GGPlot2 Essentials

Great Data Visualization in R

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Edition 1
Datanovia.com

GGPlot2 Essentials for Great Data Visualization in R

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Published by STHDA (`http://www.sthda.com`), Alboukadel Kassambara

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Preface

0.1 What you will learn

GGPlot2 is a powerful and a flexible R package, implemented by Hadley Wickham, for producing elegant graphics piece by piece.

ggplot2 has become a popular package for data visualization. The official documentation of the package is available at: `https://ggplot2.tidyverse.org/reference/`. However, going through this comprehensive documentation can "drive you crazy"!

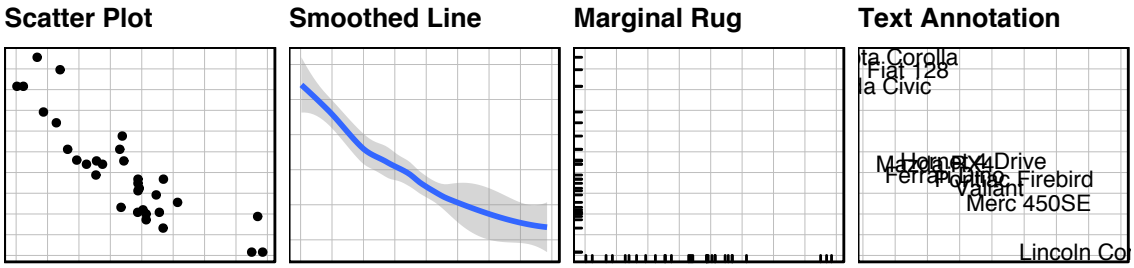
This book presents the essentials of ggplot2 to easily create beautiful graphics in R.

0.2 Key features of this book

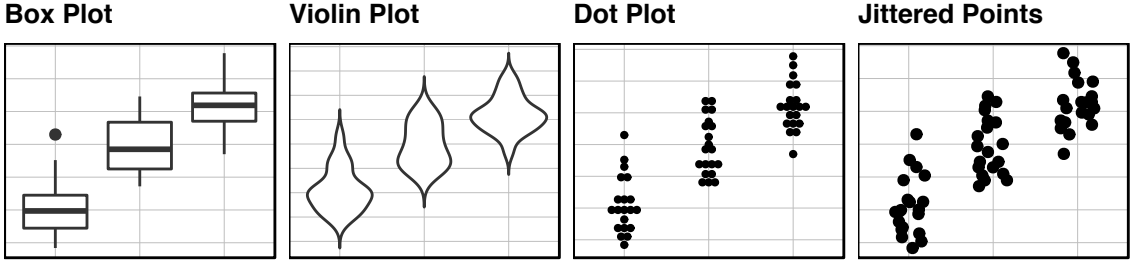
- Covers the most important graphic functions
- Short, self-contained chapters with practical examples.

Some examples of graphs, described in this book, are shown below.

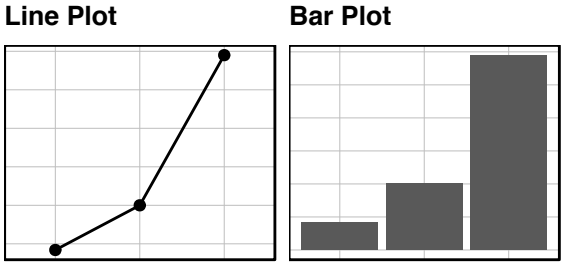
- Create **Scatter plots** to display the relationship between two continuous variables x and y



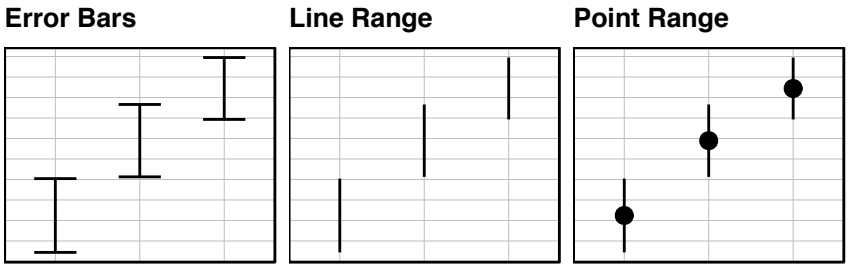
- Using Box plots and alternatives to visualize data grouped by the levels of a categorical variable



