STHDA

Statistical tools for high-throughput data analysis

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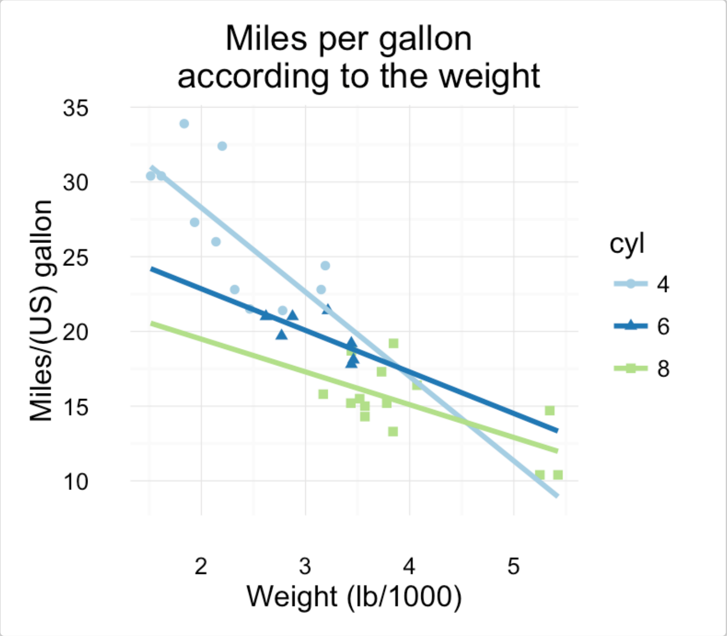
ggplot2 scatter plots : Quick start guide - R software and data visualization

Tools

This article describes how create a **scatter plot** using **R software** and **ggplot2** package. The function **geom_point()** is used.



Prepare the data

mtcars data sets are used in the examples below.

```
# Convert cyl column from a numeric to a factor variable
mtcars$cyl <- as.factor(mtcars$cyl)
head(mtcars)
```

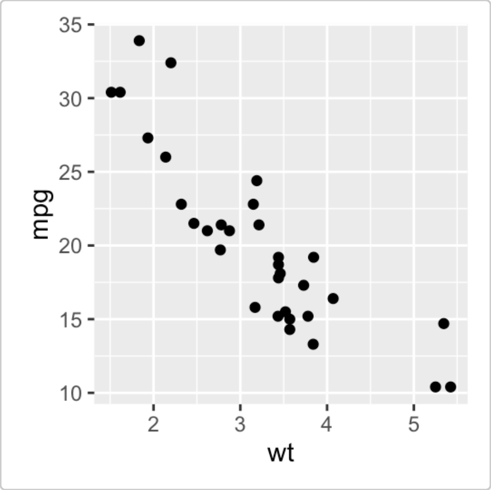
```
##                    mpg cyl disp  hp drat    wt  qsec vs am gear carb
## Mazda RX4         21.0   6  160 110 3.90 2.620 16.46  0  1    4    4
## Mazda RX4 Wag     21.0   6  160 110 3.90 2.875 17.02  0  1    4    4
## Datsun 710        22.8   4  108  93 3.85 2.320 18.61  1  1    4    1
## Hornet 4 Drive    21.4   6  258 110 3.08 3.215 19.44  1  0    3    1
## Hornet Sportabout 18.7   8  360 175 3.15 3.440 17.02  0  0    3    2
## Valiant           18.1   6  225 105 2.76 3.460 20.22  1  0    3    1
```

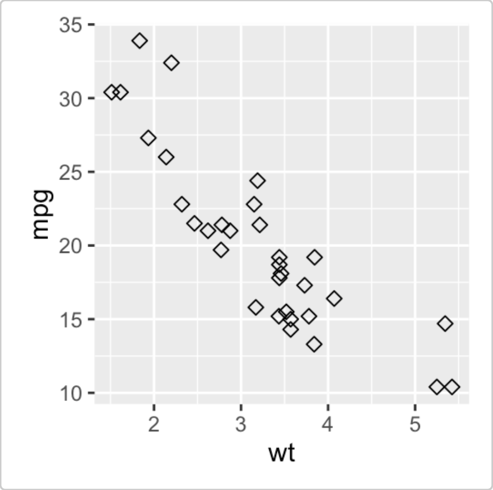
Basic scatter plots

Simple scatter plots are created using the R code below. The color, the size and the shape of points can be changed using the function **geom_point()** as follow :

```
geom_point(size, color, shape)
```

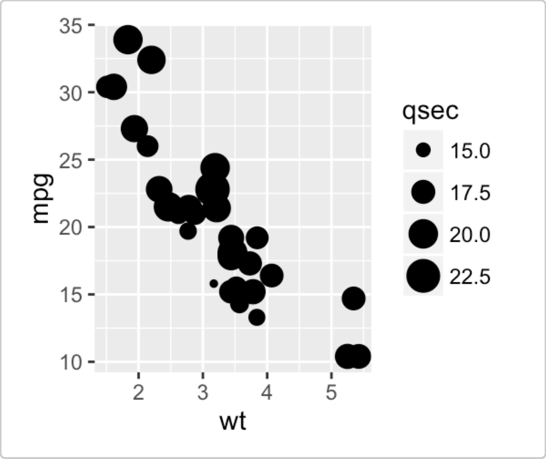
```r
library(ggplot2)
# Basic scatter plot
ggplot(mtcars, aes(x=wt, y=mpg)) + geom_point()
# Change the point size, and shape
ggplot(mtcars, aes(x=wt, y=mpg)) +
  geom_point(size=2, shape=23)
```





