Plot One Variable: Frequency Graph, Density Distribution and More

To visualize one variable, the type of graphs to use depends on the type of the variable:

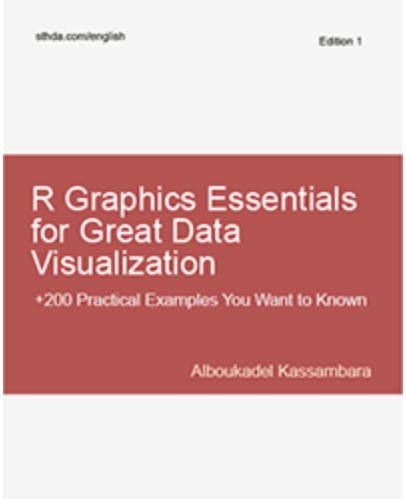
- For **categorical variables** (or grouping variables). You can visualize the count of categories using a **bar plot** or using a **pie chart** to show the proportion of each category.
- For **continuous variable**, you can visualize the distribution of the variable using **density plots**, **histograms** and alternatives.

In this R graphics tutorial, you'll learn how to:

- Visualize the frequency distribution of a categorical variable using bar plots, dot charts and pie charts
- Visualize the distribution of a continuous variable using:
  - density and histogram plots,
  - other alternatives, such as frequency polygon, area plots, dot plots, box plots, Empirical cumulative distribution function (ECDF) and Quantile-quantile plot (QQ plots).
  - Density ridgeline plots, which are useful for visualizing changes in distributions, of a continuous variable, over time or space.
  - Bar plot and modern alternatives, including lollipop charts and cleveland's dot plots.

Contents:

The Book:



R Graphics Essentials for Great Data Visualization: +200 Practical Examples You Want to Know for Data Science

Prerequisites

Load required packages and set the theme function `theme_pubr()` [in ggpubr] as the default theme:

```
library(ggplot2)
library(ggpubr)
theme_set(theme_pubr())
```

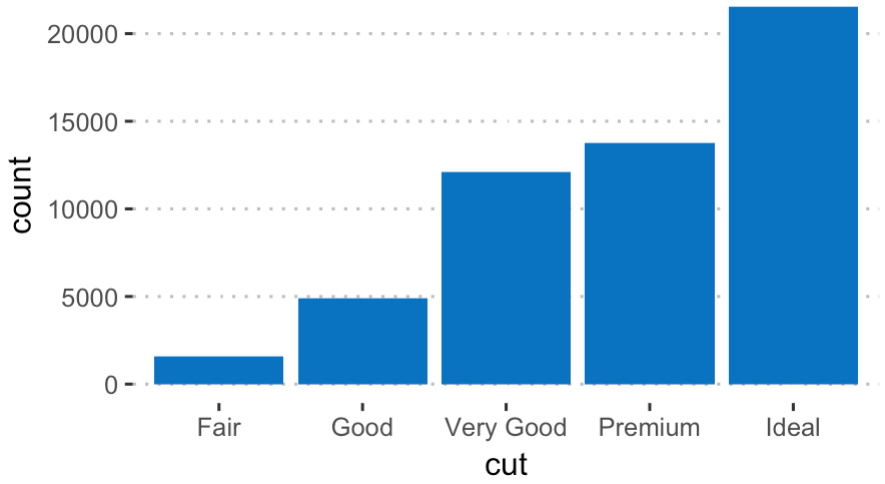
One categorical variable

Bar plot of counts

- Plot types: Bar plot of the count of group levels
- Key function: `geom_bar()`
- Key arguments: `alpha`, `color`, `fill`, `linetype` and `size`

Demo data set: `diamonds` [in ggplot2]. Contains the prices and other attributes of almost 54000 diamonds.
The column `cut`contains the quality of the diamonds cut (Fair, Good, Very Good, Premium, Ideal).
The R code below creates a bar plot visualizing the number of elements in each category of diamonds cut.

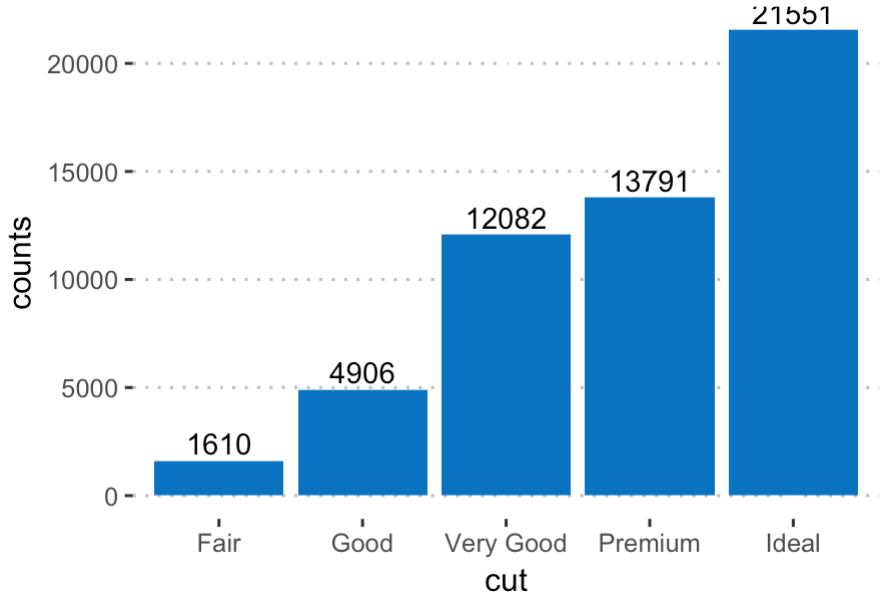
```
ggplot(diamonds, aes(cut)) +
  geom_bar(fill = "#0073C2FF") +
  theme_pubclean()
```



Compute the frequency of each category and add the labels on the bar plot:

- `dplyr` package used to summarise the data
- `geom_bar()` with option `stat = "identity"` is used to create the bar plot of the summary output as it is.
- `geom_text()` used to add text labels. Adjust the position of the labels by using `hjust` (horizontal justification) and `vjust` (vertical justification). Values should be in [0, 1].

```
# Compute the frequency
library(dplyr)
df <- diamonds %>%
  group_by(cut) %>%
  summarise(counts = n())
df
## # A tibble: 5 x 2
##         cut counts
##
## 1      Fair   1610
## 2      Good   4906
## 3 Very Good  12082
## 4   Premium  13791
## 5     Ideal  21551
# Create the bar plot. Use theme_pubclean() [in ggpubr]
ggplot(df, aes(x = cut, y = counts)) +
  geom_bar(fill = "#0073C2FF", stat = "identity") +
  geom_text(aes(label = counts), vjust = -0.3) +
  theme_pubclean()
```



Pie charts

Pie chart is just a stacked bar chart in polar coordinates.

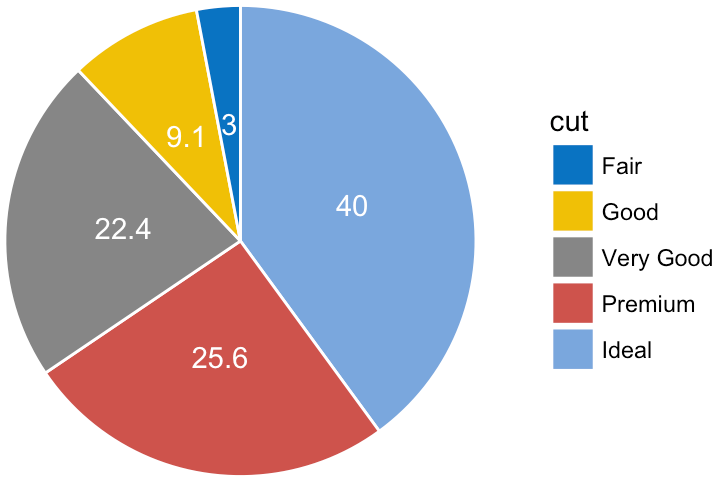
First,

- Arrange the grouping variable (`cut`) in descending order. This important to compute the y coordinates of labels.
- compute the proportion (counts/total) of each category
- compute the position of the text labels as the cumulative sum of the proportion. To put the labels in the center of pies, we'll use `cumsum(prop) - 0.5*prop` as label position.

```
df <- df %>%
  arrange(desc(cut)) %>%
  mutate(prop = round(counts*100/sum(counts), 1),
         lab.ypos = cumsum(prop) - 0.5*prop)
head(df, 4)
## # A tibble: 4 x 4
##         cut counts  prop lab.ypos
##
## 1     Ideal  21551  40.0     20.0
## 2   Premium  13791  25.6     52.8
## 3 Very Good  12082  22.4     76.8
## 4      Good   4906   9.1     92.5
```