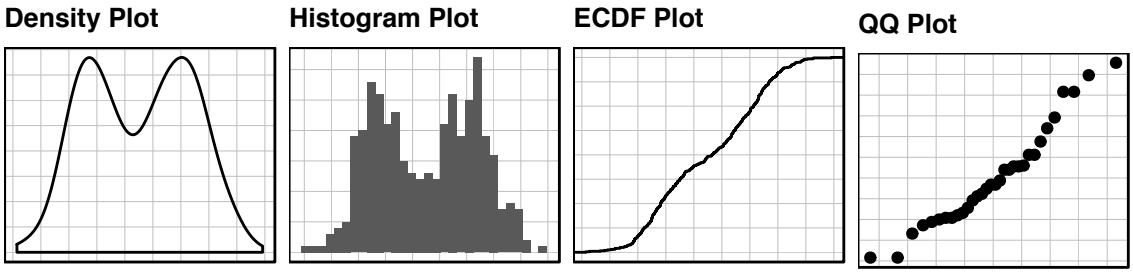
- Bar and Line Plots



- Visualizing error bars



- Inspecting the distribution of a **continuous variable** using **density plots**, **histograms** and alternatives



You will also learn how to combine multiple ggplots into one figure.

0.3 Book website

The website for this book is located at : `https://www.datanovia.com/english/`. It contains number of resources.

0.4 Executing the R codes from the PDF

For a single line R code, you can just copy the code from the PDF to the R console.

For a multiple-line R codes, an error is generated, sometimes, when you copy and paste directly the R code from the PDF to the R console. If this happens, a solution is to:

- Paste firstly the code in your R code editor or in your text editor
- Copy the code from your text/code editor to the R console

0.5 Colophon

This book was built with R 3.3.2 and the following packages :

```
##       name    version                   source
## 1 bookdown        0.7                     CRAN
## 2  cowplot      0.9.2                     CRAN
## 3    dplyr      0.7.7                     CRAN
## 4    dplyr      0.7.7                     CRAN
## 5  ggplot2 3.1.0.9000 Github:tidyverse/ggplot2
## 6   ggpubr        0.2  local:kassambara/ggpubr
## 7  ggrepel      0.8.0                     CRAN
## 8    readr      1.3.0                     CRAN
```

About the author

Alboukadel Kassambara is a PhD in Bioinformatics and Cancer Biology. He works since many years on genomic data analysis and visualization (read more: `http://www.alboukadel.com/`).

He has work experiences in statistical and computational methods to identify prognostic and predictive biomarker signatures through integrative analysis of large-scale genomic and clinical data sets.

He is the author of:

1) the bioinformatics tool named **GenomicScape** (www.genomicscape.com), an easy-to-use web tool for gene expression data analysis and visualization.
2) the **Datanovia** (`https://www.datanovia.com/en/`) and **STHDA** (`http://www.sthda.com/english/`) websites, which contains many courses and **tutorials** on data data mining and statistics for decision supports.
3) many popular **R packages** for multivariate data analysis, survival analysis, correlation matrix visualization and basic data visualization (`https://rpkgs.datanovia.com/`).
4) many **books** on data analysis, visualization and machine learning (`https://www.datanovia.com/en/shop/`)

Chapter 1

Introduction to R

R is a free and powerful statistical software for **analyzing** and **visualizing** data. If you want to learn easily the essential of R programming, visit our series of tutorials available on STHDA: `http://www.sthda.com/english/wiki/r-basics-quick-and-easy`.

In this chapter, we provide a very brief introduction to **R**, for installing R/RStudio as well as importing your data into R and installing required libraries.

1.1 Install R and RStudio

R and RStudio can be installed on Windows, MAC OSX and Linux platforms. RStudio is an integrated development environment for R that makes using R easier. It includes a console, code editor and tools for plotting.

1. R can be downloaded and installed from the Comprehensive R Archive Network (CRAN) webpage (`http://cran.r-project.org/`)
2. After installing R software, install also the RStudio software available at: `http://www.rstudio.com/products/RStudio/`.
3. Launch RStudio and start use R inside R studio.

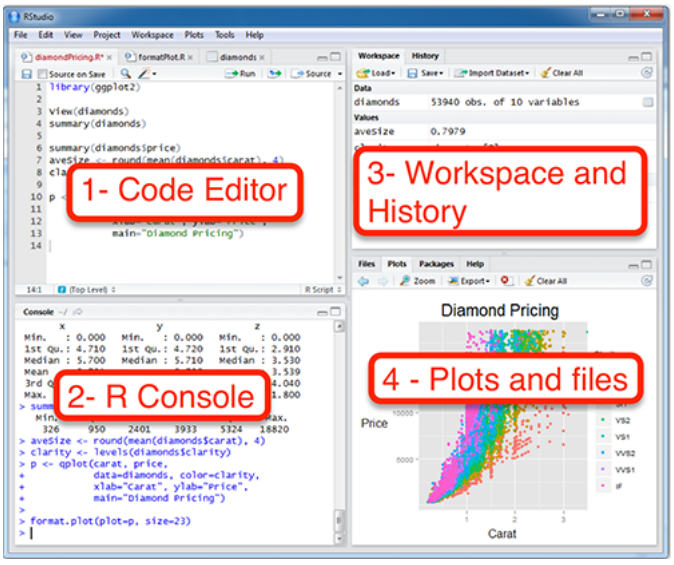


Figure 1.1: Rstudio interface

1.2 Install and load required R packages

An R package is a collection of functionalities that extends the capabilities of base R. For example, to use the R code provide in this book, you should install the following R packages:

- `tidyverse` packages, which are a collection of R packages that share the same programming philosophy. These packages include:
  - `readr`: for importing data into R
  - `dplyr`: for data manipulation
  - `ggplot2`: for data visualization.
- `ggpubr` package, which makes it easy, for beginner, to create publication ready plots.

1. **Install the tidyverse package**. Installing tidyverse will install automatically readr, dplyr, ggplot2 and more. Type the following code in the R console:

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

2. **Install the ggpubr package**.

```
install.packages("ggpubr")
```

3. **Load required packages**. After installation, you must first load the package for using the functions in the package. The function `library()` is used for this task. An alternative function is `require()`. For example, to load ggplot2 and ggpubr packages, type this:

```
library("ggplot2")
library("ggpubr")
```

Now, we can use R functions, such as *ggscatter*() [in the ggpubr package] for creating a scatter plot.

If you want a help about a given function, say ggscatter(), type this in R console: `?ggscatter`.

1.3 Data format

Your data should be in rectangular format, where columns are variables and rows are observations (individuals or samples).

- Column names should be compatible with R naming conventions. Avoid column with blank space and special characters. Good column names: `long_jump` or `long.jump`. Bad column name: `long jump`.
- Avoid beginning column names with a number. Use letter instead. Good column names: `sport_100m` or `x100m`. Bad column name: `100m`.
- Replace missing values by `NA` (for not available)

For example, your data should look like this:

```
  manufacturer model displ year cyl      trans drv
1         audi    a4   1.8 1999   4   auto(l5)   f
2         audi    a4   1.8 1999   4 manual(m5)   f
3         audi    a4   2.0 2008   4 manual(m6)   f
4         audi    a4   2.0 2008   4   auto(av)   f
```

Read more at: Best Practices in Preparing Data Files for Importing into R[1]

1.4 Import your data in R

First, save your data into txt or csv file formats and import it as follow (you will be asked to choose the file):

```
library("readr")

# Reads tab delimited files (.txt tab)
my_data <- read_tsv(file.choose())

# Reads comma (,) delimited files (.csv)
my_data <- read_csv(file.choose())

# Reads semicolon(;) separated files(.csv)
my_data <- read_csv2(file.choose())
```

Read more about how to import data into R at this link: `http://www.sthda.com/english/wiki/importing-data-into-r`

1.5 Demo data sets

R comes with several demo data sets for playing with R functions. The most used R demo data sets include: **USArrests**, **iris** and **mtcars**. To load a demo data set, use the function **data**() as follow. The function `head()` is used to inspect the data.

```
data("iris")   # Loading
head(iris, n = 3)  # Print the first n = 3 rows
```

```
##   Sepal.Length Sepal.Width Petal.Length Petal.Width Species
## 1          5.1         3.5          1.4         0.2  setosa
## 2          4.9         3.0          1.4         0.2  setosa
## 3          4.7         3.2          1.3         0.2  setosa
```

To learn more about iris data sets, type this:

```
?iris
```

After typing the above R code, you will see the description of `iris` data set: this iris data set gives the measurements in centimeters of the variables sepal length and width and petal length and width, respectively, for 50 flowers from each of 3 species of iris. The species are Iris setosa, versicolor, and virginica.

1.6 Data manipulation

After importing your data in R, you can easily manipulate it using the `dplyr` package (**?**), which can be installed using the R code: `install.packages("dplyr")`.

[1] `http://www.sthda.com/english/wiki/best-practices-in-preparing-data-files-for-importing-into-r`

After loading dplyr, you can use the following R functions:

- `filter()`: Pick rows (observations/samples) based on their values.
- `distinct()`: Remove duplicate rows.
- `arrange()`: Reorder the rows.
- `select()`: Select columns (variables) by their names.
- `rename()`: Rename columns.
- `mutate()`: Add/create new variables.
- `summarise()`: Compute statistical summaries (e.g., computing the mean or the sum)
- `group_by()`: Operate on subsets of the data set.

Note that, dplyr package allows to use the forward-pipe chaining operator (%>%) for combining multiple operations. For example, x %>% f is equivalent to f(x). Using the pipe (%>%), the output of each operation is passed to the next operation. This makes R programming easy.

