STAT 630: Homework 3

Due: September 22nd, 2022

Self-assessment:

For my first attempt, generally, my results are similar to the solution except the question 8 because I followed the previous question. For Question 11, I forgot to factor "month". I think it should be coded for plotting the graph and I revised it. Although my plots for Question 9 and 11 are different from the solution, I think they are another way to solve these questions.

I think my results should be E.

Concept Questions

The following questions relate to the `nycflights` dataset found in the `openintro` package. *Note, you may have to coerce some of the columns to factors before your start.*

Find more information on the dataset here

```
library(openintro)
library(dplyr)
library(ggplot2)
data("nycflights")
?nycflights # Description of the dataset (comment out before knitting)
```

For as many questions as you can, practice using inline R code to display your answers. For example:

The number of flights in the dataset is $n = 32735$.

I will put a * next to questions you might want to try this with.

1. Pick an airline carrier (see link above for carrier codes) and a month of the year (1-12). Input your choices into the code below. The R chunk will create a histogram of `arr_delay` (arrival delay in minutes) for the airline and month you chose. Then, using `stat_function` ggplot2 will overlay a true normal distribution with the mean and standard deviation of `arr_delay` for your carrier/month.

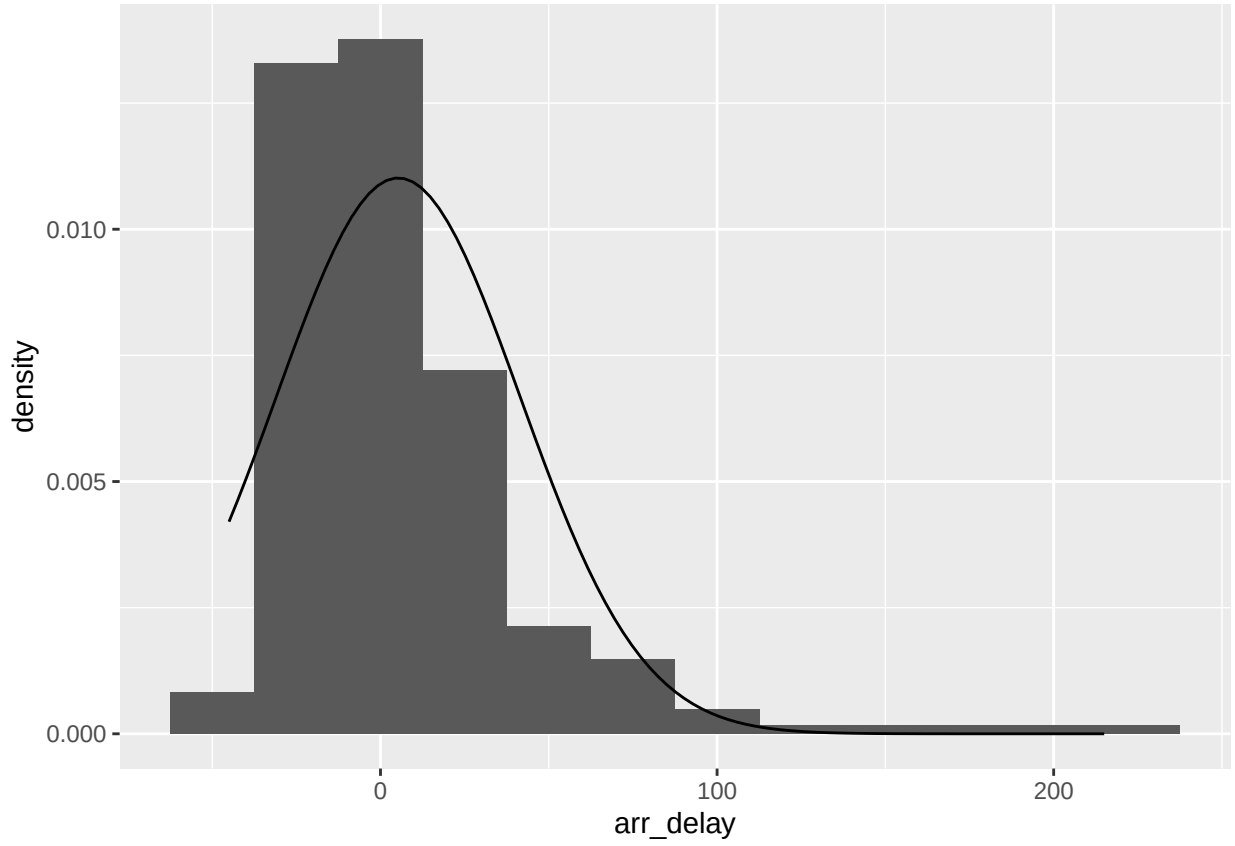
```
# Subset the data according to your chosen/carrier/month
my_flights <- nycflights %>%
  filter(carrier == "AA", month == 12)

# Calculate mean/sd of arr_delay
arr_delay_stats <- my_flights %>%
  summarise(x_bar = mean(arr_delay),
            s = sd(arr_delay))

# Plot histogram of arr_delay, overlaying true normal curve
my_flights %>%
  ggplot(aes(arr_delay)) +
  geom_histogram(aes(y = ..density..),
                 binwidth = 25) + # relative frequency
  stat_function(fun = dnorm, # overlay a stat function (a normal dist)
```

```
                args = list(mean = arr_delay_stats$x_bar, # let mu = x_bar
                            sd = arr_delay_stats$s)) # let sigma = s
```

```
## Warning: The dot-dot notation (`..density..`) was deprecated in ggplot2 3.4.0.
## i Please use `after_stat(density)` instead.
## This warning is displayed once every 8 hours.
## Call `lifecycle::last_lifecycle_warnings()` to see where this warning was
## generated.
```



2. Comment on the normality of `arr_delay` compared to the true normal curve.

The normality of arr_delay is not a normal distribution. This is a **right-skewed distribution**.

For questions 3 & 4, assume the distribution of `arr_delay` for your chosen carrier "AA" and month "12" is normally distributed with the mean and standard deviation found in Question 1.

3. *Using R functions, find the probability that the flight on [AA] during [12] was early.

The probability that the flight on [AA] during [12] was early means that the arr_delay < 0

Firstly, we calculate the z-score when the observed value = 0: -0.145

Then, we calculate the probability that the flight on [AA] during [12] was early P(X<0) = 0.449

```
my_flights <- nycflights %>%
  filter(carrier == "AA", month == 12)
z_0 = (0 - arr_delay_stats$x_bar)/arr_delay_stats$s
pnorm(z_0)
```

```
## [1] 0.442184
```

```r
#Also, in other way, we can calculate as below to have the same result.

pnorm(0, arr_delay_stats$x_bar, arr_delay_stats$s)
```

```
## [1] 0.442184
```

4. *Using R functions, calculate the probability that a randomly selected flight on [AA] in [12] is between 30 to 60 minutes late.

So, the probability that a randomly selected flight on [AA] in [12] is between 30 to 60 minutes late.

$P(30 \leq X \leq 60) = P(X \leq 60) - P(X \leq 30) = pnorm(z\_60) - pnorm(z\_30) = 0.17$

```r
pnorm(60, arr_delay_stats$x_bar, arr_delay_stats$s) - pnorm(30, arr_delay_stats$x_bar, arr_delay_stats$s
```

```
## [1] 0.1819626
```

5. *Use`quantile()` to calculate the actual 95th percentile (0.95 quantile) from the `arr_delay` data on [AA] in [12]. Interpret this value in the context of the problem.

The actual 95th percentile (0.95 quantile) from the `arr_delay` data on [AA] in [12]: 67.7. It means that 95% of the random selected flights of AA in December was not late than 67.7 minutes.

```r
quantile(my_flights$arr_delay, 0.95)
```

```
##  95%
## 67.7
```

6. *Now, use `qnorm()` to find the top 5% according to the *true* normal distribution with the same mean and standard deviation as you found in Question 1. Then, explain how this compares to your answer in question 5? Why are they different or the same?

The top 5% according to the *true* normal distribution with the same mean and standard deviation: **96.4**

This result is different from than that of question 5.

I think the actual 95th percentile is specific to the dataset and reflects the position of a value within your actual data. While **qnorm(0.05, mean, sd, lower.tail = FALSE)** provides a value based on a theoretical normal distribution, representing the point above which 5% of the data would fall in a normal distribution. These two values may or may not be the same, depending on the nature of your data and how well it approximates a normal distribution. So, for this case, which is not a normal distribution we should apply to use **quantile()** to calculate the actual 95th percentile (0.95 quantile).

```r
qnorm(0.05, arr_delay_stats$x_bar, arr_delay_stats$s,  lower.tail = FALSE)
```

```
## [1] 64.82905
```

```r
#Also, in other way, we can calculate as below to have the same result.
qnorm(0.95, arr_delay_stats$x_bar, arr_delay_stats$s)
```

```
## [1] 64.82905
```

Exploratory Data Analysis

Research Question: Do flights that are longer in distance have more arrival delays? *Note: for the remaining questions, please use the full dataset `nycflights`.

7. What is the response variable and what is the predictor of interest? Specify the type of each variable: quantitative (discrete or continuous) or categorical (ordinal or nominal).

Response Variables:

Arrival Delay: This is likely to be a continuous quantitative variable, representing the amount of delay in minutes. It's a measure of how late or early a flight arrives.

Departure Delay: Similar to arrival delay, this is likely a continuous quantitative variable representing the amount of delay in minutes at departure.

Predictor Variables:

Month: This is a categorical ordinal variable, as it represents different months of the year. Although represented as numbers (1 for January, 2 for February, etc.), it's not a continuous variable because there is no inherent "distance" between the months.

Distance: The distance the flight covers. This is a continuous quantitative variable, typically measured in miles.

8. What are two potential confounding variables that could influence the relationship between distance and arrival delays. At least one should be from the dataset. Cite any sources used. Explain how the variable could be associated with the predictor of interest *and* the response.

These two variables, weather conditions and month, can potentially confound the relationship between distance and arrival delays of the flights. They are associated with both the predictor (distance) and the response (arrival delay).

Weather Conditions: Weather conditions and arrival airports can significantly impact flight delays. Adverse weather such as thunderstorms, fog, or snow can lead to arrival delays. Poor visibility or strong winds can affect the efficiency of take-offs and landings, potentially leading to longer delays. Additionally, weather conditions along the flight path can also influence the overall travel time. In addition, every season has different weather conditions. For example, in winter, from November to February, it is snowy in somewhere, so it is possible to handle arrival and departure delay at airports. For such weather conditions, there might lead to diversions or changes in planned routes, which can affect the actual distance traveled.

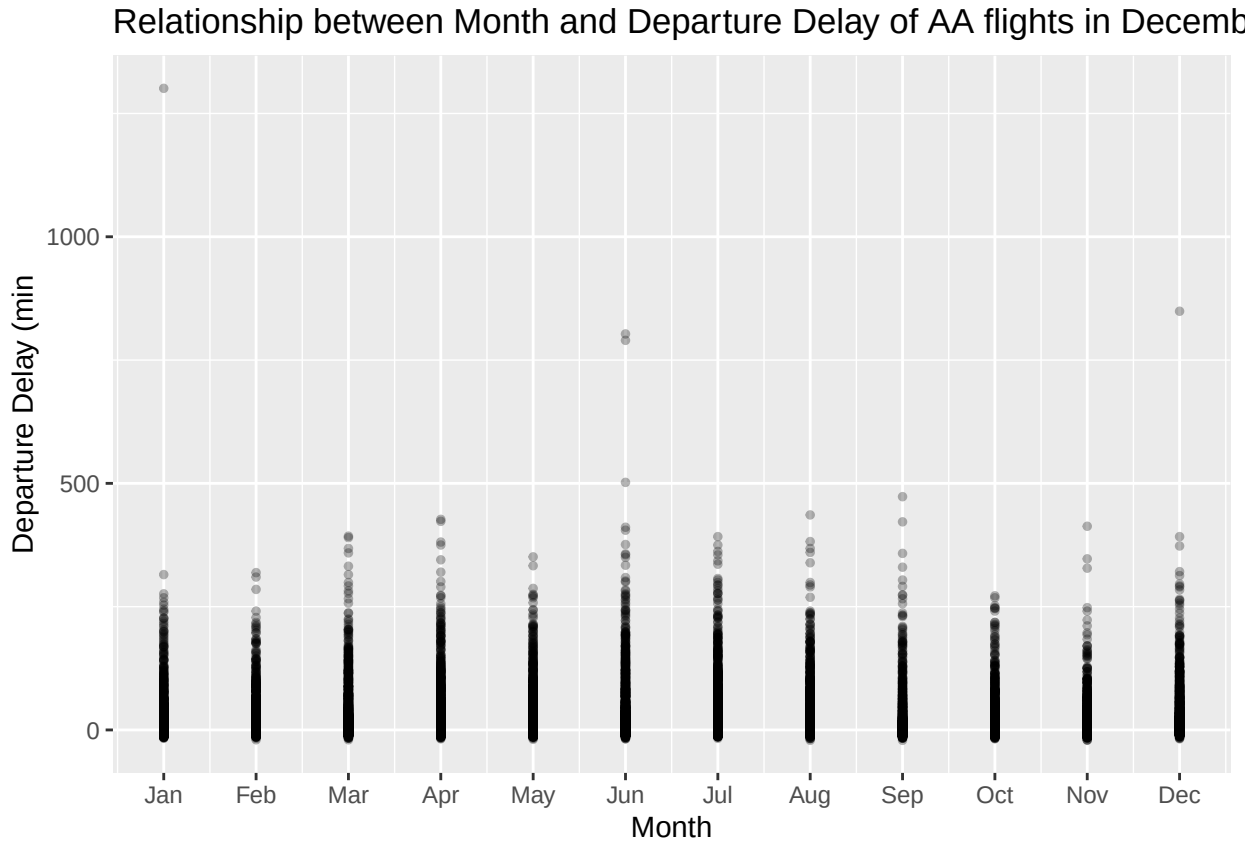
Month: Certain months may have higher or lower average arrival delays. For example, winter months might experience more weather-related delays due to snow and ice. Besides, the month might also have an impact on flight distance. For instance, during holiday seasons, there might be more long-haul flights.

9. Make a well-labeled plot (using your choice of R package), to display the relationship between the predictor of interest and the response. "

We well-labeled plot (using your choice of R package), to display the relationship between the predictor of interest (month) and the response (departure delay).

```
month_names <- c("Jan", "Feb", "Mar", "Apr", "May", "Jun",
                 "Jul", "Aug", "Sep", "Oct", "Nov", "Dec")


ggplot(nycflights, aes(x = month, y = dep_delay)) +
  geom_point(alpha = 0.3, size = 1) +
  labs(title = "Relationship between Month and Departure Delay of AA flights in December 2013",
       x = "Month",
       y = "Departure Delay (min") +
  scale_x_continuous(breaks = 1:12, labels = month_names)
```

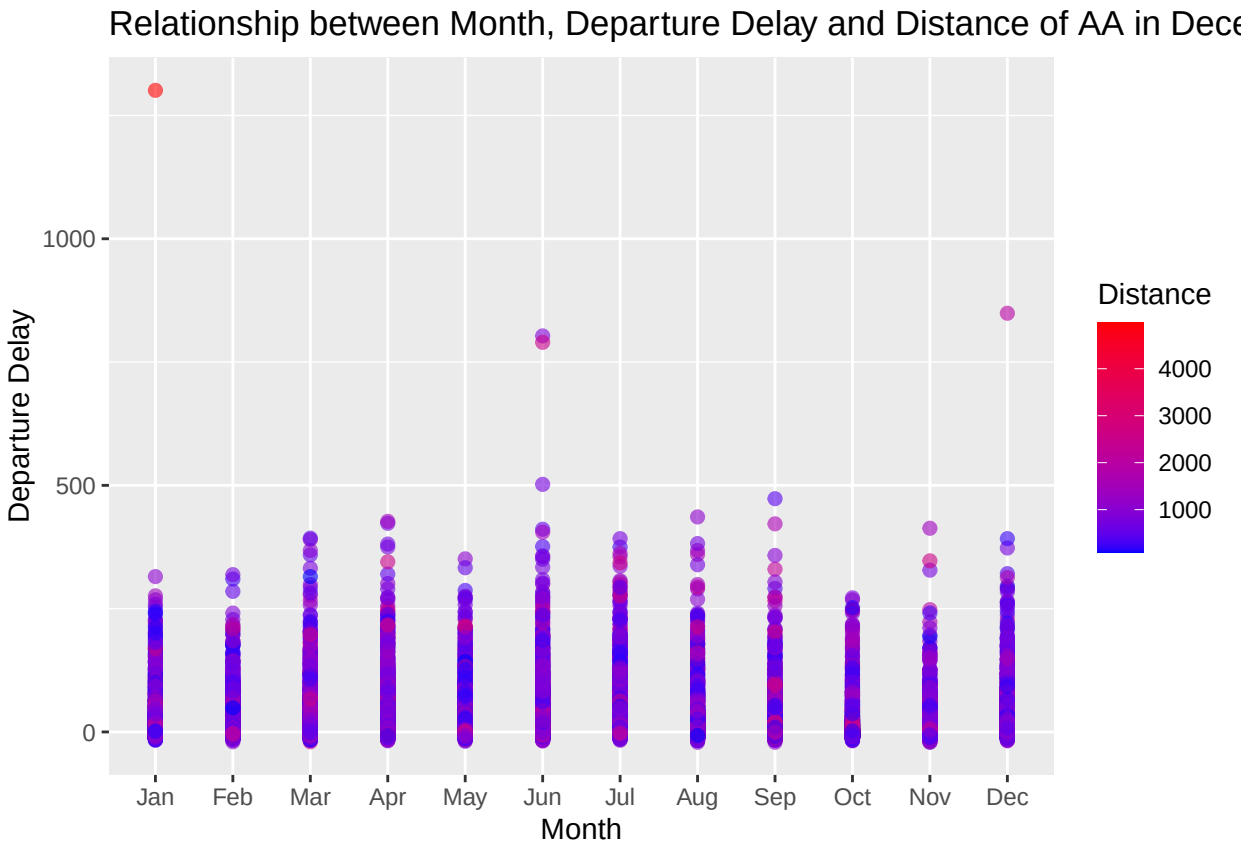


10. What do you notice about the relationship?

in general, there is not a strong relationship between arrival delay and months. The arrival delay time is quite similar to each other among 12 months in 2013. As we can see on the point plot, the departure delay for 12 months in 2013 was around from 1 to 250 minutes. However, in June and December are the months we can see the longer arrival delay time in the year compared to the others. In Jun, the departure delay situation tended to be longer. There were some flights whose delay time was up to more than 750 minutes. In addition, December was also the time when it had long departure delay flights.

11. Adjust the plot you made in Question 9 (use a new aesthetic) to also include one of the confounding variables you mentioned in Question 8. Comment on any patterns.

```
nycflights %>%
  mutate(month = factor(month)) %>%  #I forgot to include this code to factor month column
  ggplot(aes(x = month, y = dep_delay, color = distance)) +
  geom_point(size = 2, alpha = 0.6) +
  labs(title = "Relationship between Month, Departure Delay and Distance of AA in December 2013",
       x = "Month",
       y = "Departure Delay",
       col = "Distance") +
  scale_x_discrete(breaks = 1:12, labels = month_names) +
  scale_color_gradient(low = "blue", high = "red")
```


Relationship between Month, Departure Delay and Distance of AA in Dece
Departure Delay
1000
500
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Distance
4000
3000
2000
1000