Continuous Data (2 of 6)

Aug 4, 2023.

Exploring Univariate Continuous Data using `ggplot2`

THIS CHAPTER demonstrates the use of the popular **`ggplot2`** package to further explore *univariate, continuous* data.

1. In R, we can create these plots for Visualizing Univariate Continuous Data using the `ggplot2` package. For instance, the function `geom_boxplot()` produces box plots, `geom_violin()` creates violin plots, and `geom_histogram()` and `geom_density()` generate histograms and density plots, respectively. The `ggbeeswarm` package can be used for creating bee swarm plots with the `geom_beeswarm()` function. We will go into more detail about how to use these functions and interpret these plots in the upcoming sections.
2. **Data**: Let us work with the same `mtcars` data from the previous chapter. Suppose we run the following code to prepare the data for subsequent analysis. The data is now in a tibble called `tb`:

```
# Load the required libraries, suppressing annoying startup messages
library(tibble)
suppressPackageStartupMessages(library(dplyr))
# Read the mtcars dataset into a tibble called tb
data(mtcars)
tb <- as_tibble(mtcars)
attach(tb)
# Convert several numeric columns into factor variables
tb$cyl <- as.factor(tb$cyl)
tb$vs <- as.factor(tb$vs)
tb$am <- as.factor(tb$am)
tb$gear <- as.factor(tb$gear)
```

3. Let us load the `ggplot2`, `dplyr` and `ggthemes` packages. The package `ggthemes` allows us to use a variety of themes.

```
library(dplyr)
library(ggthemes)
library(ggplot2)
```

```
Attaching package: 'ggplot2'
```

```
The following object is masked from 'tb':

    mpg
```

4. Let's take a closer look at some of the most effective ways of Visualizing Univariate Continuous Data using `ggplot2` and related packages, including

   Histograms using `ggplot2`;

   PDF and CDF Density plots using `ggplot2`;

   Box plots using `ggplot2`;

   Bee Swarm plots using `ggbeeswarm`;

   Violin plots using `ggplot2`;

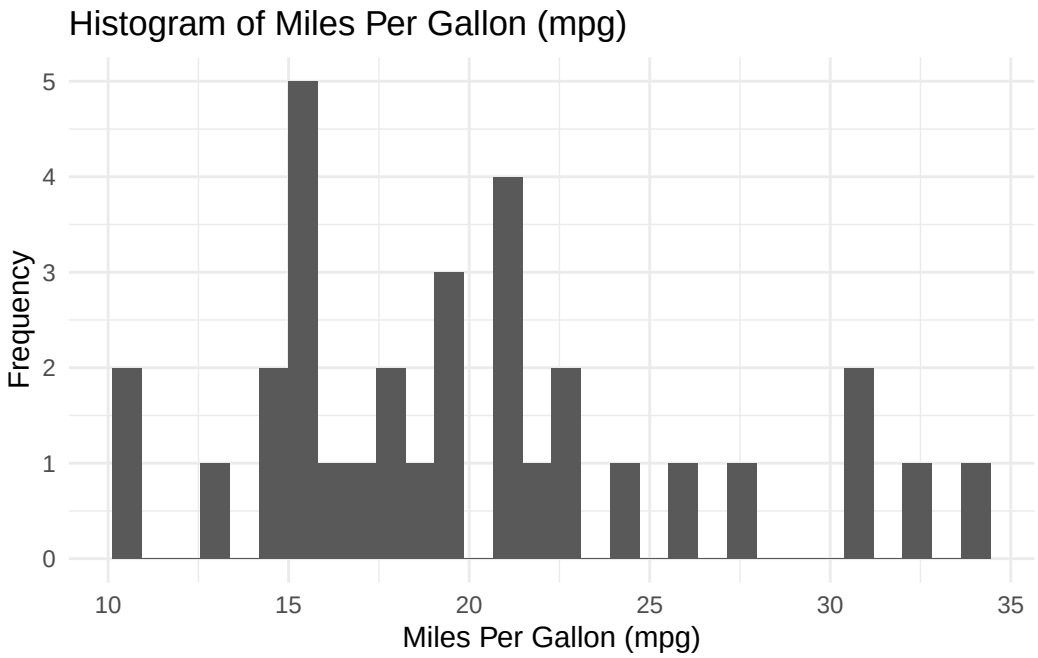
   Q-Q plots. Note that it is inconvenient to create Stem-and-Leaf plots using ggplot2 and hence we ignore this.