Read more about Data Manipulation at this link: `https://www.datanovia.com/en/courses/data-manipulation-in-r/`

1.7 Close your R/RStudio session

Each time you close R/RStudio, you will be asked whether you want to save the data from your R session. If you decide to save, the data will be available in future R sessions.

Chapter 2

Introduction to GGPlot2

2.1 What is ggplot2

GGPlot2 is a powerful and a flexible R package, implemented by Hadley Wickham, for producing elegant graphics piece by piece (Wickham et al., 2017).

The **gg** in ggplot2 means *Grammar of Graphics*, a graphic concept which describes plots by using a "grammar". According to the ggplot2 concept, a plot can be divided into different fundamental parts: **Plot = data + Aesthetics + Geometry**

- **data**: a data frame
- **aesthetics**: used to indicate the **x** and **y** variables. It can be also used to control the **color**, the **size** and the **shape** of points, etc.....
- **geometry**: corresponds to the type of graphics (histogram, box plot, line plot, ...)

The ggplot2 syntax might seem opaque for beginners, but once you understand the basics, you can create and customize any kind of plots you want.

Note that, to reduce this opacity, we recently created an R package, named **ggpubr** (ggplot2 Based Publication Ready Plots), for making ggplot simpler for students and researchers with non-advanced programming backgrounds.

2.2 Key functions

After installing and loading the ggplot2 package, you can use the following key functions:

Plot types	GGPlot2 functions
Initialize a ggplot	ggplot()
Scatter plot	geom_point()
Box plot	geom_boxplot()
Violin plot	geom_violin()
strip chart	geom_jitter()
Dot plot	geom_dotplot()
Bar chart	geom_bar() or geom_col()
Line plot	geom_line()
Histogram	geom_histogram()
Density plot	geom_density()

Plot types	GGPlot2 functions
Error bars	geom_errorbar()
QQ plot	stat_qq()
ECDF plot	stat_ecdf()
Title and axis labels	labs()

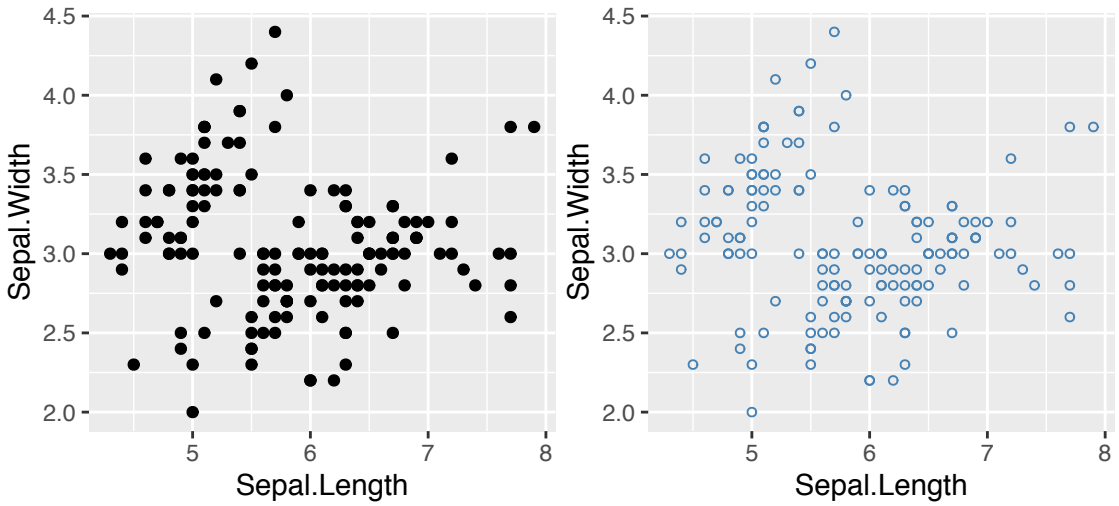
2.3 Example of plots

The main function in the ggplot2 package is `ggplot()`, which can be used to initialize the plotting system with data and x/y variables.

For example, the following R code takes the `iris` data set to initialize the ggplot and then a layer (`geom_point()`) is added onto the ggplot to create a scatter plot of `x = Sepal.Length` by `y = Sepal.Width`:

```
library(ggplot2)
ggplot(iris, aes(x = Sepal.Length, y = Sepal.Width))+
  geom_point()

# Change point size, color and shape
ggplot(iris, aes(x = Sepal.Length, y = Sepal.Width))+
  geom_point(size = 1.2, color = "steelblue", shape = 21)
```



Note that, in the code above, the shape of points is specified as number. The different point shape available in R, include: