111.55
city	Akron	driving	Ohio	United States	2020-03-05	119.94
city	Akron	driving	Ohio	United States	2020-03-06	133.31
city	Akron	driving	Ohio	United States	2020-03-07	134.39
city	Akron	driving	Ohio	United States	2020-03-08	98.89
city	Akron	driving	Ohio	United States	2020-03-09	109.00
city	Akron	driving	Ohio	United States	2020-03-10	107.88

1-10 of 10,000 rows Previous **1** 2 3 4 5 6 ... 1000 Next

annotate: Build Labels

Build our labels first!

```
lab_annotation <- labs(x = "Date",
     y = "Direction Requests",
     title = "Spring Direction Requests (Mar-Jun) in US Cities",
     subtitle = paste0(min(USCitiesMarJun$date),
                       " through ",
                       max(USCitiesMarJun$date)),
     caption = "source: https://covid19.apple.com/mobility",
     color = "Transit Type")
```

annotate: Build Line Graph

Build a line graph layer (gg_line_annotate)

```
gg_line_annotate <- USCitiesMarJun %>%
    ggplot() +
    geom_line(aes(x = date, y = dir_request,
             group = trans_type, color = trans_type),
             size = 0.20)
```

annotate: build coordinate system

Add a coordinate system layer (gg_coord_system)

```
gg_coord_system <- coord_cartesian(
 xlim = c(min(USCitiesMarJun$date),
          max(USCitiesMarJun$date)),
 ylim = c(min(USCitiesMarJun$dir_request, na.rm = TRUE),
          max(USCitiesMarJun$dir_request, na.rm = TRUE)))
```

annotate: build line segment

Build vertical line segment (gg_line_segment)

```
gg_line_segment <- annotate(geom = "segment",
          size = 1,
          color = "firebrick3",
          x = lubridate::as_date("2020-05-11"),
          xend = lubridate::as_date("2020-05-11"),
          y = 270,
          yend = 100)
```

annotate: Build Text Annotatation

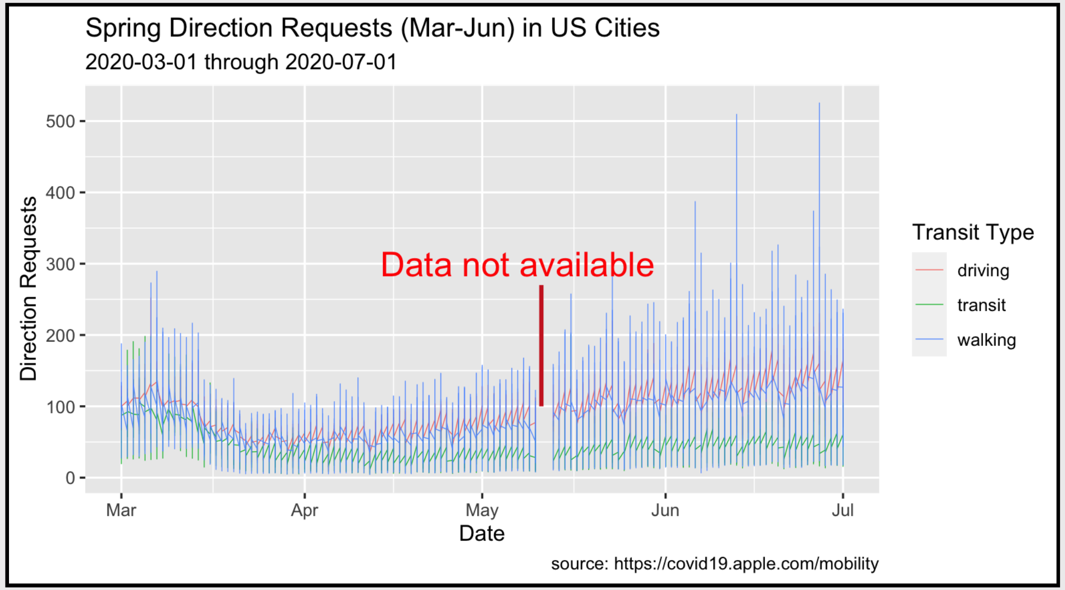
Build text annotation (gg_text_annotation)

```
gg_text_annotation <- annotate(geom = "text",
       color = "red",
       hjust = 0.5,
       size = 6,
       x = lubridate::as_date("2020-05-07"),
       y = 300,
       label = "Data not available")
```

annotate: Combine Layers

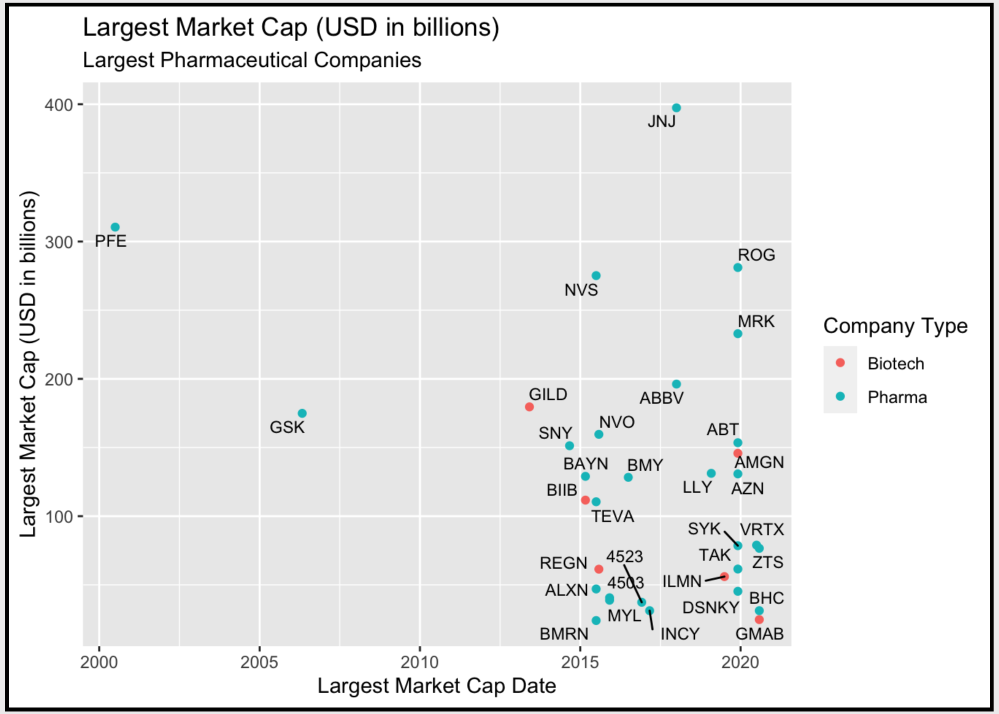
Now we can use the ggplot2 syntax to combine these layers...

```
gg_line_annotate + # line graph
  gg_coord_system + # coordinate system
  gg_line_segment + # line annotation
  gg_text_annotation + # text annotation
  lab_annotation # labels
```



Labeling Values (Review)

In the previous slides, we learned about labeling values with `ggrepel`.



Now we're going to extend this to plotting text and values on our graphs!

Highlighting Large US Cities

Filter `TidyApple` to the 5 largest US cities (by population).

```
TopUSCities <- TidyApple %>%
  filter(country == "United States" &
           region %in% c("New York City","Los Angeles",
                         "Chicago", "Houston", "Phoenix"))
```

View `TopUSCities`

```
TopUSCities
```

geo_type <chr>	region <chr>	trans_type <chr>	sub_region <chr>	country <chr>	date <date>	dir_request <dbl>
city	Chicago	driving	Illinois	United States	2020-01-13	100.00
city	Chicago	driving	Illinois	United States	2020-01-14	103.68
city	Chicago	driving	Illinois	United States	2020-01-15	104.45
city	Chicago	driving	Illinois	United States	2020-01-16	108.72
city	Chicago	driving	Illinois	United States	2020-01-17	132.80
city	Chicago	driving	Illinois	United States	2020-01-18	113.44
city	Chicago	driving	Illinois	United States	2020-01-19	87.48
city	Chicago	driving	Illinois	United States	2020-01-20	100.24
city	Chicago	driving	Illinois	United States	2020-01-21	101.30
city	Chicago	driving	Illinois	United States	2020-01-22	100.51

1-10 of 4,755 rows Previous **1** 2 3 4 5 6 ... 476 Next

Highlighting Peak Driving

Create a dataset with only the maximum direction request values for `"driving"` per `region`.

```r
MaxUSCitiesDriving <- TopUSCities %>%
  filter(trans_type == "driving") %>%
  group_by(region) %>%
  slice_max(dir_request) %>%
  ungroup()
MaxUSCitiesDriving
```

geo_type	region	trans_type	sub_region	country	date	dir_request
<chr>	<chr>	<chr>	<chr>	<chr>	<date>	<dbl>
city	Chicago	driving	Illinois	United States	2020-07-17	166.11
city	Houston	driving	Texas	United States	2020-02-14	146.20
city	Los Angeles	driving	California	United States	2020-02-14	152.08
city	New York City	driving	New York	United States	2020-09-04	152.09
city	Phoenix	driving	Arizona	United States	2020-02-29	142.68

5 rows

Create graph labels

We know we want to see the max direction requests labeled, so we will update the labels for the graph.

```
lab_line_max_drivers <- labs(
 x = "Date",
 y = "Direction Requests",
 title = "Peak Driving Direction Requests in Largest US Cities",
 subtitle = paste0(min(TopUSCities$date),
                   " through ",
                   max(TopUSCities$date)),
 caption = "source: https://covid19.apple.com/mobility",
 color = "Transit Type")
```

Create Value Labels

We will also use `paste0()` here to create a variable for the labels that combines the city and date.

```
MaxUSCitiesDriving <- MaxUSCitiesDriving
%>%
  mutate(max_driving_labels =
paste0(region, ", ", date))
```

Take a look at the labels we've created

```
MaxUSCitiesDriving %>%
  select(max_driving_labels)
```

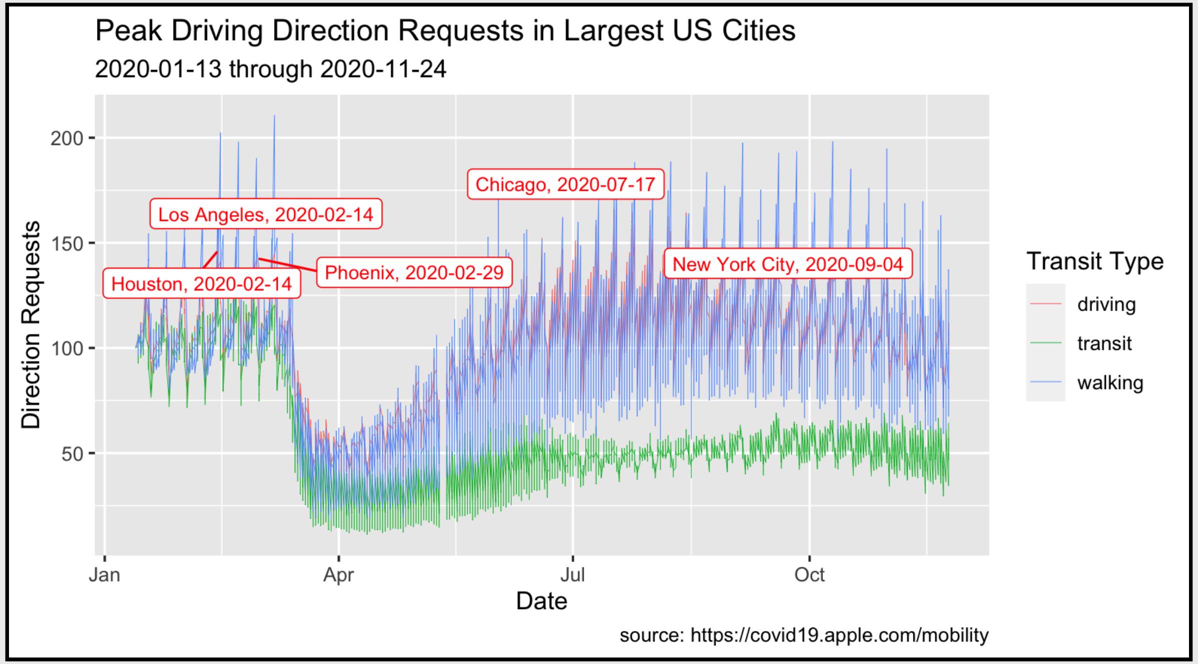
max_driving_labels
<chr>
Chicago, 2020-07-17
Houston, 2020-02-14
Los Angeles, 2020-02-14
New York City, 2020-09-04
Phoenix, 2020-02-29

5 rows

Create Line Layer + Label Layer

Now we combine the `geom_line()` layer, the `geom_label_repel()` layer, and the `lab_line_max_drivers`.

```r
library(ggrepel)
TopUSCities %>%
    ggplot() +
    geom_line(aes(
            x = date,
            y = dir_request,
        group = trans_type,
        color = trans_type),
  # make these slightly smaller again...
         size = 0.15) +
    geom_label_repel(
        data = MaxUSCitiesDriving,
        aes(x = date,
            y = dir_request,
        label = max_driving_labels),
  # set color and size...
        color = "red",
         size = 3) +
  lab_line_max_drivers
```


Peak Driving Direction Requests in Largest US Cities

2020-01-13 through 2020-11-24

source: https://covid19.apple.com/mobility

Adding Reference Lines

Reference Line Data

```
TopUSCities
```

geo_type <chr>	region <chr>	trans_type <chr>	sub_region <chr>	country <chr>	date <date>
city	Chicago	driving	Illinois	United States	2020-01-13
city	Chicago	driving	Illinois	United States	2020-01-14
city	Chicago	driving	Illinois	United States	2020-01-15
city	Chicago	driving	Illinois	United States	2020-01-16
city	Chicago	driving	Illinois	United States	2020-01-17
city	Chicago	driving	Illinois	United States	2020-01-18
city	Chicago	driving	Illinois	United States	2020-01-19
city	Chicago	driving	Illinois	United States	2020-01-20
city	Chicago	driving	Illinois	United States	2020-01-21
city	Chicago	driving	Illinois	United States	2020-01-22

1-10 of 4,755 rows | 1-6 of 7 columns Previous **1** 2 3 4 5 6 ... 476 Next

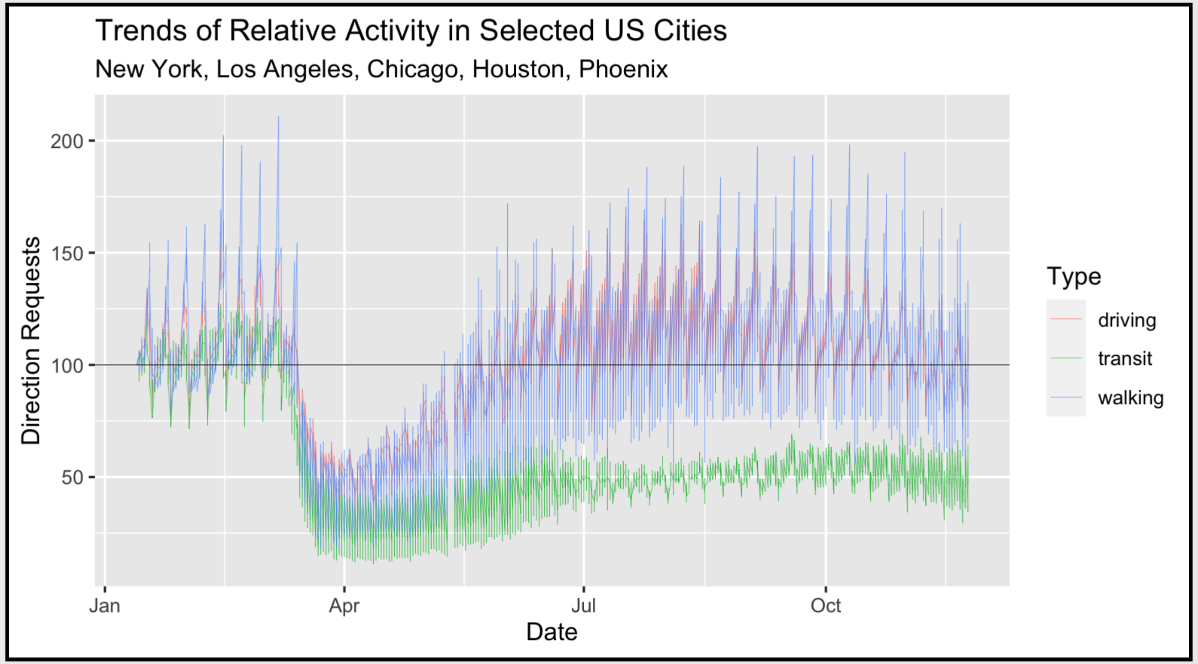
Reference Line Labels

```
labs(x = "Date",
 y  = "Direction Requests",
 title = "Trends of Relative Activity in Selected US Cities",
 subtitle = "New York, Los Angeles, Chicago, Houston, Phoenix",
 color = "Type") -> lab_ref_lines
```

Horizontal Reference Lines

Add the `geom_hline()` for a horizontal reference line (at `100`)

```
TopUSCities %>%
  ggplot(aes(x = date,
             y = dir_request,
             group = trans_type,
             color = trans_type)) +
  geom_line(size = 0.1) +
  geom_hline(yintercept = 100,
             size = 0.2,
             color = "gray20") +
  lab_ref_lines
```

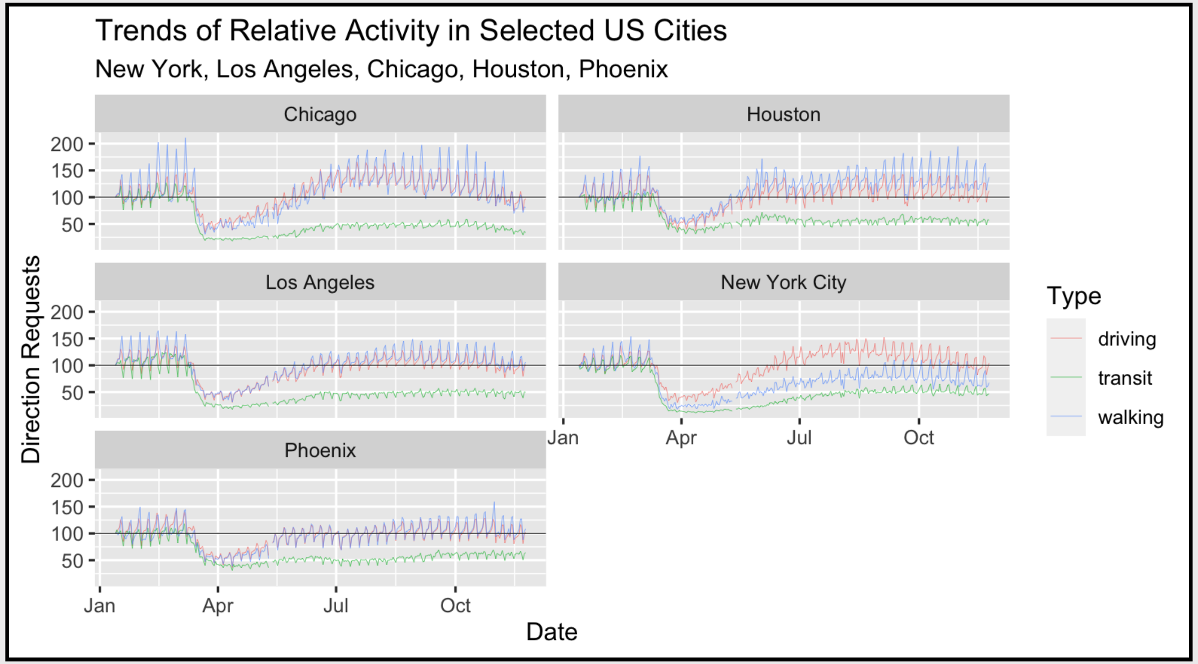


Advanced Facetting

Faceting basics

Facets create subplots across levels of a categorical variable.