Histogram using `ggplot2`

1. The following code creates a histogram using the `ggplot2` package:

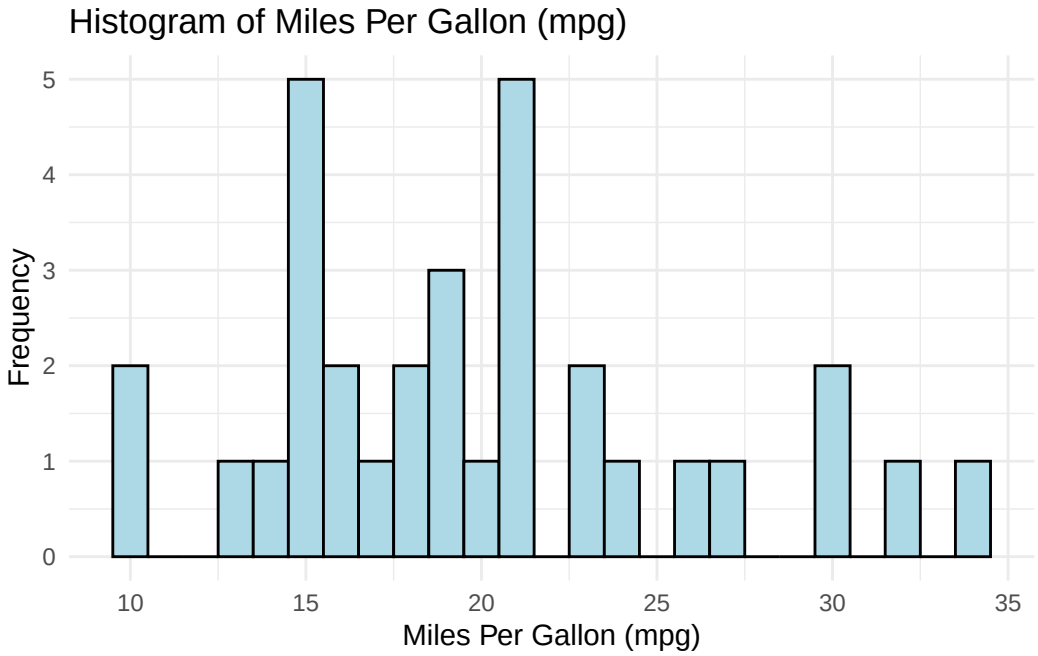
```
ggplot(tb,
       aes(x = mpg)) +
  geom_histogram() +
  theme_minimal() +
  labs(title = "Histogram of Miles Per Gallon (mpg)", x = "Miles Per Gallon (mpg)", y = "F
```

```
`stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



2. We can personalize the appearance of the histogram, as follows:

```
ggplot(tb,
       aes(x = mpg)) +
  geom_histogram(binwidth = 1,
                 fill = "lightblue",
                 color = "black") +
  theme_minimal() +
  labs(title = "Histogram of Miles Per Gallon (mpg)", x = "Miles Per Gallon (mpg)", y = "F
```



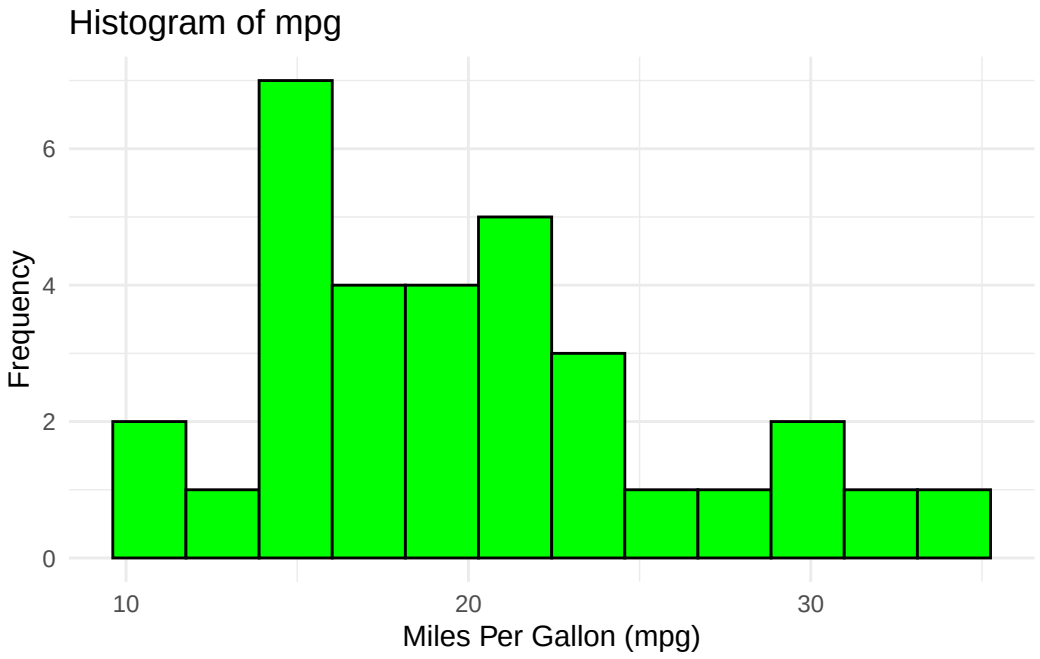
3. Discussion:

- First, we specify our data set and the aesthetic mappings with the `ggplot()` function. The x aesthetic, which stands for the variable that we are binning (`mpg`), is needed for a histogram.
- Next, we use the `geom_histogram()` function to draw the histogram. The `binwidth` argument specifies the width of the bins in the histogram, and we have chosen `1` as an arbitrary width. The `fill` color of the bars and border are set to lightblue and black respectively.
- We apply a minimalist theme to our plot with `theme_minimal()`, giving it a clean and polished look.
- Lastly, the `labs()` function allows us to add a title to our plot and labels for our x and y axes. [1]

4. We can set the number of bins in the histogram using the `bins` argument within the `geom_histogram()` function instead of `binwidth`. For example, in order to create a histogram with 12 bins of equal width, we can modify the code as follows:

```
ggplot(tb,
       aes(x = mpg)) +
  geom_histogram(bins = 12,
                 fill = "green",
```

```
                color = "black") +
  theme_minimal() +
  labs(title = "Histogram of mpg", x = "Miles Per Gallon (mpg)", y = "Frequency")
```

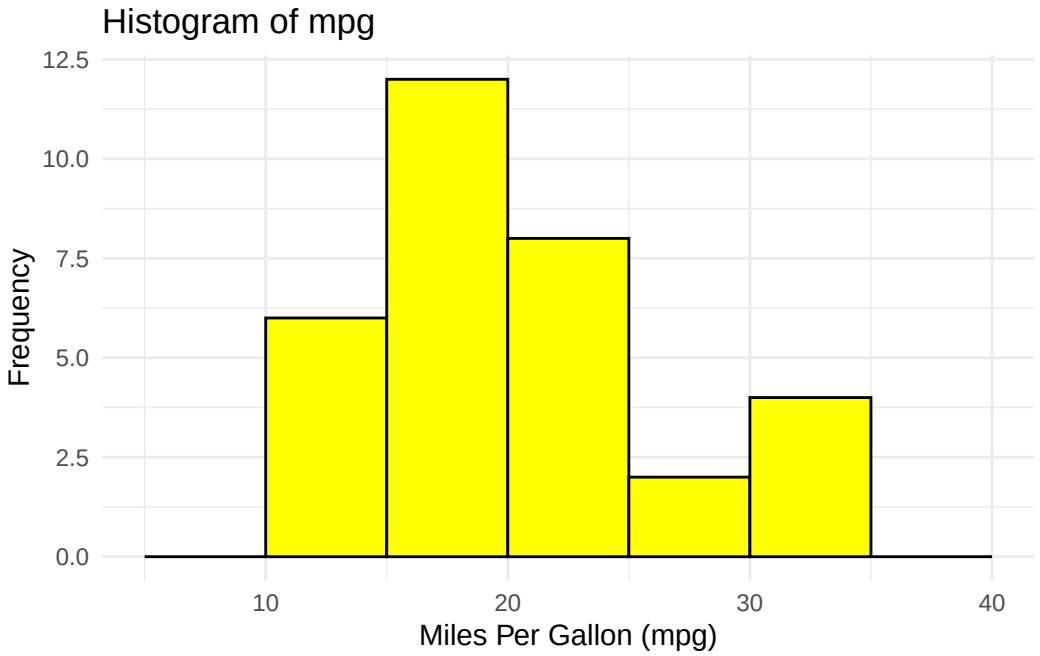


5. Discussion:

- By replacing `binwidth = 2` with `bins = 12`, we instruct R to create 12 bins of equal width. The bins argument decides the number of bins in the histogram, and the width of the bins is calculated by dividing the range of the data by the number of bins.

6. We can specify custom bin ranges in a histogram. We typically use the `breaks` argument within the `geom_histogram()` function. We need to supply a vector of breakpoints which defines the range of each bin. For example, if we wanted to define bins with ranges of 5-10, 10-15, 15-20, 20-25, 25-30, 30-35, 35-40, for the `mpg` variable, we could write the following code:

```
ggplot(tb,
       aes(x = mpg)) +
  geom_histogram(breaks = seq(5, 40, by = 5),
                 fill = "yellow",
                 color = "black") +
  theme_minimal() +
  labs(title = "Histogram of mpg", x = "Miles Per Gallon (mpg)", y = "Frequency")
```



- In this code, the `seq()` function is used to generate a sequence of numbers from 5 to 40, with an increment of 5. These numbers serve as the breakpoints for the bins in the histogram. The `breaks` argument then uses these numbers to set the bin ranges. The plot aesthetics remain the same as before.

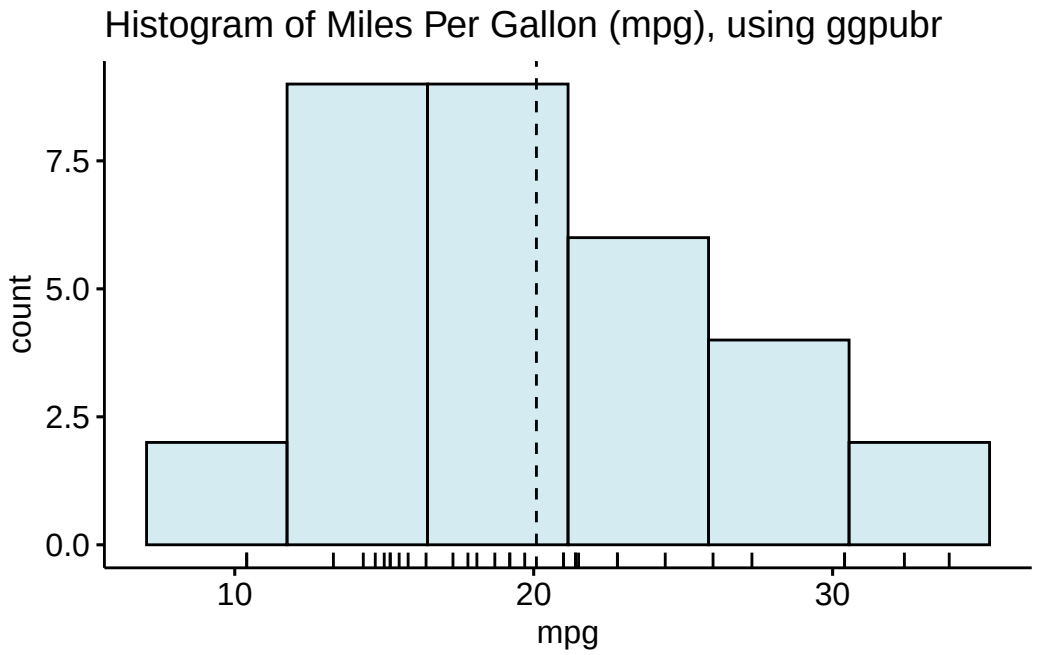
Histogram using `ggpubr`

- The provided R code creates a histogram of the mpg (miles per gallon) variable in the tb dataset, using the gghistogram() function from the ggpubr package.