- Create the pie charts using ggplot2 verbs. Key function: `coord_polar()`.

```
ggplot(df, aes(x = "", y = prop, fill = cut)) +
  geom_bar(width = 1, stat = "identity", color = "white") +
  geom_text(aes(y = lab.ypos, label = prop), color = "white")+
  coord_polar("y", start = 0)+
  ggpubr::fill_palette("jco")+
  theme_void()
```



- Alternative solution to easily create a pie chart: use the function `ggpie()` [in ggpubr]:

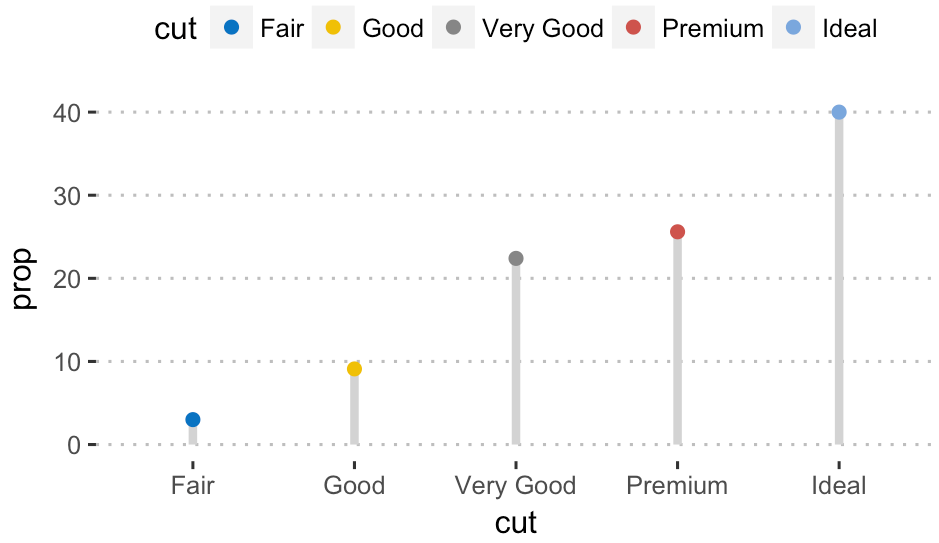
```
ggpie(
  df, x = "prop", label = "prop",
  lab.pos = "in", lab.font = list(color = "white"),
  fill = "cut", color = "white",
  palette = "jco"
)
```

Dot charts

Dot chart is an alternative to bar plots. Key functions:

- `geom_linerange()`:Creates line segments from x to ymax
- `geom_point()`: adds dots
- `ggpubr::color_palette()`: changes color palette.

```
ggplot(df, aes(cut, prop)) +
  geom_linerange(
    aes(x = cut, ymin = 0, ymax = prop),
    color = "lightgray", size = 1.5
    )+
  geom_point(aes(color = cut), size = 2)+
  ggpubr::color_palette("jco")+
  theme_pubclean()
```



Easy alternative to create a dot chart. Use `ggdotchart()` [ggpubr]:

```
ggdotchart(
  df, x = "cut", y = "prop",
  color = "cut", size = 3,        # Points color and size
  add = "segment",                # Add line segments
  add.params = list(size = 2),
  palette = "jco",
  ggtheme = theme_pubclean()
)
```

One continuous variable

Different types of graphs can be used to visualize the distribution of a continuous variable, including: density and histogram plots.

Data format

Create some data (`wdata`) containing the weights by sex (M for male; F for female):

```
set.seed(1234)
wdata = data.frame(
        sex = factor(rep(c("F", "M"), each=200)),
        weight = c(rnorm(200, 55), rnorm(200, 58))
        )
head(wdata, 4)
##   sex weight
## 1   F   53.8
## 2   F   55.3
## 3   F   56.1
## 4   F   52.7
```

Compute the mean weight by sex using the `dplyr` package. First, the data is grouped by sex and then summarized by computing the mean weight by groups. The operator `%>%` is used to combine multiple operations:

```
library("dplyr")
mu <- wdata %>%
  group_by(sex) %>%
  summarise(grp.mean = mean(weight))
mu
## # A tibble: 2 x 2
##      sex grp.mean
##
## 1      F     54.9
## 2      M     58.1
```

Basic plots

We start by creating a plot, named `a`, that we'll finish in the next section by adding a layer.

```
a <- ggplot(wdata, aes(x = weight))
```

Possible layers include: `geom_density()` (for density plots) and `geom_histogram()` (for histogram plots).

Key arguments to customize the plots:

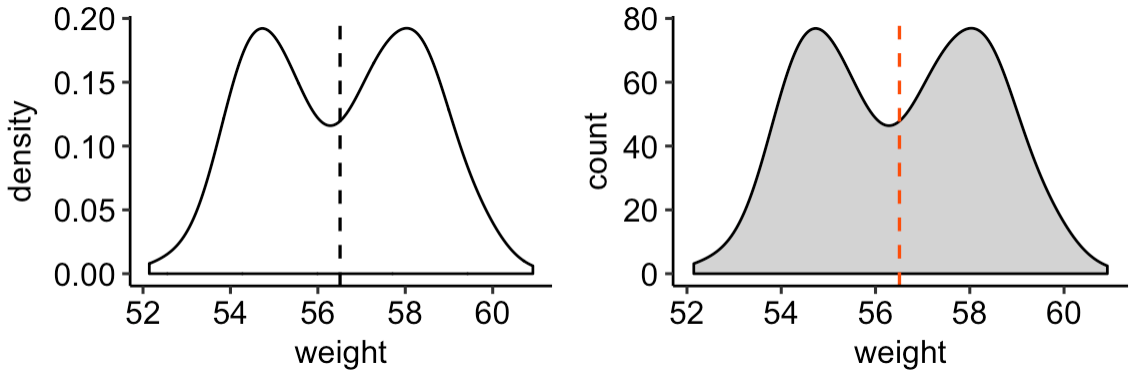
- `color, size, linetype`: change the line color, size and type, respectively
- `fill`: change the areas fill color (for bar plots, histograms and density plots)
- `alpha`: create a semi-transparent color.

Density plots

Key function: `geom_density()`.

1. **Create basic density plots**. Add a vertical line corresponding to the mean value of the weight variable (`geom_vline()`):

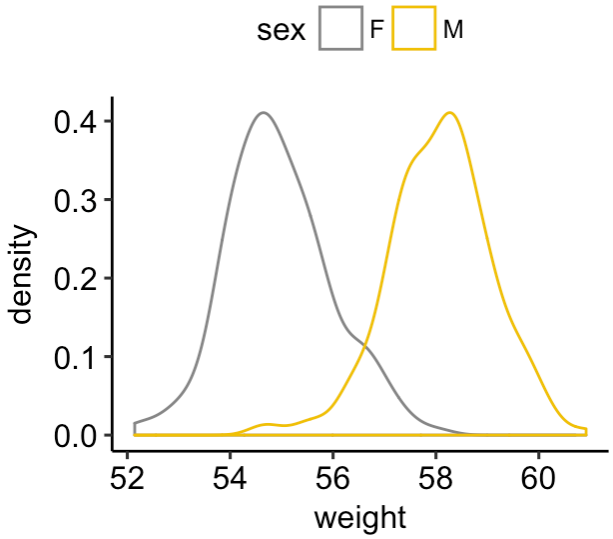
```
# y axis scale = ..density.. (default behaviour)
a + geom_density() +
  geom_vline(aes(xintercept = mean(weight)),
             linetype = "dashed", size = 0.6)

# Change y axis to count instead of density
a + geom_density(aes(y = ..count..), fill = "lightgray") +
  geom_vline(aes(xintercept = mean(weight)),
             linetype = "dashed", size = 0.6,
             color = "#FC4E07")
```

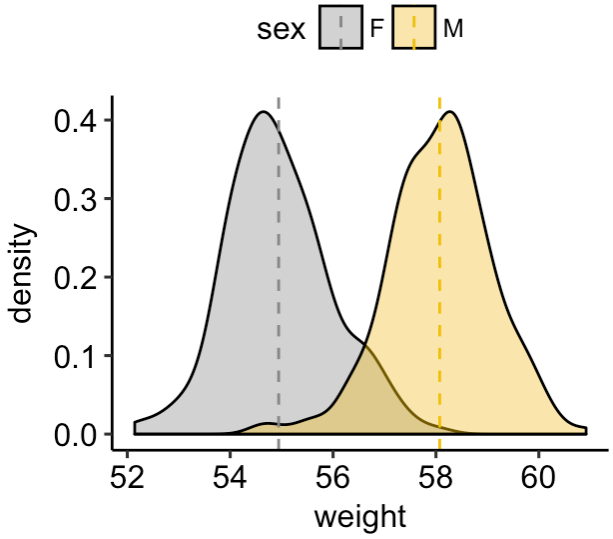


2. **Change areas fill and add line color by groups** (sex):

- Add vertical mean lines using `geom_vline()`. Data: `mu`, which contains the mean values of weights by sex (computed in the previous section).
- Change color manually:
  - use `scale_color_manual()` or `scale_colour_manual()` for changing line color
  - use `scale_fill_manual()` for changing area fill colors.

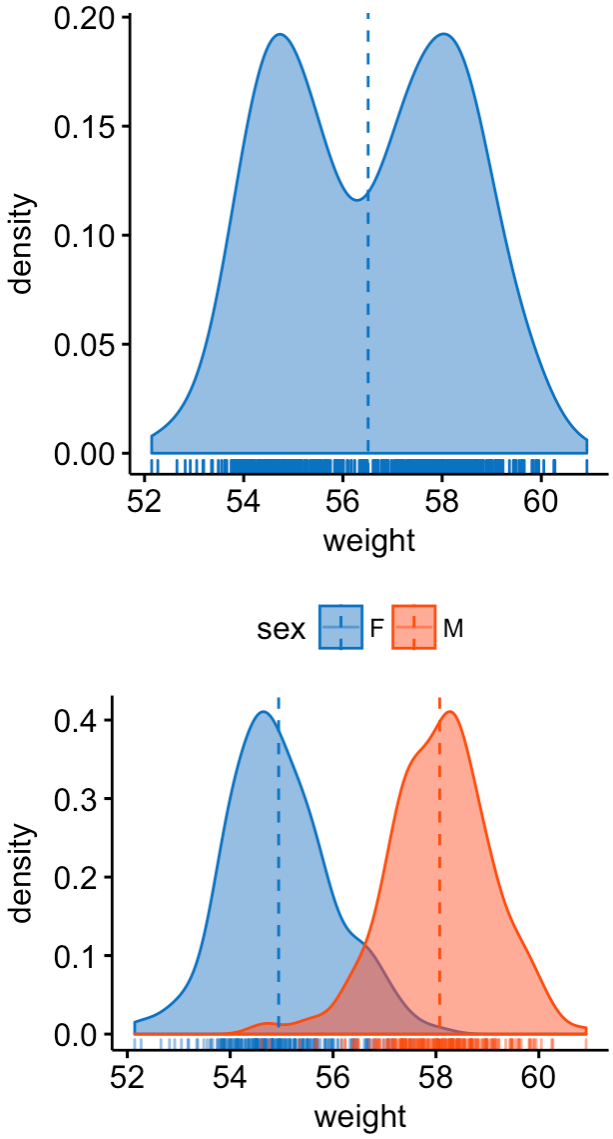
```
# Change line color by sex
a + geom_density(aes(color = sex)) +
  scale_color_manual(values = c("#868686FF", "#EFC000FF"))
# Change fill color by sex and add mean line
# Use semi-transparent fill: alpha = 0.4
a + geom_density(aes(fill = sex), alpha = 0.4) +
      geom_vline(aes(xintercept = grp.mean, color = sex),
                 data = mu, linetype = "dashed") +
  scale_color_manual(values = c("#868686FF", "#EFC000FF"))+
  scale_fill_manual(values = c("#868686FF", "#EFC000FF"))
```





3. **Simple solution to create a ggplot2-based density plots**: use `ggboxplot()` [in ggpubr].

```
library(ggpubr)
# Basic density plot with mean line and marginal rug
ggdensity(wdata, x = "weight",
          fill = "#0073C2FF", color = "#0073C2FF",
          add = "mean", rug = TRUE)

# Change outline and fill colors by groups ("sex")
# Use a custom palette
ggdensity(wdata, x = "weight",
   add = "mean", rug = TRUE,
   color = "sex", fill = "sex",
   palette = c("#0073C2FF", "#FC4E07"))
```



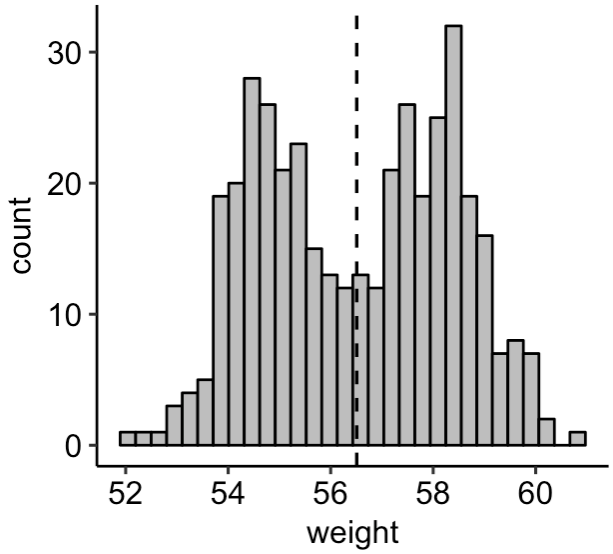
Histogram plots

An alternative to density plots is histograms, which represents the distribution of a continuous variable by dividing into bins and counting the number of observations in each bin.

Key function: `geom_histogram()`. The basic usage is quite similar to `geom_density()`.

1. **Create a basic plots**. Add a vertical line corresponding to the mean value of the weight variable:

```
a + geom_histogram(bins = 30, color = "black", fill = "gray") +
  geom_vline(aes(xintercept = mean(weight)),
             linetype = "dashed", size = 0.6)
```



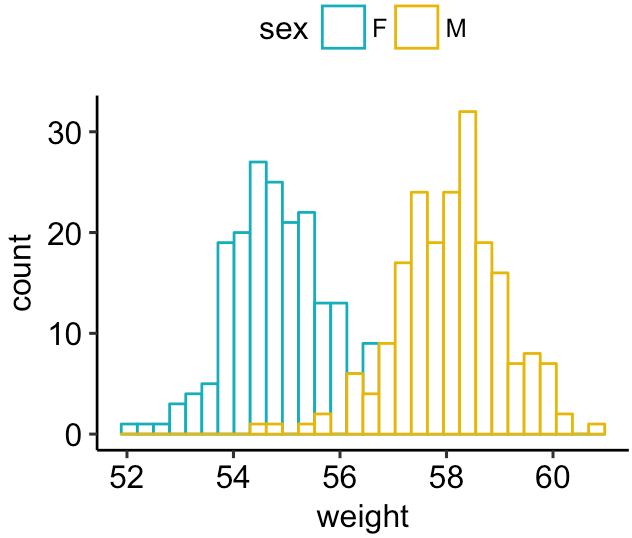
Note that, by default:

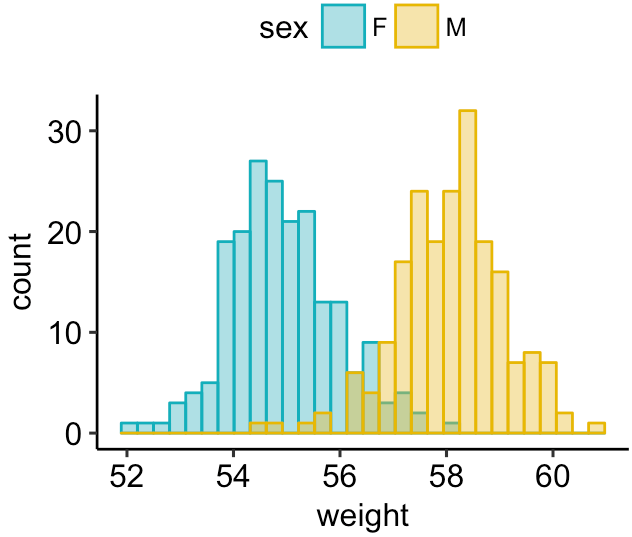
- By default, `geom_histogram()` uses 30 bins - this might not be good default. You can change the number of bins (e.g.: bins = 50) or the bin width (e.g.: binwidth = 0.5)
- The y axis corresponds to the count of weight values. If you want to change the plot in order to have the density on y axis, specify the argument `y = ..density..` in `aes()`.

2. **Change areas fill and add line color by groups** (sex):

- Add vertical mean lines using `geom_vline()`. Data: `mu`, which contains the mean values of weights by sex.
- Change color manually:
  - use `scale_color_manual()` or `scale_colour_manual()` for changing line color
  - use `scale_fill_manual()` for changing area fill colors.
- Adjust the position of histogram bars by using the argument `position`. Allowed values: “identity”, “stack”, “dodge”. Default value is “stack”.

```
# Change line color by sex
a + geom_histogram(aes(color = sex), fill = "white",
                   position = "identity") +
  scale_color_manual(values = c("#00AFBB", "#E7B800"))
# change fill and outline color manually
a + geom_histogram(aes(color = sex, fill = sex),
                           alpha = 0.4, position = "identity") +
  scale_fill_manual(values = c("#00AFBB", "#E7B800")) +
  scale_color_manual(values = c("#00AFBB", "#E7B800"))
```

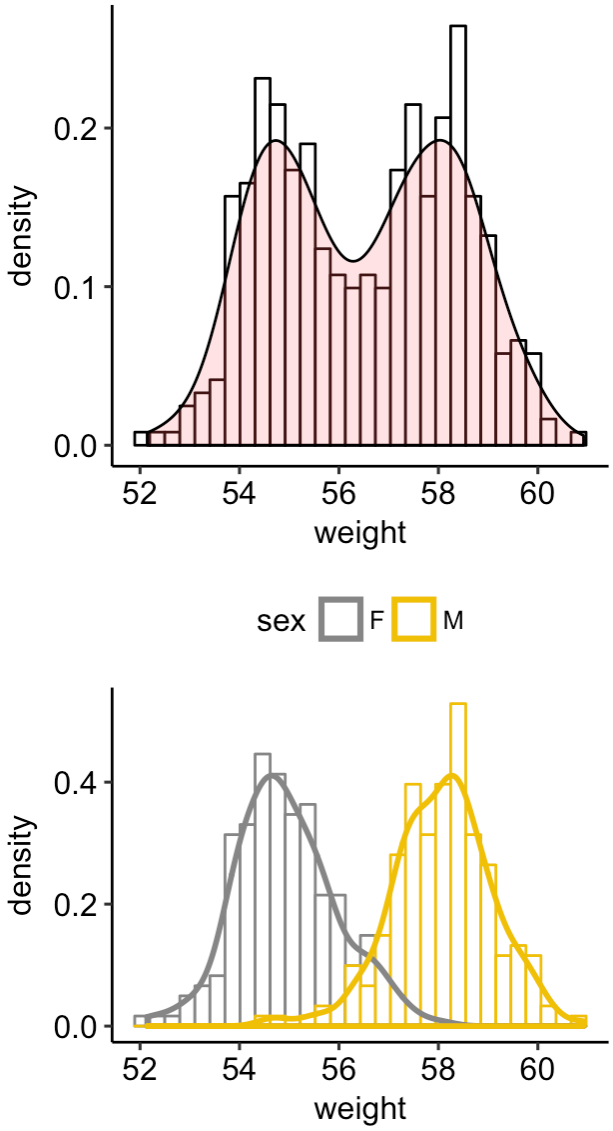




3. **Combine histogram and density plots**:

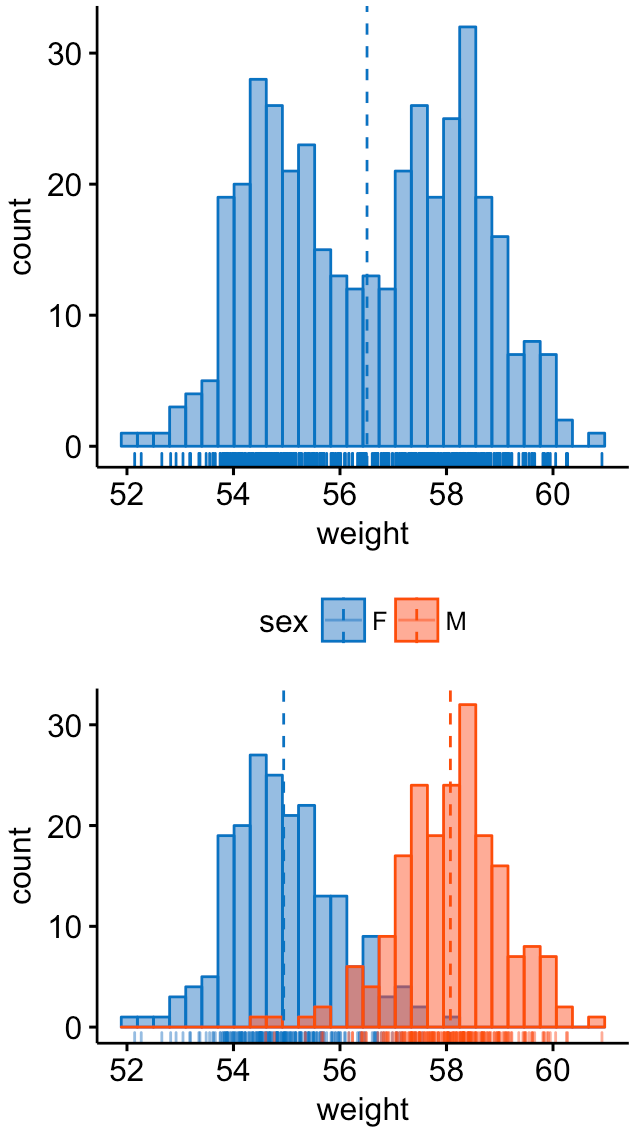
- Plot histogram with density values on y-axis (instead of count values).
- Add density plot with transparent density plot

```
# Histogram with density plot
a + geom_histogram(aes(y = ..density..),
                   colour="black", fill="white") +
  geom_density(alpha = 0.2, fill = "#FF6666")

# Color by groups
a + geom_histogram(aes(y = ..density.., color = sex),
                   fill = "white",
                   position = "identity")+
  geom_density(aes(color = sex), size = 1) +
  scale_color_manual(values = c("#868686FF", "#EFC000FF"))
```



4. **Simple solution to create a ggplot2-based histogram plots**: use `gghistogram()` [in ggpubr].

```
library(ggpubr)
# Basic histogram plot with mean line and marginal rug
gghistogram(wdata, x = "weight", bins = 30,
            fill = "#0073C2FF", color = "#0073C2FF",
            add = "mean", rug = TRUE)

# Change outline and fill colors by groups ("sex")
# Use a custom palette
gghistogram(wdata, x = "weight", bins = 30,
   add = "mean", rug = TRUE,
   color = "sex", fill = "sex",
   palette = c("#0073C2FF", "#FC4E07"))
```



Alternative to density and histogram plots

1. **Frequency polygon**. Very close to histogram plots, but it uses lines instead of bars.
   - Key function: `geom_freqpoly()`.
   - Key arguments: `color`, `size`, `linetype`: change, respectively, line color, size and type.
2. **Area plots**. This is a continuous analog of a stacked bar plot.
   - Key function: `geom_area()`.
   - Key arguments:
     - `color`, `size`, `linetype`: change, respectively, line color, size and type.
     - `fill`: change area fill color.

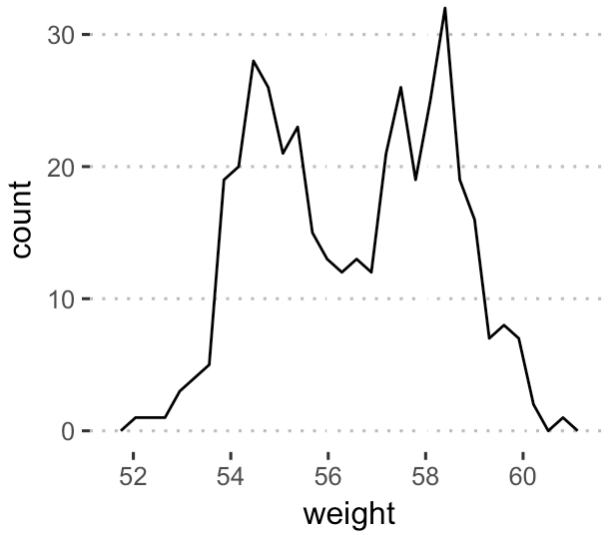
In this section, we'll use the theme `theme_pubclean()` [in ggpubr]. This is a theme without axis lines, to direct more attention to the data. Type this to use the theme:

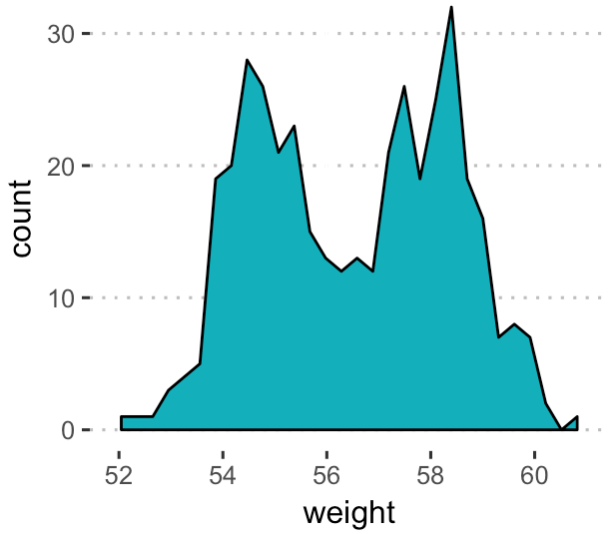
```
theme_set(theme_pubclean())
```

- Create a basic frequency polygon and basic area plots:

```
# Basic frequency polygon
```

```
a + geom_freqpoly(bins = 30)
# Basic area plots, which can be filled by color
a + geom_area( stat = "bin", bins = 30,
               color = "black", fill = "#00AFBB")
```

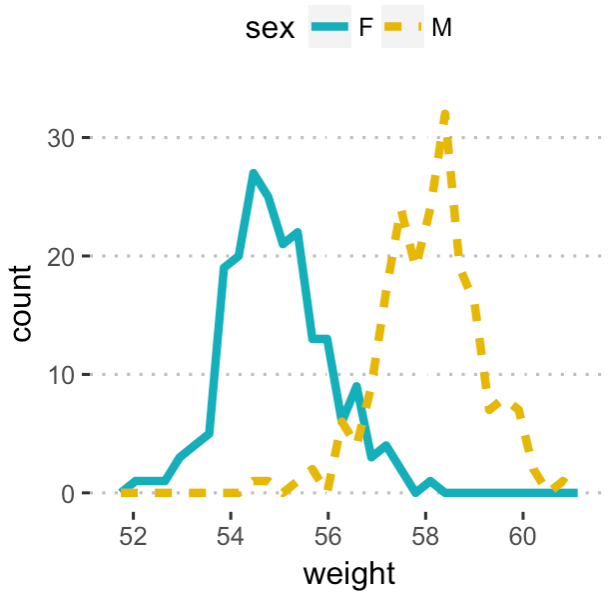


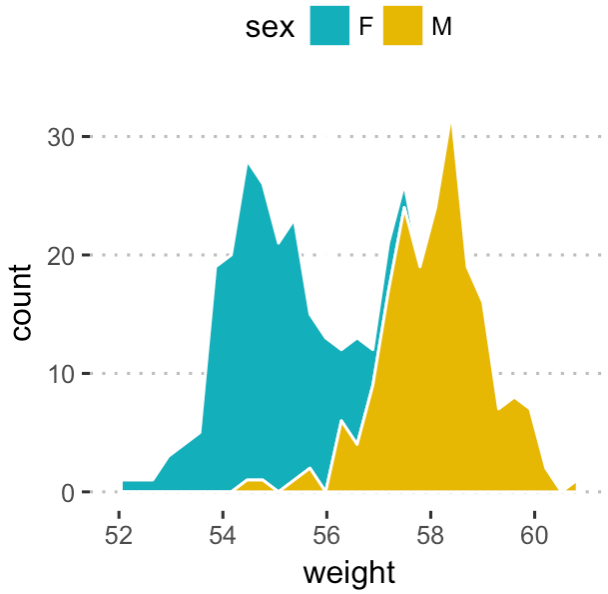


- Change colors by groups (sex):

```
# Frequency polygon:
# Change line colors and types by groups
a + geom_freqpoly( aes(color = sex, linetype = sex),
                   bins = 30, size = 1.5) +
  scale_color_manual(values = c("#00AFBB", "#E7B800"))
# Area plots: change fill colors by sex
# Create a stacked area plots
a + geom_area(aes(fill = sex), color = "white",
              stat ="bin", bins = 30) +
```

```
  scale_fill_manual(values = c("#00AFBB", "#E7B800"))
```





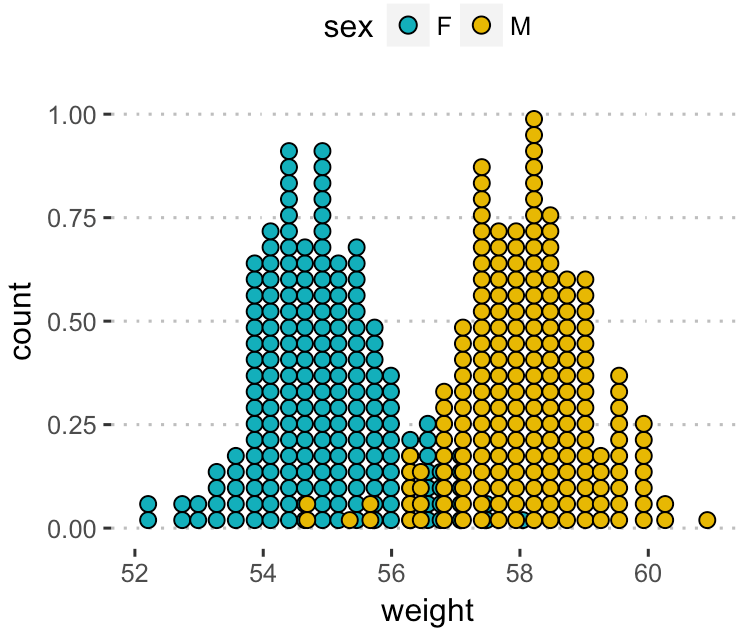
As in histogram plots, the default y values is count. To have density values on y axis, specify `y = ..density..` in `aes()`.

3. **Dot plots**. Represents another alternative to histograms and density plots, that can be used to visualize a continuous variable. Dots are stacked with each dot representing one observation. The width of a dot corresponds to the bin width.

- Key function: `geom_dotplot()`.
- Key arguments: `alpha`, `color`, `fill` and `dotsize`.

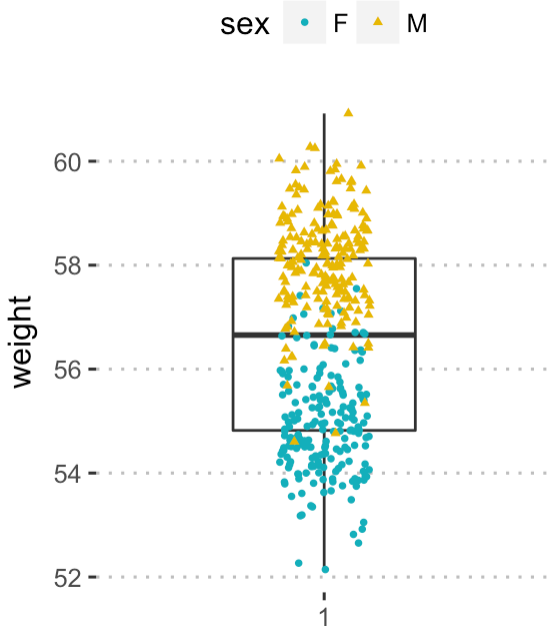
Create a dot plot colored by groups (sex):

```
a + geom_dotplot(aes(fill = sex), binwidth = 1/4) +
  scale_fill_manual(values = c("#00AFBB", "#E7B800"))
```



4. **Box plot**:
   - Create a box plot of one continuous variable: `geom_boxplot()`
   - Add jittered points, where each point corresponds to an individual observation: `geom_jitter()`. Change the color and the shape of points by groups (sex)

```
ggplot(wdata, aes(x = factor(1), y = weight)) +
  geom_boxplot(width = 0.4, fill = "white") +
  geom_jitter(aes(color = sex, shape = sex),
              width = 0.1, size = 1) +
  scale_color_manual(values = c("#00AFBB", "#E7B800")) +
  labs(x = NULL)    # Remove x axis label
```

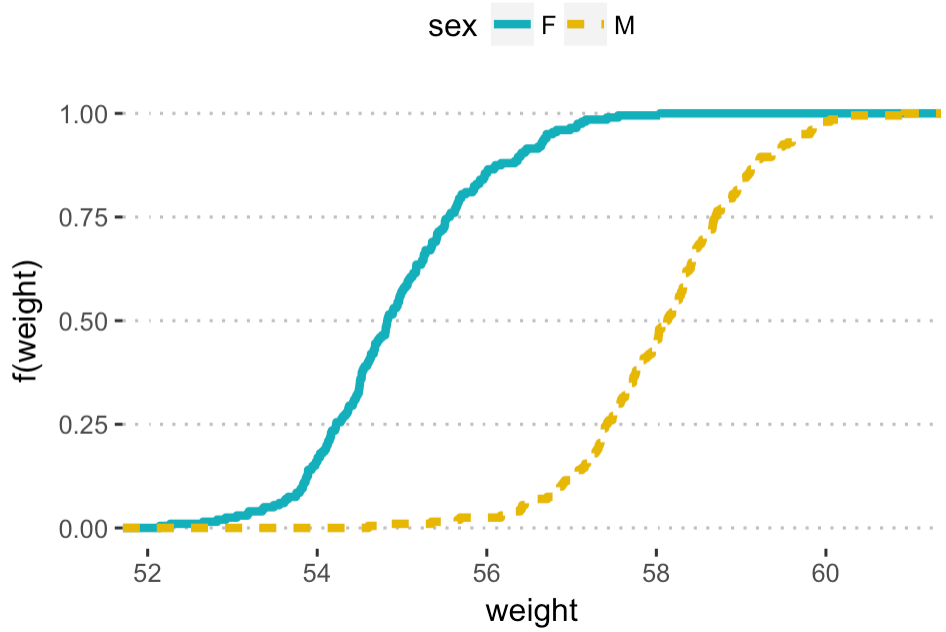


5. **Empirical cumulative distribution function (ECDF)**. Provides another alternative visualization of distribution. It reports for any given number the percent of individuals that are below that threshold.

For example, in the following plots, you can see that:

- about 25% of our females are shorter than 50 inches
- about 50% of males are shorter than 58 inches

```
# Another option for geom = "point"
a + stat_ecdf(aes(color = sex,linetype = sex),
              geom = "step", size = 1.5) +
  scale_color_manual(values = c("#00AFBB", "#E7B800"))+
  labs(y = "f(weight)")
```

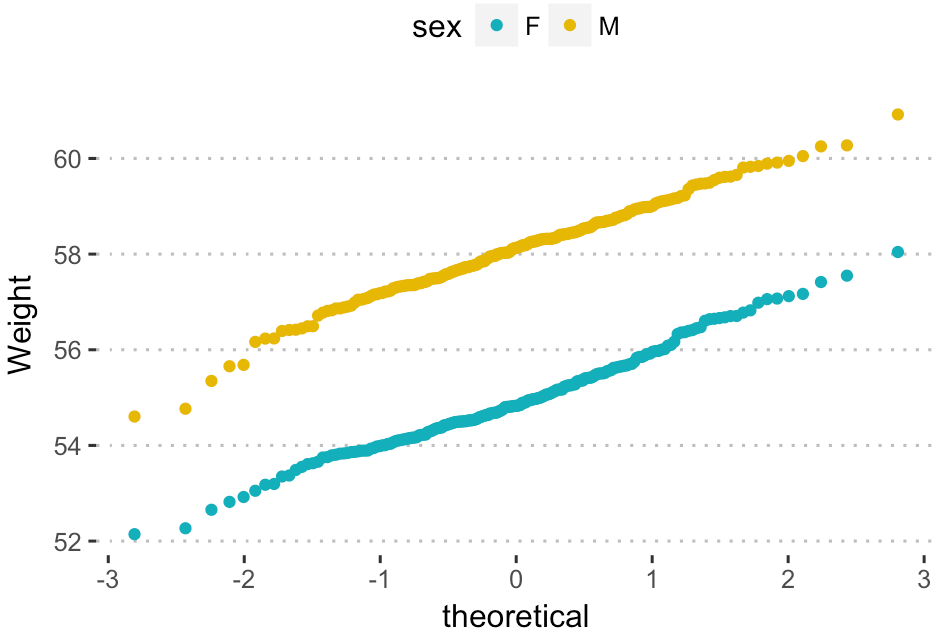


6. **Quantile-quantile plot** (QQ plots). Used to check whether a given data follows normal distribution.

- Key function: `stat_qq()`.
- Key arguments: `color`, `shape` and `size` to change point color, shape and size.

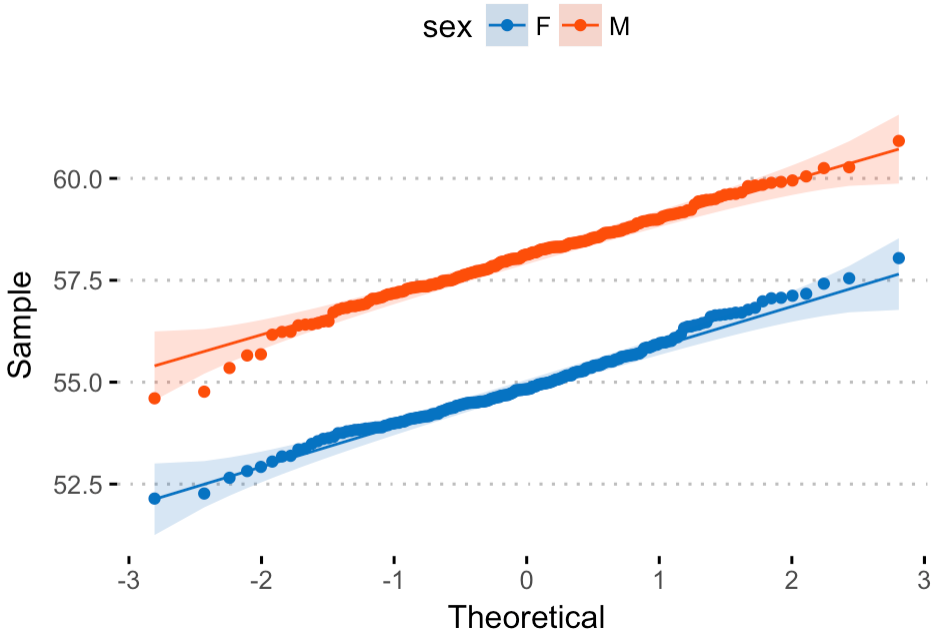
Create a qq-plot of weight. Change color by groups (sex)

```
# Change point shapes by groups
ggplot(wdata, aes(sample = weight)) +
  stat_qq(aes(color = sex)) +
  scale_color_manual(values = c("#00AFBB", "#E7B800"))+
  labs(y = "Weight")
```



Alternative plot using the function `ggqqplot()` [in ggpubr]. The 95% confidence band is shown by default.

```
library(ggpubr)
ggqqplot(wdata, x = "weight",
   color = "sex",
   palette = c("#0073C2FF", "#FC4E07"),
   ggtheme = theme_pubclean())
```



Density ridgeline plots

The density ridgeline plot is an alternative to the standard `geom_density()` function that can be useful for visualizing changes in distributions, of a continuous variable, over time or space. Ridgeline plots are partially overlapping line plots that create the impression of a mountain range.
This functionality is provided in the R package `ggridges` (Wilke 2017).

1. **Installation**:

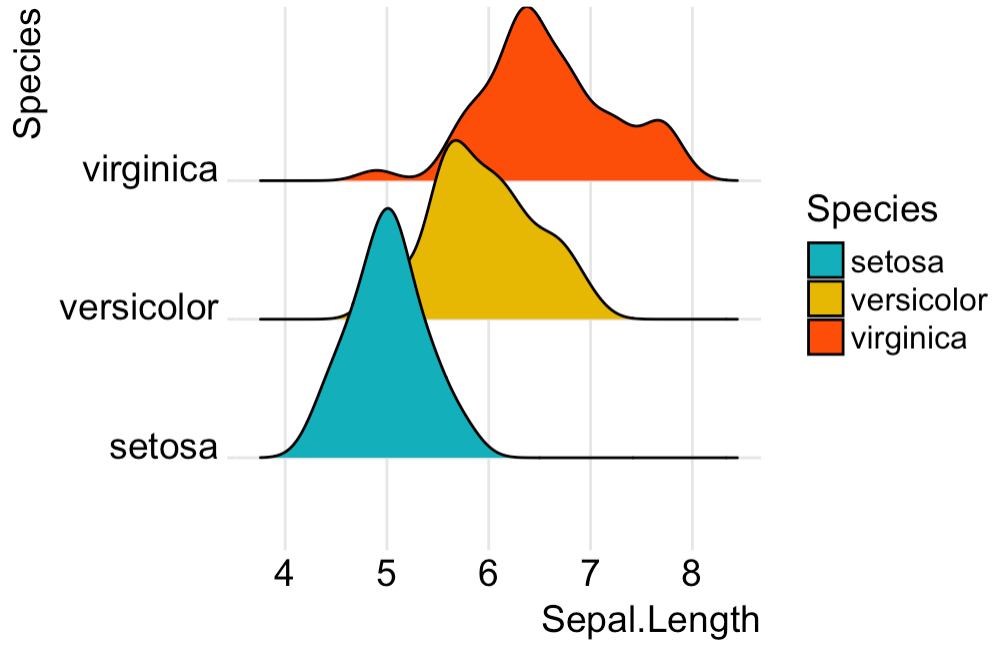
```
install.packages("ggridges")
```

2. **Load and set the default theme** to `theme_ridges()` [in ggridges]:

```
library(ggplot2)
library(ggridges)
theme_set(theme_ridges())
```

3. **Example 1: Simple distribution plots by groups**. Distribution of Sepal.Length by Species using the `iris` data set. The grouping variable Species will be mapped to the y-axis:

```
ggplot(iris, aes(x = Sepal.Length, y = Species)) +
  geom_density_ridges(aes(fill = Species)) +
  scale_fill_manual(values = c("#00AFBB", "#E7B800", "#FC4E07"))
```



You can control the overlap between the different densities using the `scale` option. Default value is 1. Smaller values create a separation between the curves, and larger values create more overlap.

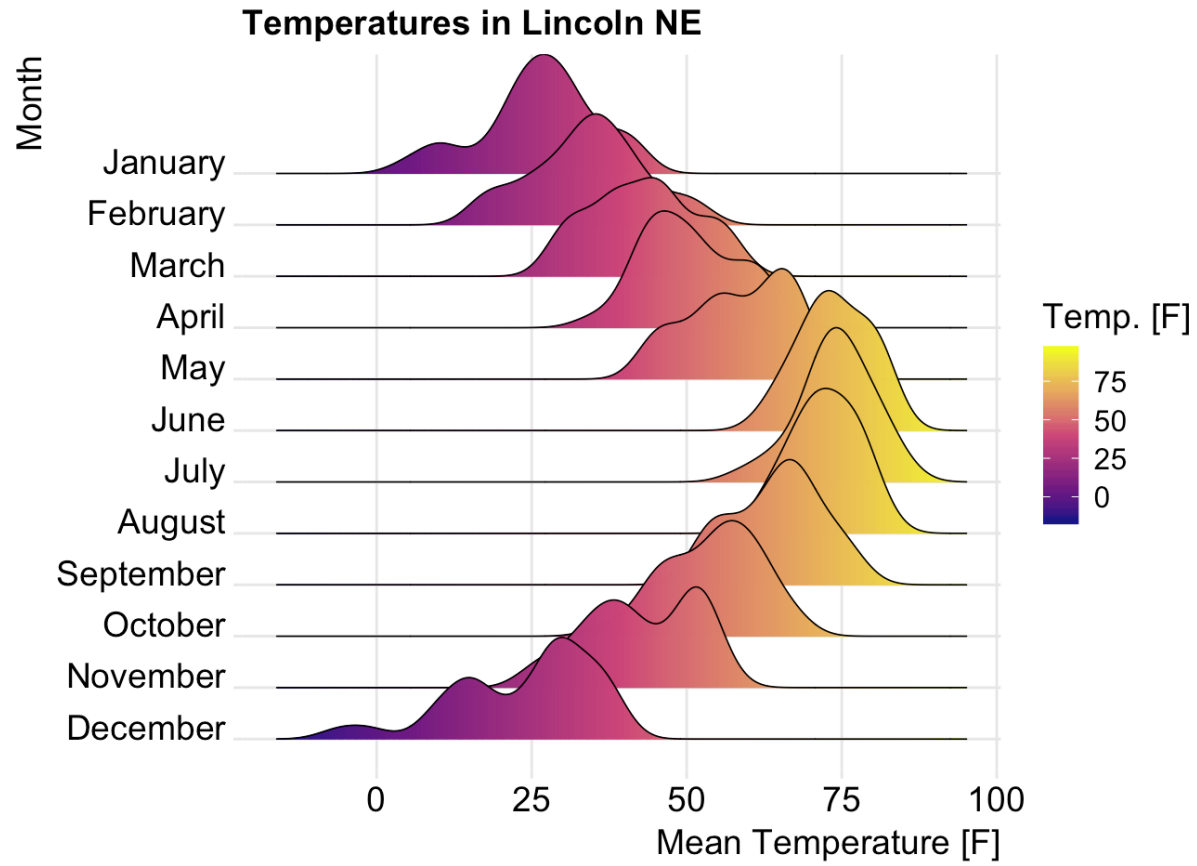
```
ggplot(iris, aes(x = Sepal.Length, y = Species)) +
  geom_density_ridges(scale = 0.9)
```

4. **Example 4: Visualize temperature data**.

- Data set: `lincoln_weather` [in ggridges]. Weather in Lincoln, Nebraska in 2016.
- Create the density ridge plots of the `Mean Temperature` by `Month` and change the fill color according to the temperature value (on x axis). A gradient color is created using the function `geom_density_ridges_gradient()`

```
ggplot(
  lincoln_weather,
  aes(x = `Mean Temperature [F]`, y = `Month`)
  ) +
  geom_density_ridges_gradient(
```

```
    aes(fill = ..x..), scale = 3, size = 0.3
    ) +
  scale_fill_gradientn(
    colours = c("#0D0887FF", "#CC4678FF", "#F0F921FF"),
    name = "Temp. [F]"
    )+
  labs(title = 'Temperatures in Lincoln NE')
```



For more examples, type the following R code:

```
browseVignettes("ggridges")
```

Bar plot and modern alternatives

In this section, we'll describe how to create easily basic and ordered bar plots using ggplot2 based helper functions available in the ggpubr R package. We'll also present some modern alternatives to bar plots, including lollipop charts and cleveland's dot plots.

- Load required packages:

```
library(ggpubr)
```

- Load and prepare data:

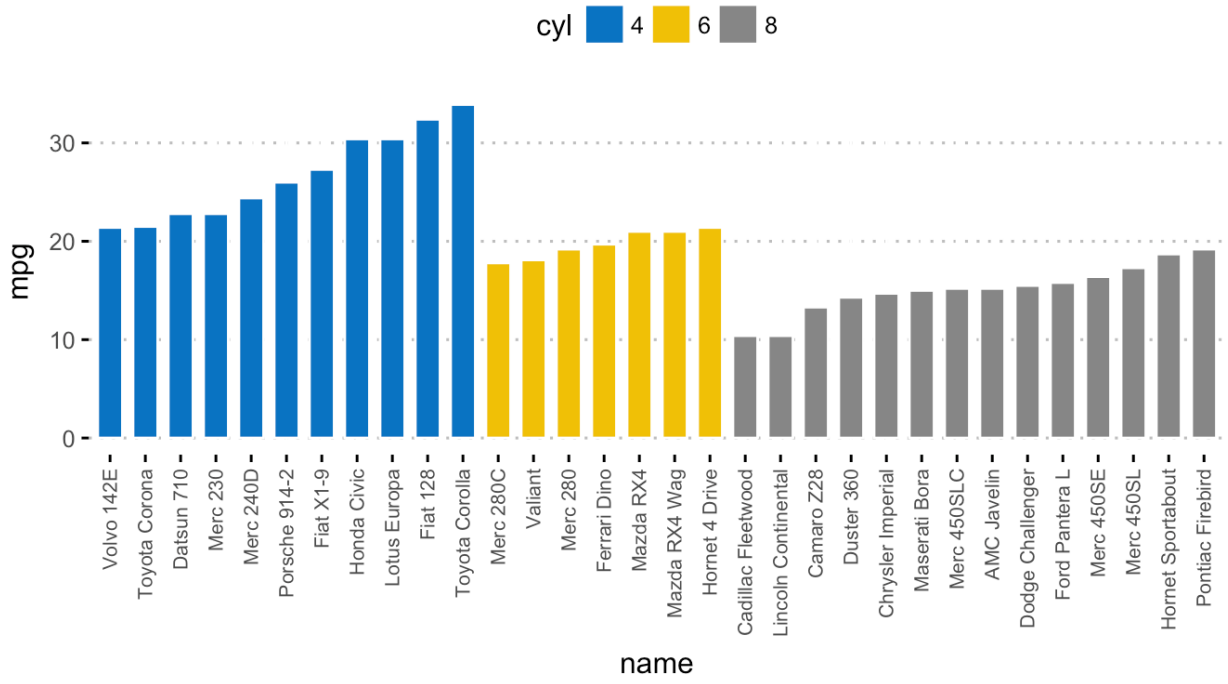
```
# Load data
dfm <- mtcars
```

```r
# Convert the cyl variable to a factor
dfm$cyl <- as.factor(dfm$cyl)
# Add the name colums
dfm$name <- rownames(dfm)
# Inspect the data
head(dfm[, c("name", "wt", "mpg", "cyl")])
```

```
##                                   name   wt  mpg cyl
## Mazda RX4                     Mazda RX4 2.62 21.0   6
## Mazda RX4 Wag             Mazda RX4 Wag 2.88 21.0   6
## Datsun 710                   Datsun 710 2.32 22.8   4
## Hornet 4 Drive           Hornet 4 Drive 3.21 21.4   6
## Hornet Sportabout Hornet Sportabout 3.44 18.7   8
## Valiant                         Valiant 3.46 18.1   6
```