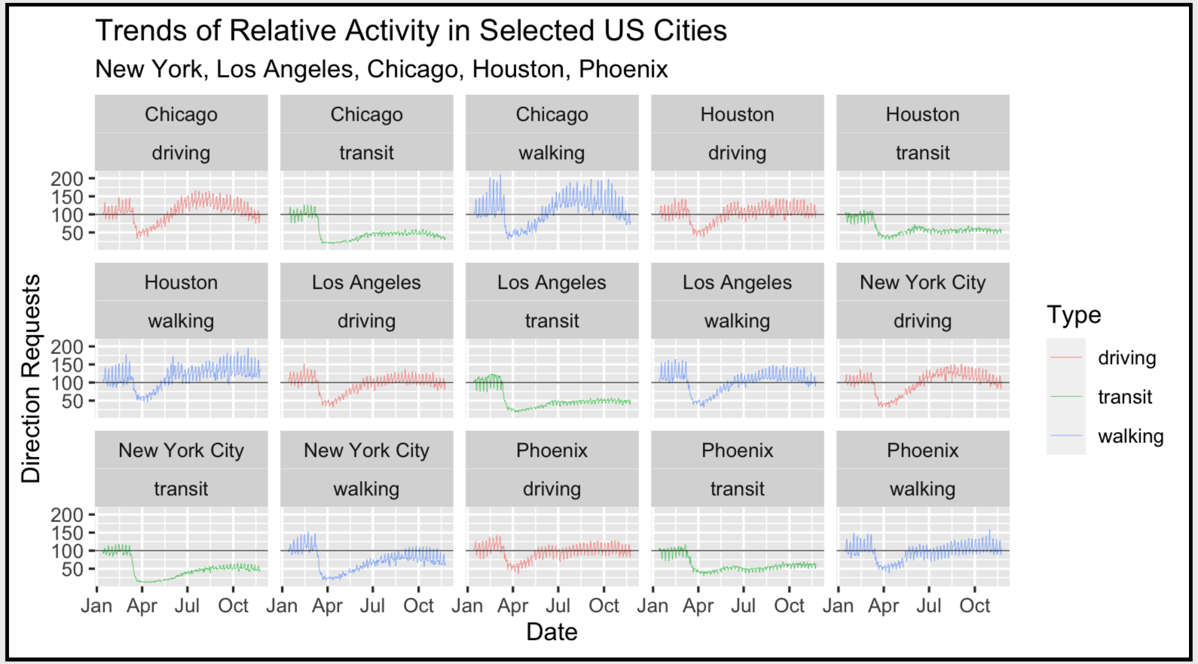
```
TopUSCities %>%
  ggplot(aes(x = date, y = dir_request,
             group = trans_type,
             color = trans_type)) +
  geom_line(size = 0.1) +
  geom_hline(yintercept = 100,
             size = 0.2,
             color = "gray20") +
  facet_wrap(~ region,  ncol = 2) +
  lab_ref_lines
```



Multiple Variable Facets

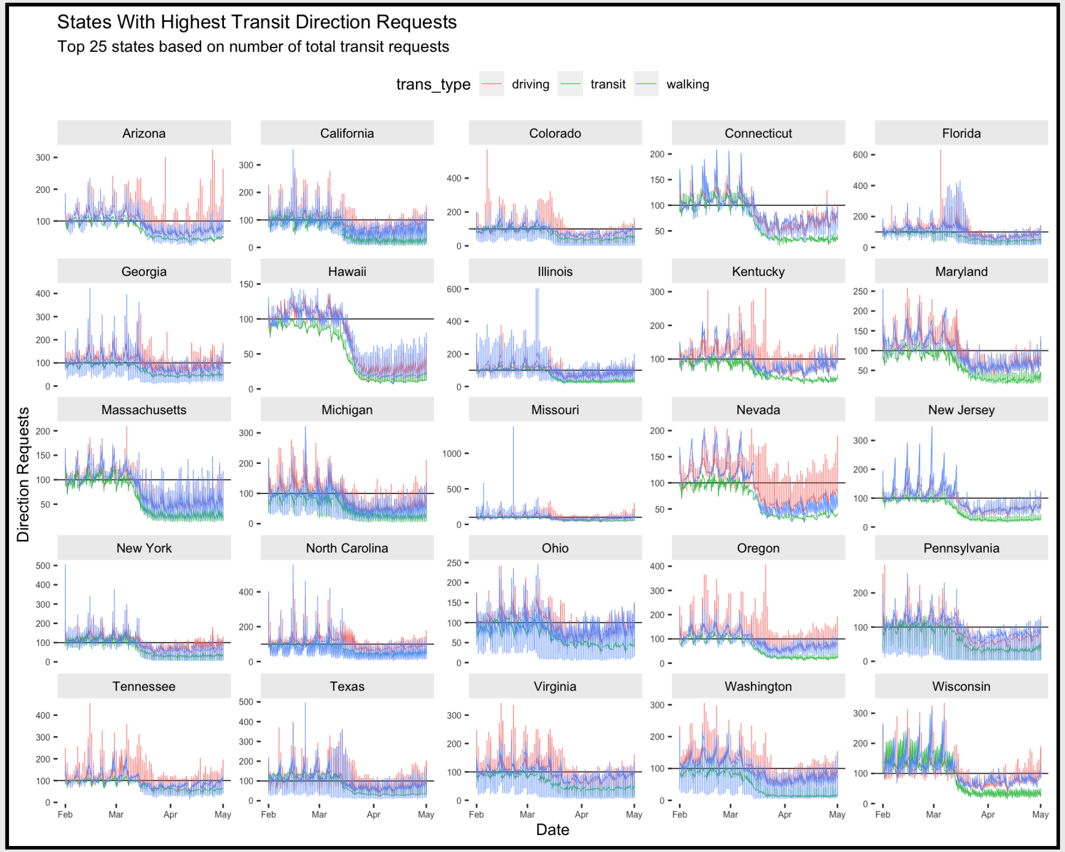
Add the `ncol = 5` to specify the number of columns
(or rows with `nrow =`)

```
TopUSCities %>%
  ggplot(aes(x = date,
             y = dir_request,
             group = region,
             color = trans_type)) +
  geom_line(size = 0.1) +
  geom_hline(yintercept = 100,
             size = 0.2,
             color = "gray20") +
  facet_wrap(region ~ trans_type,
             ncol = 5) +
  lab_ref_lines
```



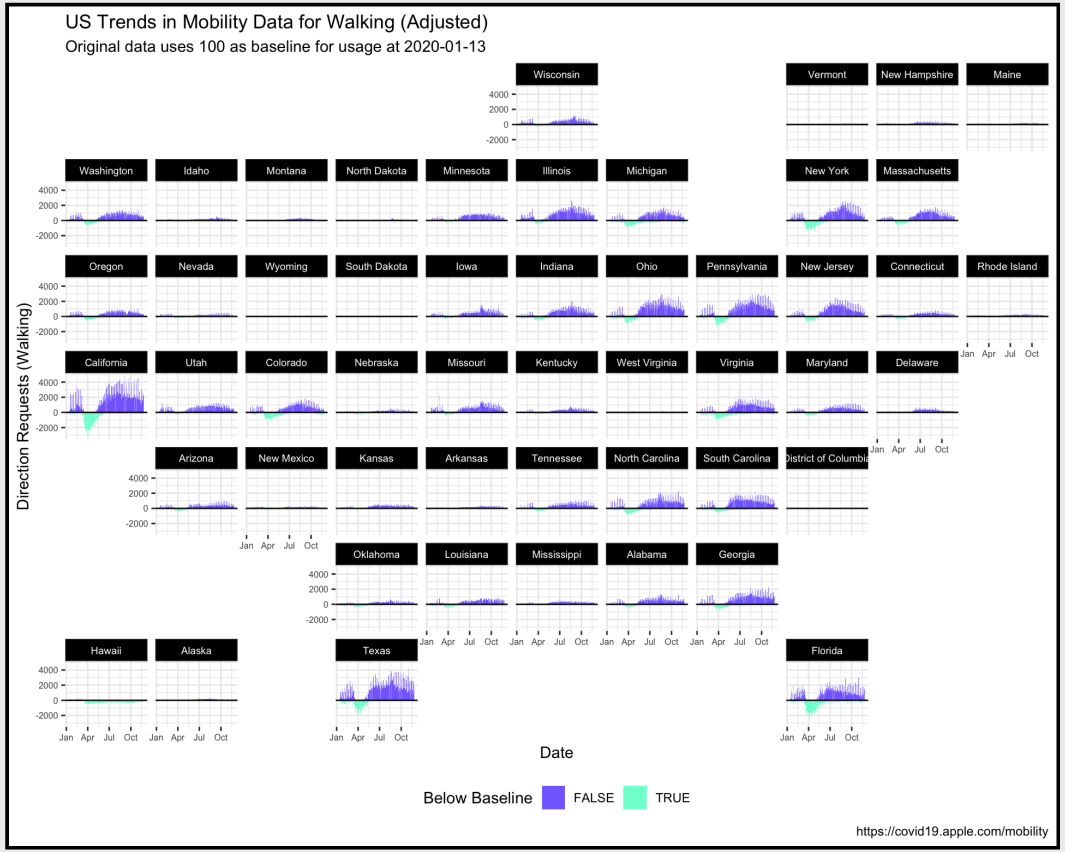
Advanced Faceting (`facet_wrap_paginate`)

Check out the exercises for more advanced faceting with `facet_wrap_paginate()` from the `ggforce` package.



Advanced Faceting (`facet_geo`)

Check out the exercises for more advanced faceting with `facet_geo()` from the `geofacet` package.



US Trends in Mobility Data for Walking (Adjusted)

Original data uses 100 as baseline for usage at 2020-01-13

https://covid19.apple.com/mobility

More Resources

Fundamentals of Data Visualization

ggplot2 extensions gallery

R Graphics Cookbook