```
library(ggpubr)
gghistogram(tb,
            x = "mpg",
            add = "mean",
            bins = 6,
            rug = TRUE,
            color = "black" ,
            fill = "lightblue",
            title = "Histogram of Miles Per Gallon (mpg), using ggpubr"
)
```

```
Warning: `geom_vline()`: Ignoring `mapping` because `xintercept` was provided.
```

```
Warning: `geom_vline()`: Ignoring `data` because `xintercept` was provided.
```



Discussion:

gghistogram(tb, x = “mpg”, add = “mean”, bins = 6, rug = TRUE, color = “black”, fill = “lightblue”, title = “Histogram of Miles Per Gallon (mpg), using ggpubr”):

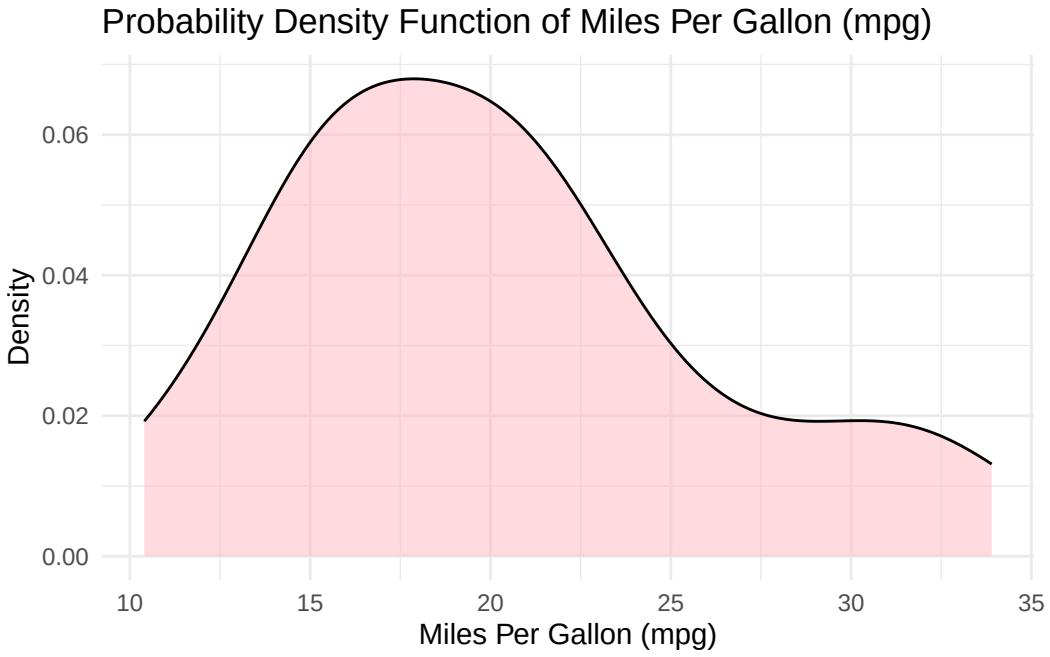
This line uses the gghistogram() function to create a histogram of the mpg variable from the tb dataset.

- tb: Specifies the dataset to use.
- x = “mpg”: Specifies the variable to create a histogram for.
- add = “mean”: Adds a vertical line at the mean of mpg.
- bins = 6: Specifies the number of bins in the histogram. This can be adjusted based on the specific data and desired level of granularity.
- rug = TRUE: Adds a rug plot at the bottom of the histogram, which displays a small vertical line for each observation along the range of mpg.
- color = “black”: Specifies the color of the border of the bars in the histogram.
- fill = “lightblue”: Specifies the fill color of the bars in the histogram.
- title = “Histogram of Miles Per Gallon (mpg), using ggpubr”: Specifies the title of the plot.

Probability Density Function (PDF) plot using `ggplot2`

- Recall that this type of plot shows the distribution of a single variable, and the area under the curve represents the probability of an observation falling within a particular range of values.

```
ggplot(tb,
       aes(x = mpg)) +
  geom_density(fill = "lightpink",
               alpha = 0.5) +
  theme_minimal() +
  labs(title = "Probability Density Function of Miles Per Gallon (mpg)", x = "Miles Per Ga
```



- We designate our data source and the aesthetic mappings using the `ggplot()` function. The aesthetic mapping for x is `mpg`.
- Subsequently, we append a density plot to our plot by using the `geom_density()` function. We fill the area under the curve with a light pink color by setting `fill` to "lightpink" and `alpha` to 0.5.

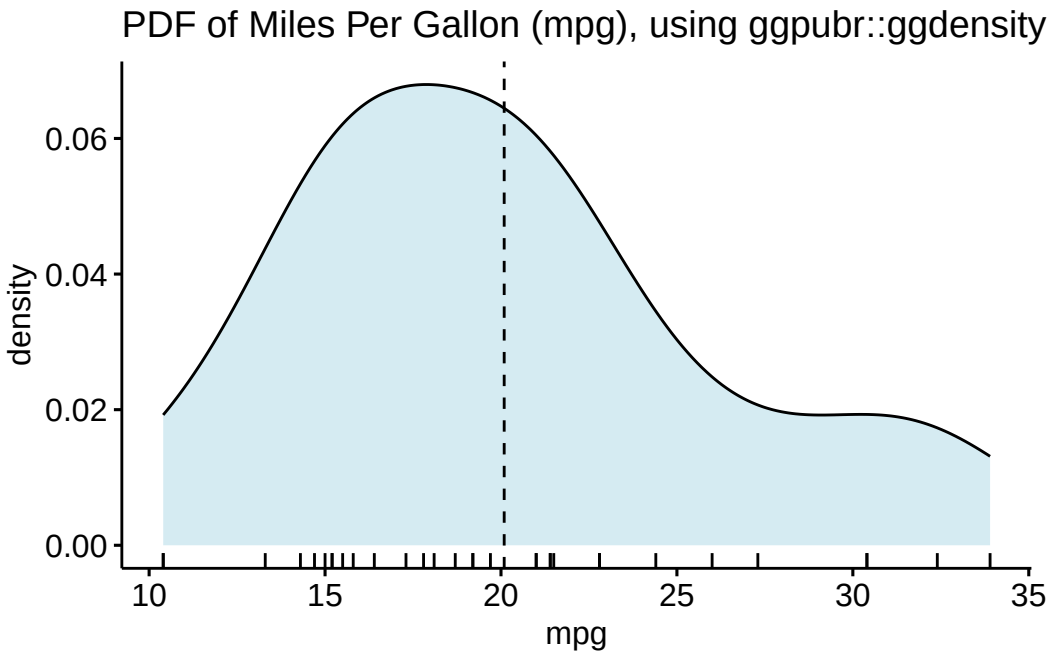
PDF using `ggpubr`

- The provided R code creates a PDF of the mpg (miles per gallon) variable in the tb dataset, using the `ggdensity()` function from the `ggpubr` package.

