Untitled

Theodore Ho

1/17/2022

Data: Trails in San Francisco, CA.

Today's data comes from the Metropolitan Transportation Commission (MTC) Open Data Catalog an Open Data program managed by the MTC and the Association of Bay Area Governments to provide local agencies and the public with their data needs.

In this lab, we will focus on data about the existing and planned segments of the San Francisco Bay trail. The data is located in the *SFO_trails.csv* file located in the *data* folder. Use the code below to read in the .csv file and save it in the RStudio environment as a data frame called `trails`.

```
trails <- read_csv("data/SFO-trails.csv")
```

```
## Rows: 739 Columns: 12
```

```
## -- Column specification --------------------------------------------------------
## Delimiter: ","
## chr (7): county, city, surface, agency, status, year_cmplt, legend
## dbl (5): objectid, class, seg_num, length, SHAPE_Length
```

```
##
## i Use `spec()` to retrieve the full column specification for this data.
## i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

A full list of the variables in the dataset is available here. For today's analysis, we will primarily focus on the following variables:

`status`	Whether the trail is proposed or existing
`class`	Category for the trail segment (4 types)
`length`	Length of the trail segment in miles

Exercises

Write your answers in complete sentences and show all code and output.

Before doing any analysis, we may want to get quick view of the data. This is a useful thing to do after importing data to see if the data imported correctly. One way to do this, is to look at the actual dataset. Type the code below in the **console** to view the entire dataset.

```
View(trails)
```

Exploratory Data Analysis

1. Now that we've had a quick view of the dataset, let's get more details about its structure. Sometimes viewing a summary of the data structure is more useful than viewing the raw data, especially if the dataset has a large number of observations and/or rows. Run the code below to use the `glimpse` function to see a summary of the `trails` dataset.

   How many observations are in the `trails` dataset? How many variables? There are 739 observations and 12 variables.