- Create an ordered bar plot of the `mpg` variable. Change the fill color by the grouping variable "cyl". Sorting will be done globally, but not by groups.

```r
ggbarplot(dfm, x = "name", y = "mpg",
          fill = "cyl",                # change fill color by cyl
          color = "white",             # Set bar border colors to white
          palette = "jco",             # jco journal color palett. see ?ggpar
          sort.val = "asc",           # Sort the value in dscending order
          sort.by.groups = TRUE,      # Don't sort inside each group
          x.text.angle = 90,            # Rotate vertically x axis texts
          ggtheme = theme_pubclean()
          )+
  font("x.text", size = 8, vjust = 0.5)
```

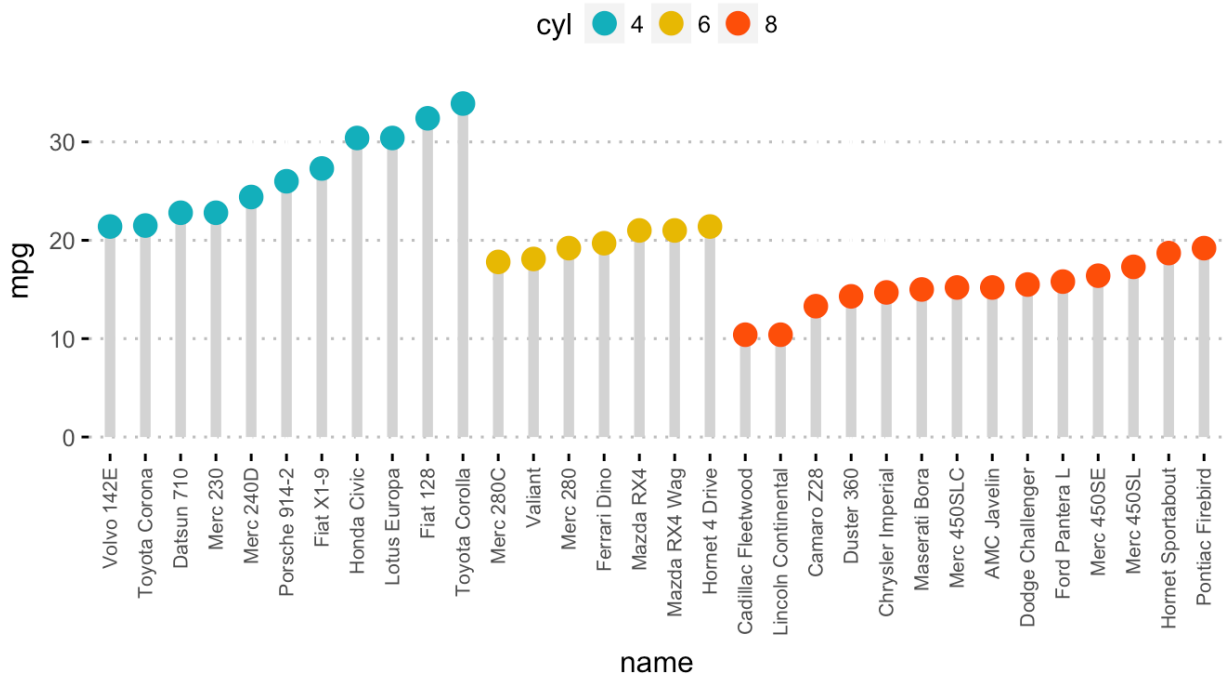


To sort bars inside each group, use the argument **sort.by.groups = TRUE**

- Create a Lollipop chart:

- Color by groups and set a custom color palette.
- Sort values in ascending order.
- Add segments from y = 0 to dots. Change segment color and size.

```
ggdotchart(dfm, x = "name", y = "mpg",
           color = "cyl",
           palette = c("#00AFBB", "#E7B800", "#FC4E07"),
           sorting = "asc", sort.by.groups = TRUE,
           add = "segments",
           add.params = list(color = "lightgray", size = 2),
           group = "cyl",
           dot.size = 4,
           ggtheme = theme_pubclean()
           )+
  font("x.text", size = 8, vjust = 0.5)
```



Read more: Bar Plots and Modern Alternatives

Conclusion

- Create a bar plot of a grouping variable:

```
ggplot(diamonds, aes(cut)) +
  geom_bar(fill = "#0073C2FF") +
  theme_minimal()
```

- Visualize a continuous variable:

Start by creating a plot, named `a`, that we'll be finished by adding a layer.

```
a <- ggplot(wdata, aes(x = weight))
```

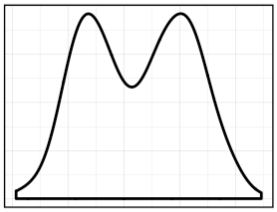
Possible layers include:

- **geom_density()**: density plot
- **geom_histogram()**: histogram plot
- **geom_freqpoly()**: frequency polygon
- **geom_area()**: area plot
- **geom_dotplot()**: dot plot
- **stat_ecdf()**: empirical cumulative density function
- **stat_qq()**: quantile - quantile plot

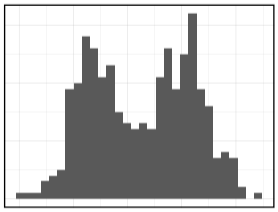
Key arguments to customize the plots:

- `color, size, linetype`: change the line color, size and type, respectively
- `fill`: change the areas fill color (for bar plots, histograms and density plots)
- `alpha`: create a semi-transparent color.

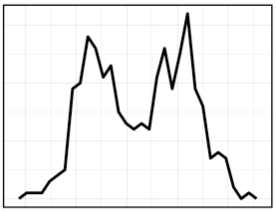
a + geom_density()



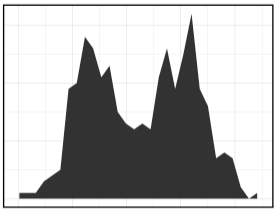
a + geom_histogram()



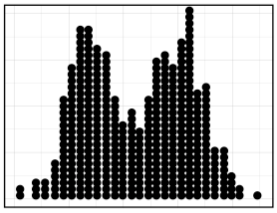
a + geom_freqpoly()



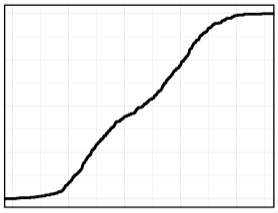
a + geom_area()



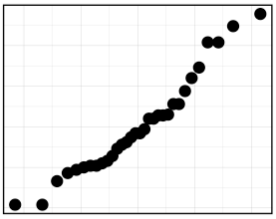
a + geom_dotplot()



a + stat_ecdf()



x + stat_qq()



References

Wilke, Claus O. 2017. *Ggridges: Ridgeline Plots in 'Ggplot2'*. https://CRAN.R-project.org/package=ggridges.