```
library(ggpubr)
ggdensity(tb,
             x = "mpg",
             add = "mean",
             rug = TRUE,
             color = "black" ,
             fill = "lightblue",
             title = "PDF of Miles Per Gallon (mpg), using ggpubr::ggdensity()"
)
```

```
Warning: `geom_vline()`: Ignoring `mapping` because `xintercept` was provided.
```

```
Warning: `geom_vline()`: Ignoring `data` because `xintercept` was provided.
```



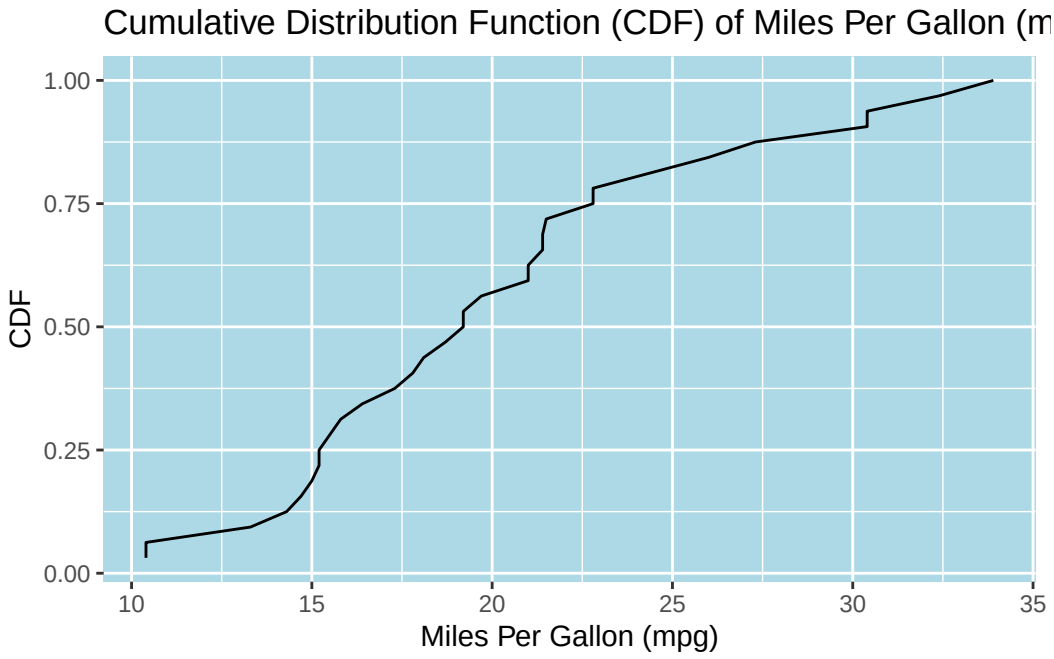
Cumulative Distribution Function (CDF) Plot using `ggplot2`

- We can generate a CDF plot. First, we'll calculate the cumulative distribution. This can be achieved by arranging the data in ascending order, then adding a column representing the proportion of values less than or equal to each value:

```
tb <- tb %>%
  arrange(mpg) %>%
  mutate(cdf = row_number() / n())
```

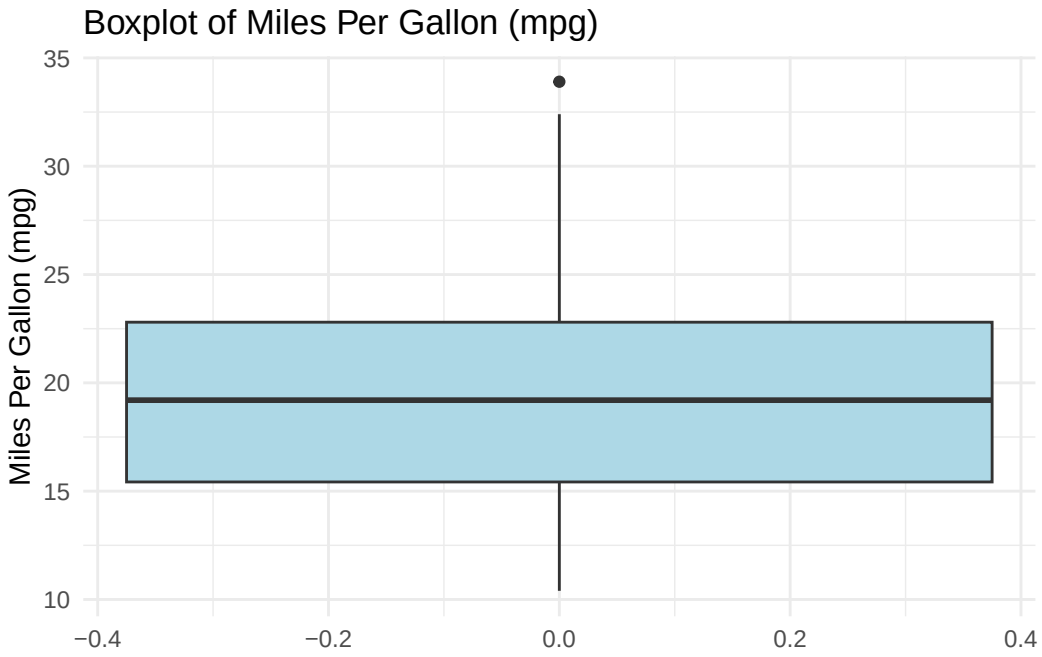
- The `arrange()` function sorts the data, `mutate()` creates a new column, and `row_number()` gives the rank of each row, while `n()` provides the total number of rows.
- The quotient of these represents the proportion of values less than or equal to each value.
- Finally, we can create the CDF plot using the following code:

```
ggplot(tb,
       aes(x = mpg, y = cdf)) +
  geom_line() +
  theme(panel.background = element_rect(fill = "lightblue")) +
  labs(x = "Miles Per Gallon (mpg)", y = "CDF", title = "Cumulative Distribution Function
```



Boxplots using `ggplot2`

```
ggplot(tb,
       aes(y = mpg)) +
  geom_boxplot(fill = "lightblue") +
  theme_minimal() +
  labs(title = "Boxplot of Miles Per Gallon (mpg)", y = "Miles Per Gallon (mpg)")
```

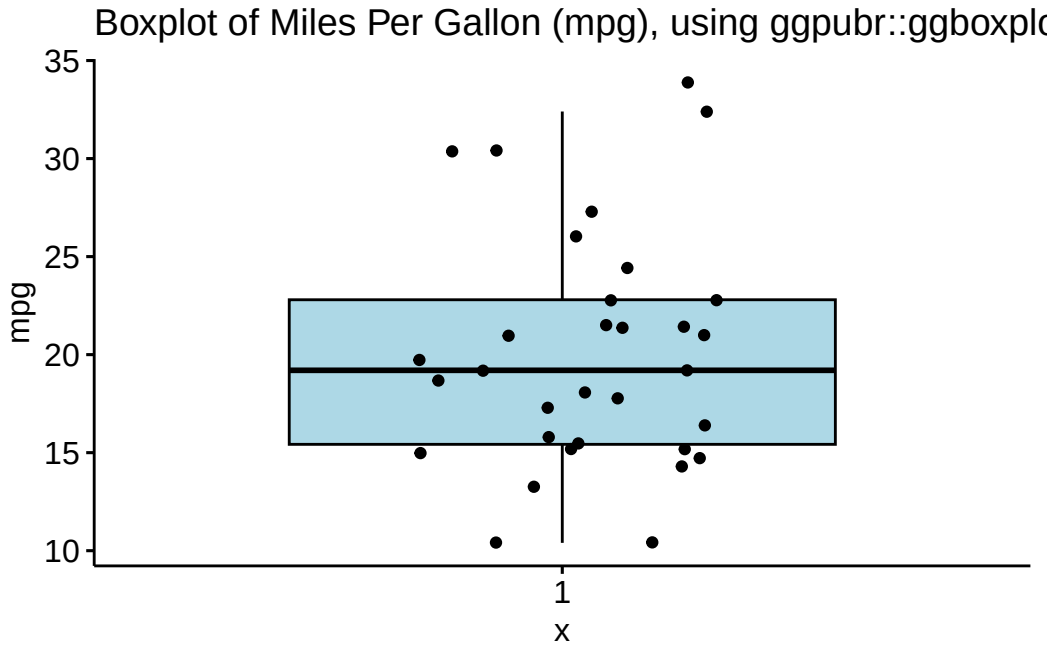


1. We're first specifying the source of our data and the aesthetic mappings, which define how variables in the data are mapped to visual properties. In this case, we're only specifying the y aesthetic, since a boxplot of a single variable doesn't need an x aesthetic. The y aesthetic is mapped to the mpg variable.
2. Then, we add a boxplot using `geom_boxplot()`.
3. After this, `theme_minimal()` is used to apply a minimalist theme to the plot, which has a clean and professional appearance.
4. Finally, we're adding some labels to the plot with the `labs()` function.

Boxplot using `ggpubr`

- The provided R code creates a Boxplot of the `mpg` (miles per gallon) variable in the `tb` dataset, using the `ggboxplot()` function from the `ggpubr` package.

```
library(ggpubr)
ggboxplot(tb,
            y = "mpg",
            rug = TRUE,
            color = "black" ,
            fill = "lightblue",
            add = "jitter",
            title = "Boxplot of Miles Per Gallon (mpg), using ggpubr::ggboxplot()"
)
```

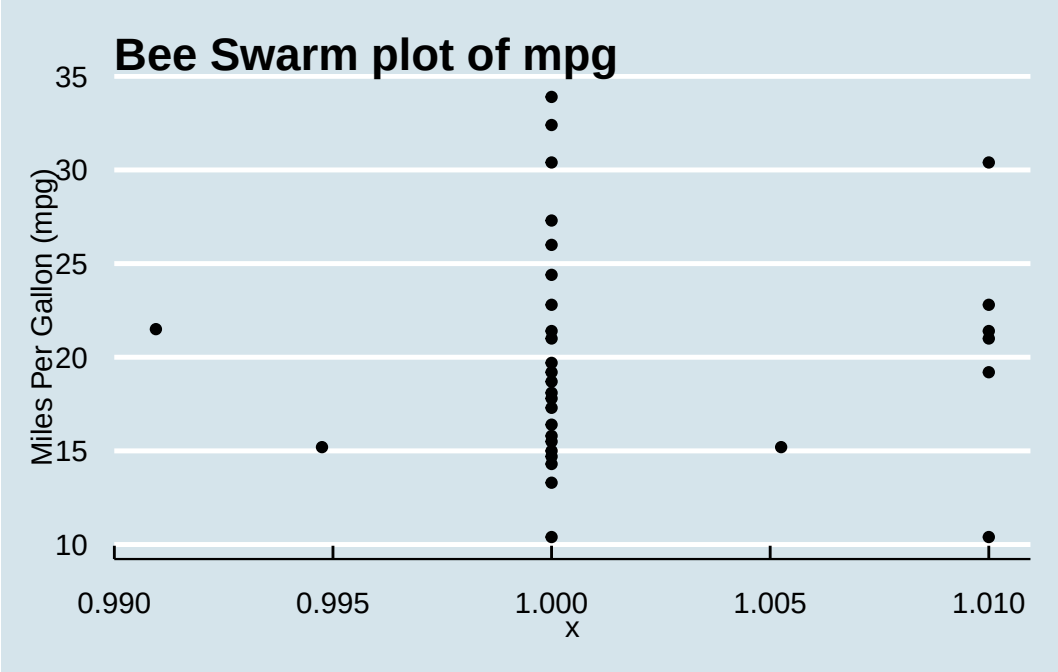


Bee Swarm plot using `ggbeeswarm`

1. The bee swarm plot is an alternative to the box plot, where each point is plotted in a manner that avoids overlap.
2. We use the `ggbeeswarm` package on the `mpg` column of the `tb` tibble.