```
glimpse(trails)
```

```
## Rows: 739
## Columns: 12
## $ objectid     <dbl> 2952, 2953, 2954, 2955, 2956, 2957, 2958, 2959, 2960, 296~
## $ county       <chr> "Marin", "Marin", "Marin", "San Mateo", "San Mateo", "San~
## $ city         <chr> "Novato", "Novato", "San Rafael", "Brisbane", "S San Fran~
## $ surface      <chr> NA, NA, NA, NA, "paved", NA, "paved", NA, NA, NA, NA, NA,~
## $ class        <dbl> 1, 1, 2, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 2, 2, 1, 1, 2, ~
## $ agency       <chr> "Caltrans", "Sonoma-Marin Area Rail Transit", "San Rafael~
## $ status       <chr> "Proposed", "Proposed", "Proposed", "Proposed", "Existing~
## $ seg_num      <dbl> 9002, 9009, 9024, 2001, 2010, 1032, 2047, 2042, 2089, 206~
## $ length       <dbl> 3.20483759, 2.21318493, 1.47142826, 1.24527351, 0.5966338~
## $ year_cmplt   <chr> NA, NA, NA, NA, "2009", NA, NA, NA, NA, NA, NA, NA, "2014~
## $ legend       <chr> "Planned Bay Trail", "Planned Bay Trail", "Planned Bay Tr~
## $ SHAPE_Length <dbl> 0.052688281, 0.034781330, 0.022816134, 0.018364298, 0.009~
```

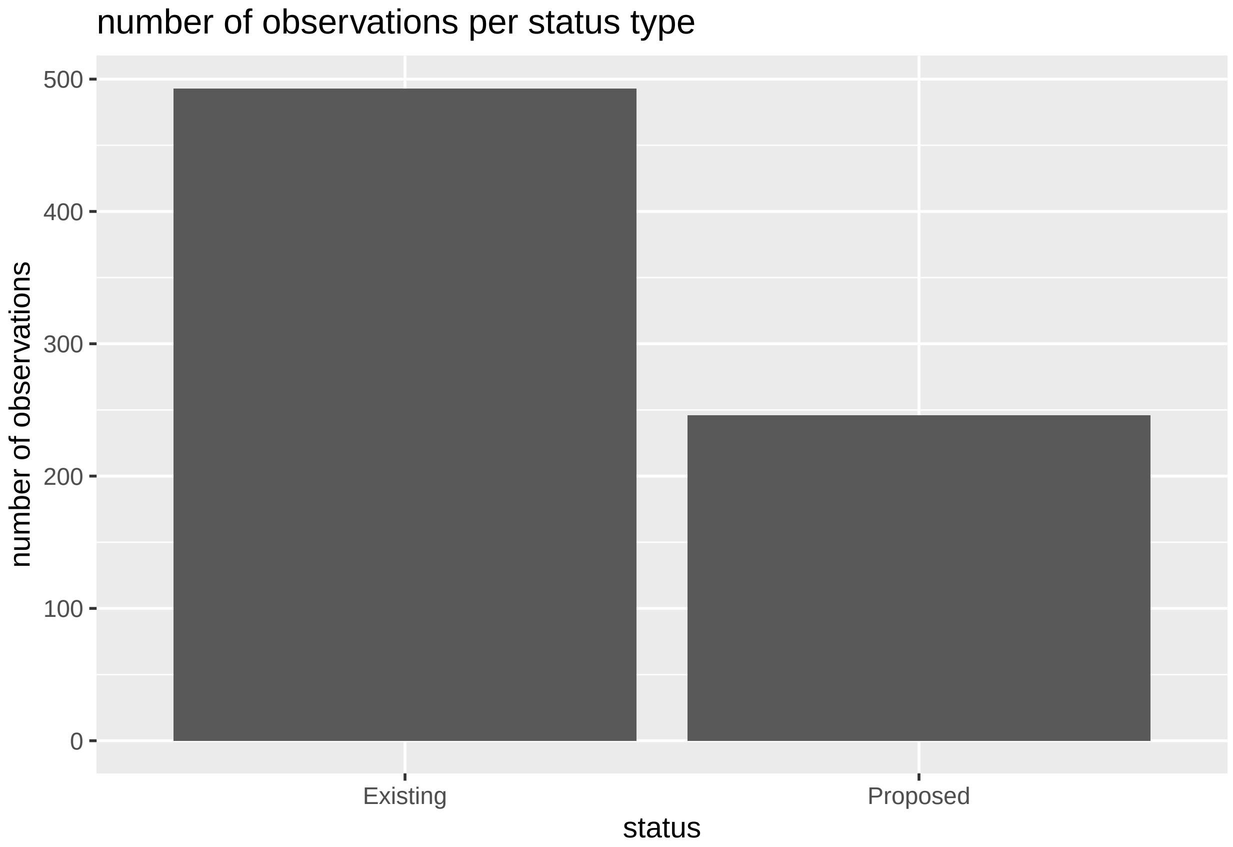
2. Before conducting statistical inference (or eventually fitting regression models), we need do some exploratory data analysis (EDA). Much of EDA consists of visualizing the data but it also includes calculating summary statistics for the variables in our dataset. Let's begin by examining the distribution of `status` with a data visualization and summary statistics.

   - What is a type of graph that's appropriate to visualize the distribution of `status`? Fill in the `ggplot` code below to plot the distribution of `status`. Include informative axis labels and title on the graph.

   The appropiate graph is a bar graph because the status is a categorical value.

   - Then, calculate the proportion of observations in each category of `status` by completing the code below.

```
ggplot(data = trails, aes(x = status)) +
  geom_bar() +
  labs(x = "status",
       y = "number of observations",
       title = "number of observations per status type")
```



```
trails %>%
  count(status) %>%
  mutate(proportion = n / sum(n))
```

```
## # A tibble: 2 x 3
##   status       n proportion
##   <chr>    <int>      <dbl>
## 1 Existing   493      0.667
## 2 Proposed   246      0.333
```

3. Since we want to analyze characteristics for trails in the Bay Area, we will just use data from currently existing trails for the remainder of the analysis. Complete the code below to use the `filter` function to create a subset consisting only of trails that currently exist and have a value reported for `length`. Assign the subset the name `current_trails`. (*Hint: There should be 493 observations in current_trails.*)

```
current_trails <- trails %>%
  filter(status == "Existing", !is.na(length))
```

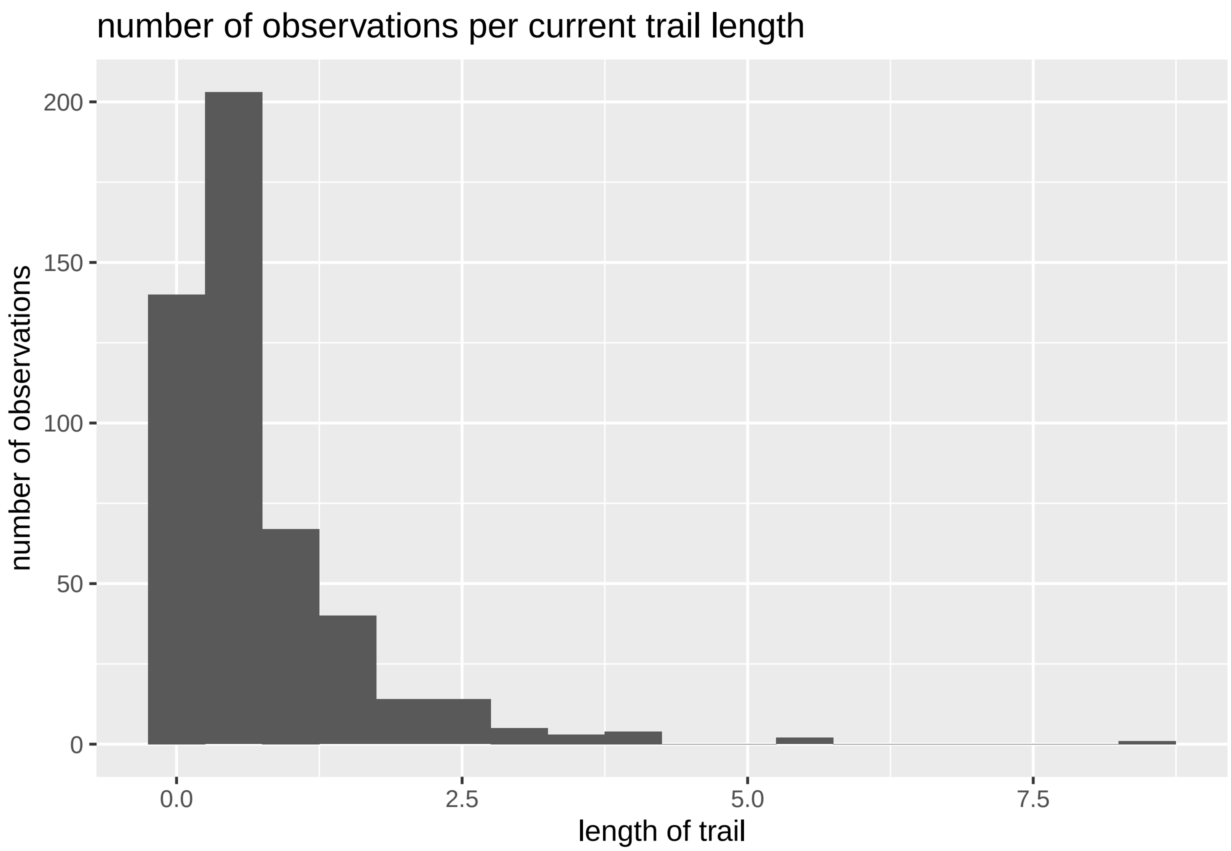
This is a good place to knit, commit, and push changes to your remote lab-01 repo on GitHub. Be sure to write an informative commit message (e.g. "Completed exercises 1 - 3"), and push every file to GitHub by clicking the checkbox next to each file in the Git pane. After you push the changes, the Git pane in RStudio should be empty."

Use `current_trails` for Exercises 4 - 7.

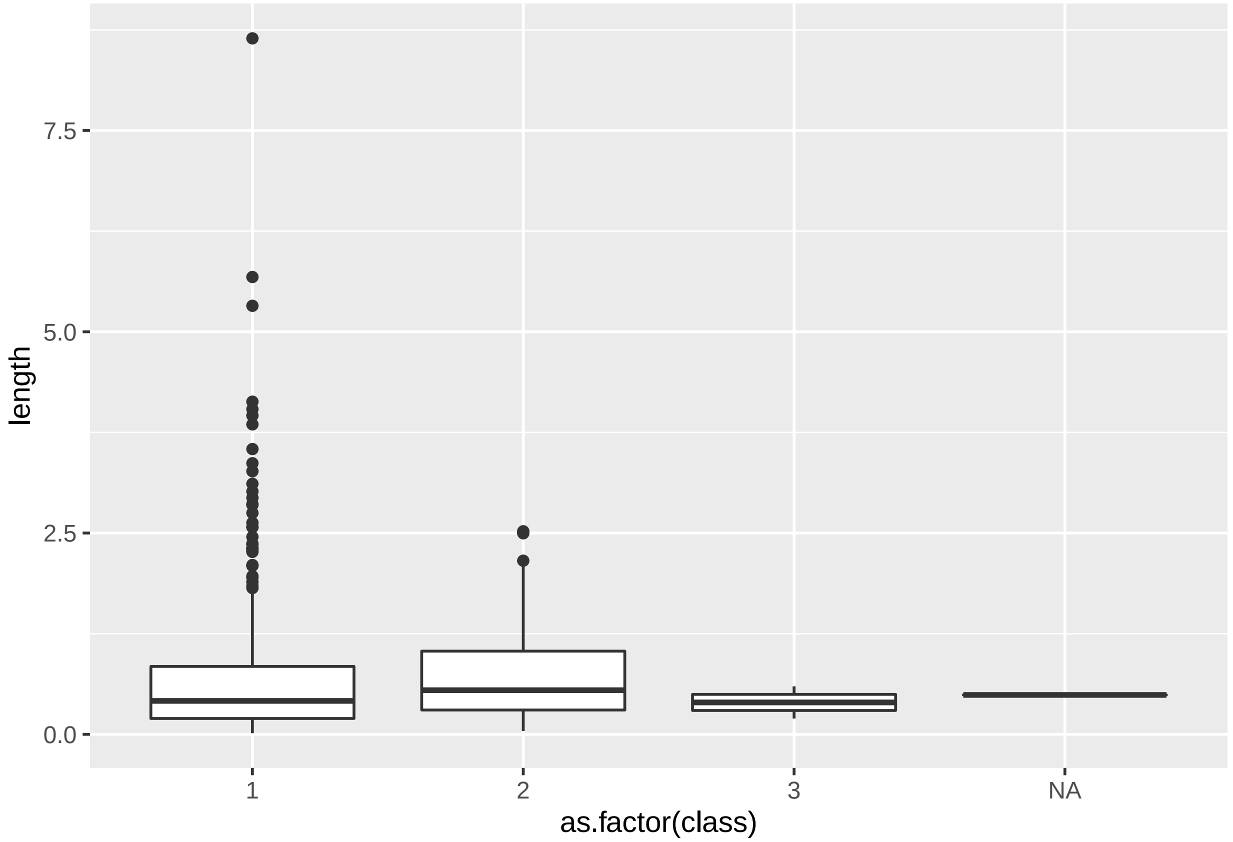
4. Let's examine the distribution of `length`. One important part of EDA is creating data visualizations to see the shape, center, spread, and outliers in a distribution. Data visualizations are also useful for examining the relationship between multiple variables. There are a lot of ways to make data visualizations in R; we will use the functions available in the `ggplot2` package.

   Make a graph to visualize the distribution of `length`. Include an informative title and axis labels.

```
ggplot(data = current_trails) +
  geom_histogram(mapping = aes(x = length), binwidth = 0.5) +
  labs(x = "length of trail",
       y = "number of observations",
       title = "number of observations per current trail length")
```



```
ggplot(data = current_trails, mapping = aes(x = as.factor(class), y = length)) +
  geom_boxplot()
```



See Section 7.3.1 “Visualizing Distributions” or the ggplot2 reference page for details and example code.

5. Next, fill in the code below to use the `summarise` function to calculate various summary statistics for the variable `length`. You can use the summarise reference page for more information about the function and example code.

```
current_trails %>%
  summarise(min = min(length),
            q1 = quantile(length, .25),
            median = median(length),
            q3 = quantile(length, .75),
            max = max(length),
            iqr = IQR(length),
            mean = mean(length),
            std_dev = sd(length)
            )
```

```
## # A tibble: 1 x 8
##      min    q1 median    q3   max   iqr  mean std_dev
##    <dbl> <dbl>  <dbl> <dbl> <dbl> <dbl> <dbl>   <dbl>
## 1 0.0148 0.209  0.448 0.936  8.64 0.727 0.724   0.852
```

6. Describe the distribution of `length`. Your description should include comments about the shape, center, spread, and any potential outliers. Use the graph from Exercise 4 and relevant summary statistics from Exercise 5 in your description.

The distribution of length seems to roughly follow the shape of a long tail distribution. The lengths have a center of about .72 and 50% of the observations have a length between .209 and .9357. However, there are a few outliers with length greater than 5. The spread can be quantified with a standard deviation of .85.

7. We want to limit the analysis to trails that are more likely intended for day hikes, rather than multi-day hikes and camping. Therefore, let's remove the extreme outliers from the data for this analysis and only consider those trails that are 5 miles or shorter.

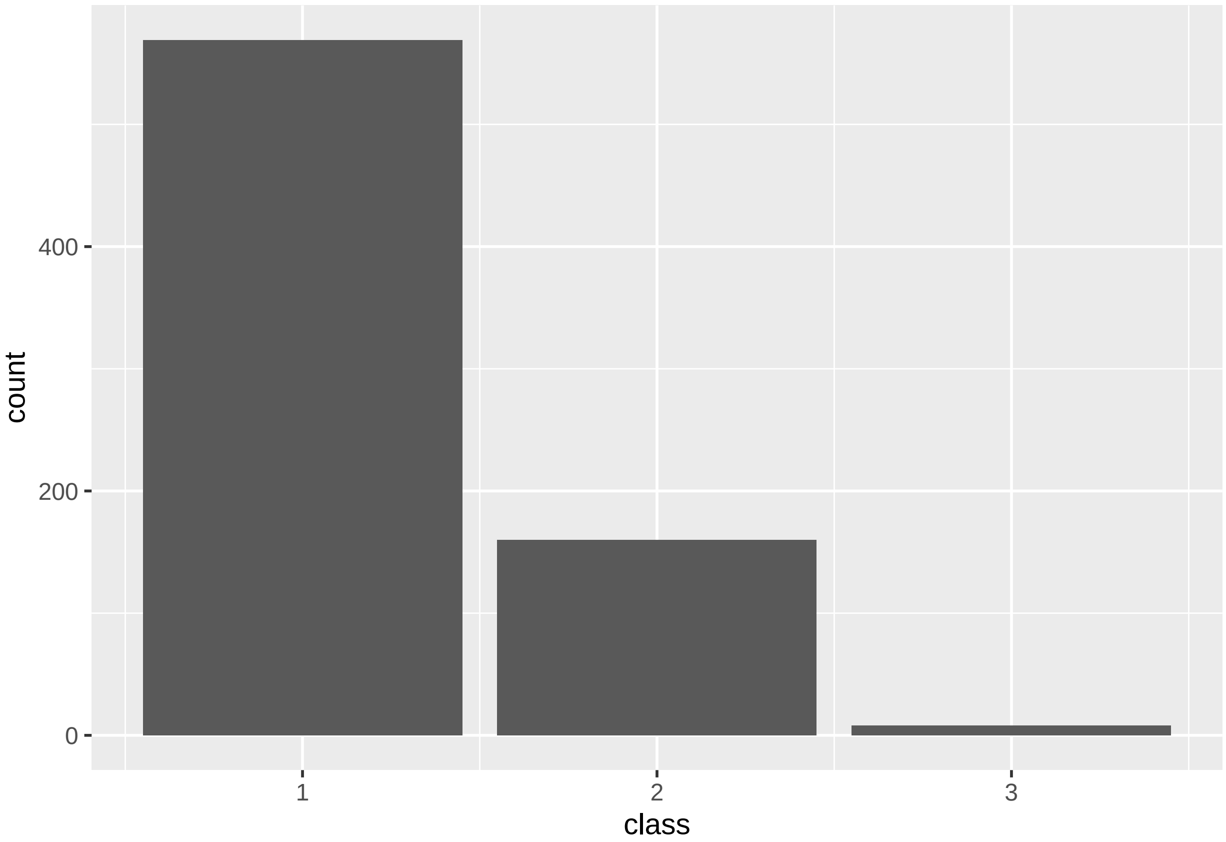
```
c_trails2 <- current_trails %>% filter(length < 5)
```

```
Filter the dataset to remove the extreme outliers. **Be sure to save the updated dataset, so you can us
```

This is a good place to knit, commit, and push changes to your remote lab-01 repo on GitHub. Be sure to write informative commit message (e.g. "Completed exercises 4 - 7"), and push every file to GitHub by clicking the checkbox next to each file in the Git pane. After you push the changes, the Git pane in RStudio should be empty."

```
ggplot(data = trails , aes(x = class))+
  geom_bar()
```

```
## Warning: Removed 2 rows containing non-finite values (stat_count).
```



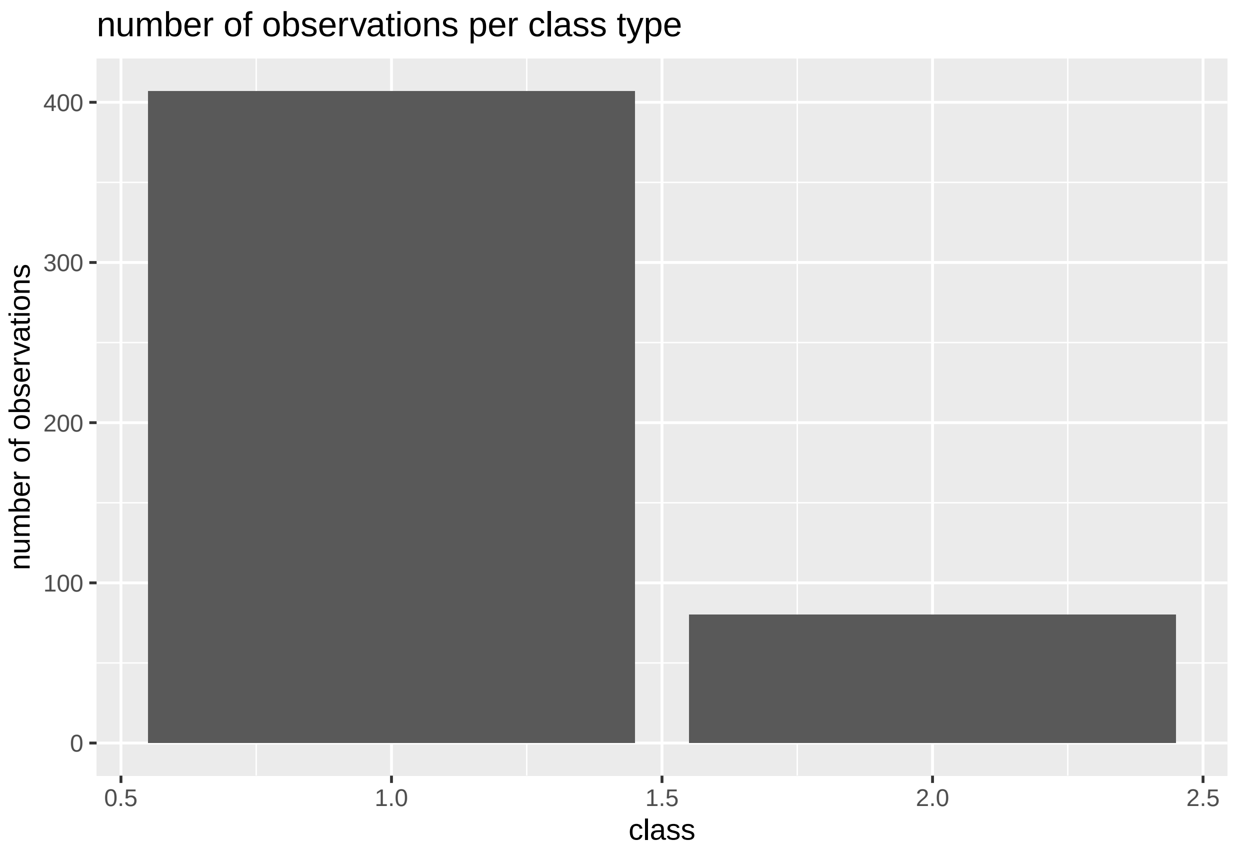
8. Consider the distribution of `class`.

- What are the values of `class` in the dataset? Show the code and output to support your answer. Based on the bar chart above, and the console warning that observations were removed due to non-finite values, a class can be a 1, 2, 3 or missing/na.
- What do you think is the most likely reason for the missing observations of `class`? In other words, what does a missing value of `class` indicate? A missing value of class could indicate that the trail has no type of use defined. That is, the trail does not say if it is for bikers, pedestrians, or bikers and pedestrians.

9. Complete the code below to impute (i.e. fill in) the missing values of `class` with the appropriate value. After that, eliminate all the observations from class = 3, since we are not going to use the. Then, display the distribution of `class` to check that the missing values were correctly imputed.

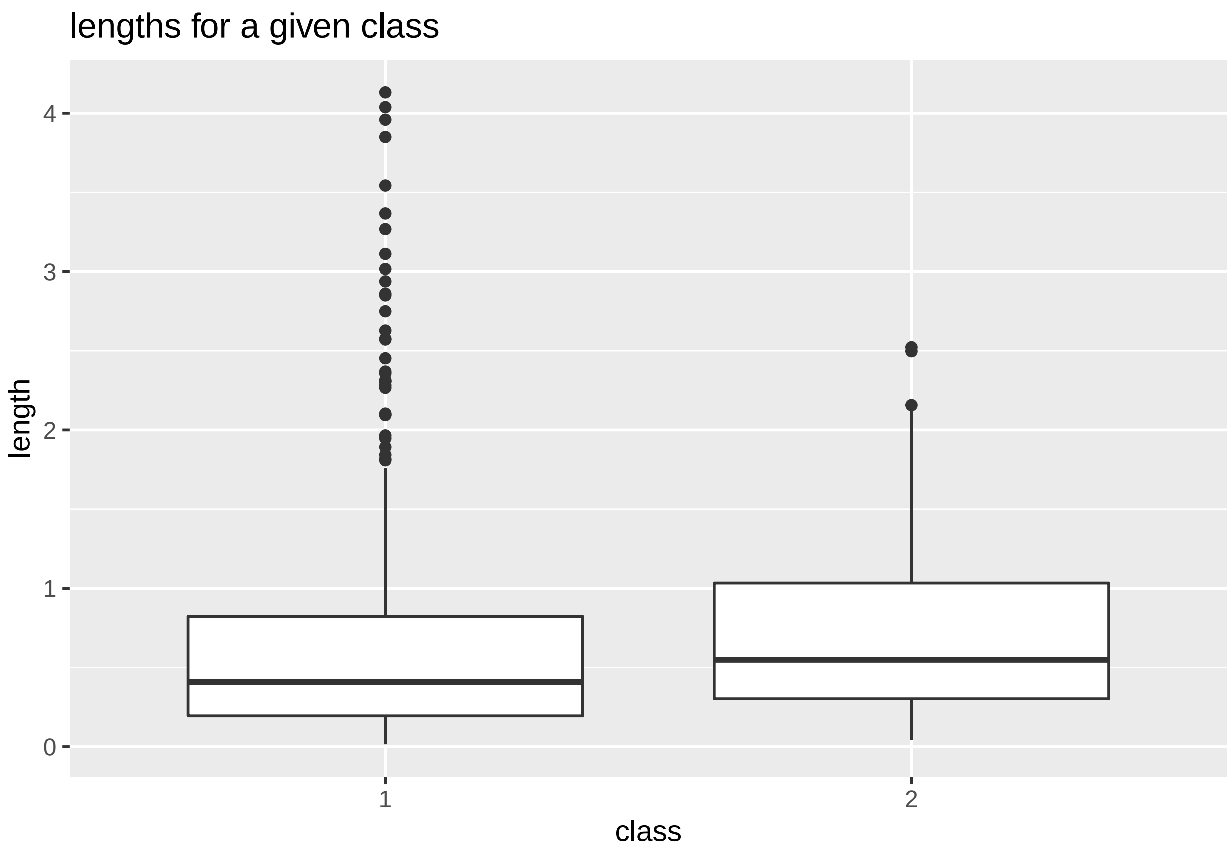
```
class_trails <- c_trails2 %>% filter(class != 3) %>%
  mutate(class = if_else(is.na(class),0,class))

ggplot(data = class_trails, aes(x = class)) +
  geom_bar() +
  labs(x = "class",
       y = "number of observations",
       title = "number of observations per class type")
```



10. Now that we've completed the univariate EDA (i.e. examining one variable at a time), let's examine the relationship between the length of the trail and its class variable. Make a graph to visualize the relationship between `length` and `class` and calculate the appropriate summary statistics. Include informative axis labels and title on your graph.

```
ggplot(data = class_trails, mapping = aes(x = as.factor(class), y = length)) +
 geom_boxplot() +
  labs(x = "class",
       y = "length",
       title = "lengths for a given class")
```



11. Describe the relationship between `length` and `class`. In other words, describe how the distribution of `length` compares between trails that have different classes (1 = shared use bicycle and pedestrian path, 2 = bike lane, and 3 = bike route). Include information from the graph and summary statistics from the previous exercise in your response.

It appears from this graph that the average length of a bike lane in the sample is slightly higher than the average length for a shared use path. However, the difference in average seems to be very small and possibly insignificant.

This is a good place to knit, commit, and push changes to your remote lab-01 repo on GitHub. Be sure to write informative commit message (e.g. "Completed exercises 8 - 11"), and push every file to GitHub by clicking the checkbox next to each file in the Git pane. After you push the changes, the Git pane in RStudio should be empty."

Statistical Inference

We'd like to use the data from the trails in SFO to make more general conclusions about trails in urban areas in California, United States. We will reasonably consider the trails in SFO representative of the trails in other urban areas in the West Coast of United States.

Over the next few questions, will use statistical inference to assess whether there is a difference in the mean length of trails that share use bicycle and pedestrian path (class = 1) and those that only have a bike line (class = 2).

12. The following conditions must be met when we conduct statistical inference on the difference in means between two groups. For each condition, specify whether it is met and a brief explanation of your reasoning.

    - **Independence**
    - **Sample Size**
    - **Independent Groups**

Independence: If we are using this sample to conduct inference on all trails in urban areas in California, then we cannot guarantee independence because this is not a random sample. This sample is not a random sample because it only contains trails in SFO. If we wanted this to be a random sample then we would have to randomly sample from the population of all urban areas in California, not just one city. However, the instructions say we should assume this sample is representative of the population. Therefor it is a random sample.

I would imagine this sample is less than 10% of the population because it would be unlikely to have less than a few thousand trails in all of California urban areas.

Sample size: The sample size is greater than 30 so it is considered a large enough sample.

Independent Groups: The groups are independent from one another. That is, the class value of one group does not affect the class value of another.

13. While we have observed a small difference in the mean length in trails with bike lanes (class = 2) and trials that share bikes with pedestrians (class = 1), let's assess if there is enough evidence to consider the difference "statistically significant" or if it appears to be due to random chance.

The null and alternative hypotheses are written in statistical notation below. State the hypotheses in words in the context of this analysis.

$$H_0 : \mu_1 - \mu_2 = 0 H_a : \mu_1 - \mu_2 \neq 0$$

The null hypothesis is that there is no difference in the means of lengths between the two groups. In other words, the class value does not affect the length of a trail.

The hypothesis is that there is a difference in the means of the lengths between the two groups. In other words, the class value affects the length of a trail.

14. Fill in the code below to use the `t.test` function to calculate the test statistic and p-value. Replace `response` with the variable we're interested in drawing conclusions about and `group_var` with the variable used to define the two groups.

```
#?t.test # to see the help page from the function
t.test(length ~ class, data = class_trails,
       alternative = "two.sided",
       conf.level = 0.99) #less, greater, or two.sided
```

```
##
##  Welch Two Sample t-test
##
```

```
## data:  length by class
## t = -0.69986, df = 137.16, p-value = 0.4852
## alternative hypothesis: true difference in means between group 1 and group 2 is not equal to 0
## 99 percent confidence interval:
##  -0.2434412  0.1405578
## sample estimates:
## mean in group 1 mean in group 2
##       0.6819343       0.7333760
```

15. Use the output from the previous exercise to answer the following:

    - Write the definition of the test statistic in the context of this analysis.

    The definition of the test statistic is the difference in observed means minus the null hypothesized difference (or 0) divided by the standard error. The test statistic follows a T distribution.

- Write the definition of the p-value in the context of this analysis.

```
Given the test stastic T distribution, the p value is the probability of observing the observed
test statistic or a more extreme test statistic, given the null hypothesis is true.
In other words, the p value states the probability of observing the observed difference in
means or a more extreme difference, given the null hypothesis is true

- State your conclusion in the context of this analysis. Use a significance level of $\alpha = 0.01$.

If the significance value is .01, then I conclude there is no
significant evidence to suggest the hypothesis is true because the
p value is much higher than the significance value.
```

16. Notice the confidence interval for the difference in mean trail length printed in the output from Exercise 14. Interpret this confidence interval in the context of this analysis.

We are 99% confident the population mean length of class 1, minus the population mean length of class 2 is between (-.24344, .14055)

You're done and ready to submit your work! Knit, commit, and push all remaining changes. You can use the commit message "Done with Lab 1!", and make sure you have pushed all the files to GitHub (your Git pane in RStudio should be empty) and thatall documents are updated in your repo on GitHub. Then submit the pdf for your assignment on Gradescope. Include your repo name, so I can check your commits.

repo: https://github.com/theoho8033/lab0-1