```
library(ggbeeswarm)
ggplot(tb,
       aes(x = 1, y = mpg)) +
  geom_beeswarm() +
  theme_economist() +
```

```
labs(title = "Bee Swarm plot of mpg", y = "Miles Per Gallon (mpg)")
```



3. Discussion:

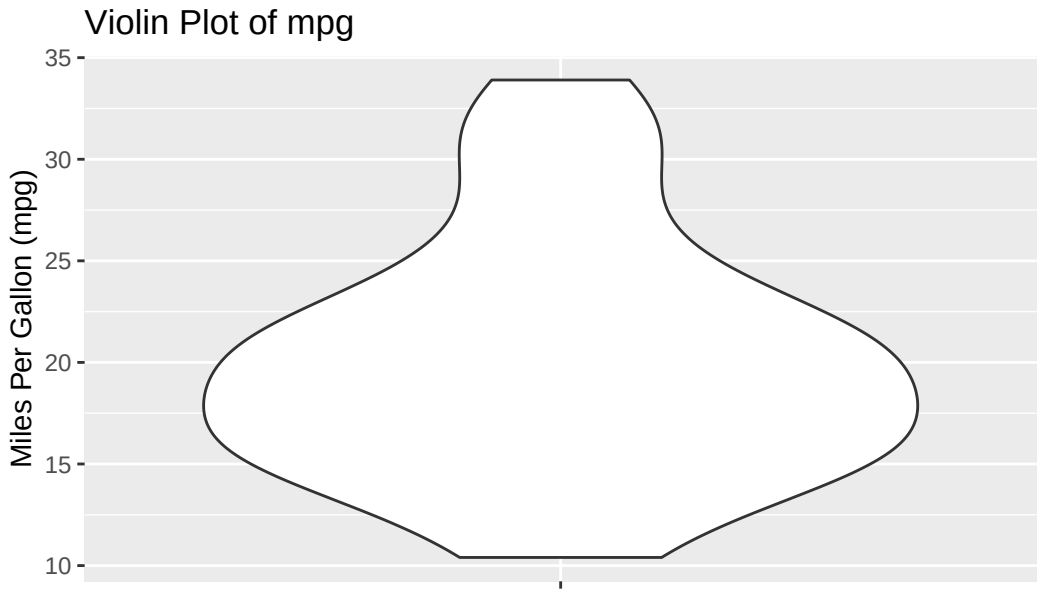
- Initially, we declare our dataset and the aesthetic mappings, defining how variables in the data are visually represented. For the bee swarm plot, we only need a y aesthetic, which is `mpg`. We set the x aesthetic to 1 as a placeholder, because bee swarm plots require an x aesthetic, but we only have one variable.
- Following that, we append a bee swarm plot using the `geom_beeswarm()` function.
- We then adopt a minimalist theme by using `theme_minimal()` to give our plot a sleek and simple look.
- We use the `labs()` function to label the plot.

Violin plot using `ggplot2`

1. We will now generate a violin plot using the ggplot2 package for the `mpg` column

```
ggplot(tb,
       aes(x = "", y = mpg)) +
  geom_violin() +
```

```
  labs(x = "", y = "Miles Per Gallon (mpg)", title = "Violin Plot of mpg")
```

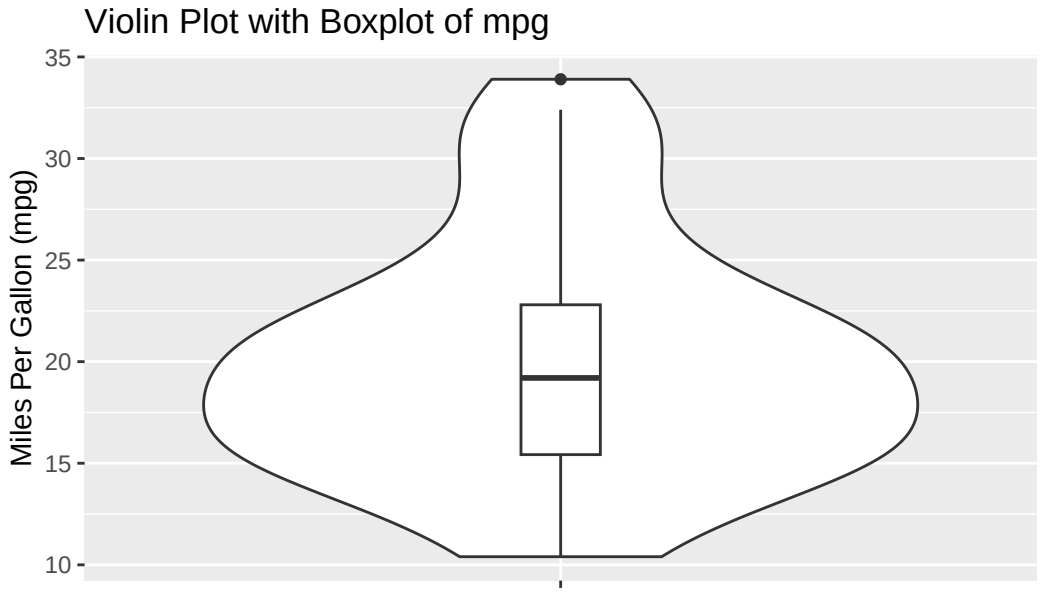


2. Discussion:

- Here, `aes()` defines aesthetic mappings, mapping `mpg` to the y-axis.
- `geom_violin()` generates the violin plot, and `labs()` adds a title for the plot and labels the y-axis

3. We can add a boxplot to the violin plot, as follows:

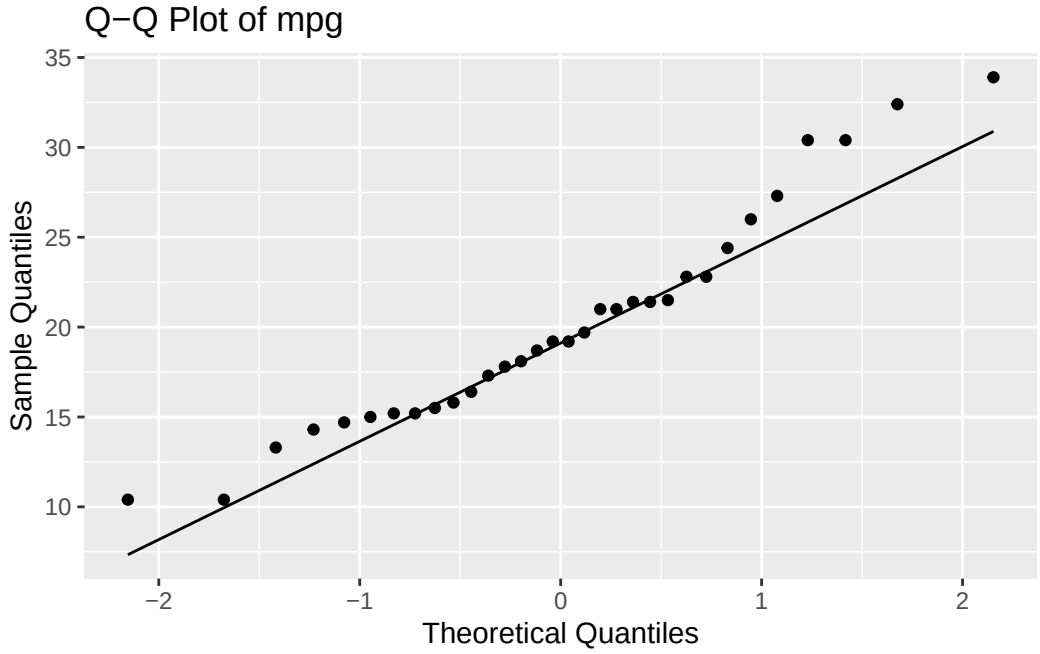
```
ggplot(tb, aes(x = "", y = mpg)) +
  geom_violin() +
  geom_boxplot(width = 0.1) +
  labs(x = "", y = "Miles Per Gallon (mpg)", title = "Violin Plot with Boxplot of mpg")
```



Quantile-Quantile (Q-Q) Plots using `ggplot2`

- In order to create a Q-Q plot, we use the `ggplot()` function to specify our dataset and aesthetic mappings `aes()`. Subsequently, we use `stat_qq()` to generate the Q-Q plot and `stat_qq_line()` to add the reference line:

```
ggplot(tb,
       aes(sample = mpg)) +
  stat_qq() +
  stat_qq_line() +
  labs(x = "Theoretical Quantiles", y = "Sample Quantiles", title = "Q-Q Plot of mpg")
```



Summary of Chapter 13 – Continuous Data (2 of 5)

In this chapter, we explore how to visualize univariate continuous data using the `ggplot2` package in R. We use the `mtcars` data set, converting it to a tibble called `tb` for easier manipulation.

The visualization methods we cover include histograms, density plots (Probability Density Function and Cumulative Density Function), box plots, bee swarm plots, violin plots, and Q-Q plots. These are created using functions like `geom_histogram()`, `geom_density()`, `geom_boxplot()`, `geom_beeswarm()`, `geom_violin()`, `stat_qq()`, and `stat_qq_line()`.

For the histogram, we can adjust bin width, color, and number of bins, or define custom bin ranges. The density plots provide a visual representation of the distribution of a variable, and we can color the area under the curve. To create the CDF plot, we first arrange our data and calculate the cumulative distribution, which is plotted as a line graph. For the violin plot, we show how to add a box plot within the violin for additional information. Finally, we explore Q-Q plots, which compare the quantiles of our data to a theoretical distribution, useful for assessing if the data follows a certain theoretical distribution.

References

[1]

Wickham, H. (2016). ggplot2: Elegant Graphics for Data Analysis. Springer-Verlag New York.

Henderson, D. R. (1974). Motor Trend Car Road Tests. Motor Trend, 1974. Data retrieved from R mtcars dataset.

Eklund, A. (2020). ggbeeswarm: Categorical Scatter (Violin Point) Plots. R package version 0.6.0. https://CRAN.R-project.org/package=ggbeeswarm

Henderson, D. R. (1974). Motor Trend Car Road Tests. Motor Trend, 1974. Data retrieved from R mtcars dataset.

[2]

Kassambara A (2023). ggpubr: 'ggplot2' Based Publication Ready Plots. R package version 0.6.0, https://rpkgs.datanovia.com/ggpubr/.