Note that, the size of the points can be controlled by the values of a continuous variable as in the example below.

```r
# Change the point size
ggplot(mtcars, aes(x=wt, y=mpg)) +
  geom_point(aes(size=qsec))
```

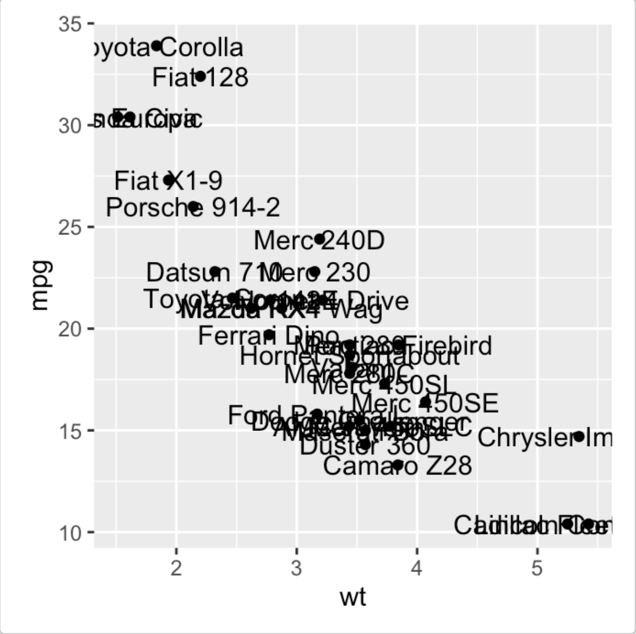


Read more on point shapes : ggplot2 point shapes

Label points in the scatter plot

The function **geom_text()** can be used :

```
ggplot(mtcars, aes(x=wt, y=mpg)) +
  geom_point() +
  geom_text(label=rownames(mtcars))
```



Read more on text annotations : ggplot2 - add texts to a plot

Add regression lines

The functions below can be used to add regression lines to a scatter plot :

- **geom_smooth()** and **stat_smooth()**
- **geom_abline()**

geom_abline() has been already described at this link : ggplot2 add straight lines to a plot.

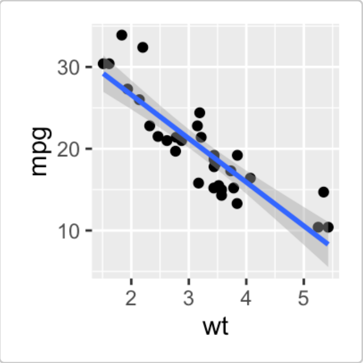
Only the function **geom_smooth()** is covered in this section.

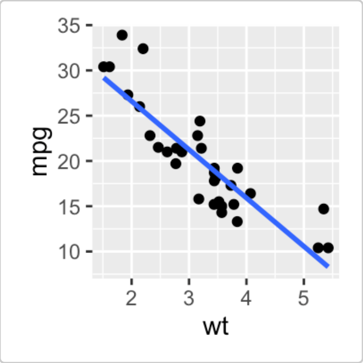
A simplified format is :

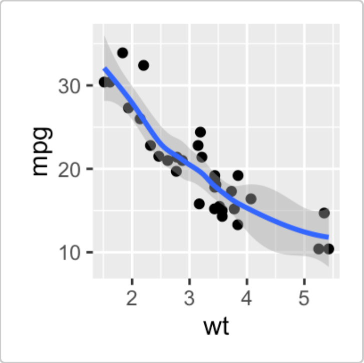
```
geom_smooth(method="auto", se=TRUE, fullrange=FALSE, level=0.95)
```

- **method** : smoothing method to be used. Possible values are lm, glm, gam, loess, rlm.
    - **method = "loess"**: This is the default value for small number of observations. It computes a smooth local regression. You can read more about **loess** using the R code **?loess**.
    - **method ="lm"**: It fits a **linear model**. Note that, it's also possible to indicate the formula as **formula = y ~ poly(x, 3)** to specify a degree 3 polynomial.
- **se** : logical value. If TRUE, confidence interval is displayed around smooth.
- **fullrange** : logical value. If TRUE, the fit spans the full range of the plot
- **level** : level of confidence interval to use. Default value is 0.95

```
# Add the regression line
ggplot(mtcars, aes(x=wt, y=mpg)) +
  geom_point()+
  geom_smooth(method=lm)
# Remove the confidence interval
ggplot(mtcars, aes(x=wt, y=mpg)) +
  geom_point()+
  geom_smooth(method=lm, se=FALSE)
# Loess method
ggplot(mtcars, aes(x=wt, y=mpg)) +
  geom_point()+
  geom_smooth()
```





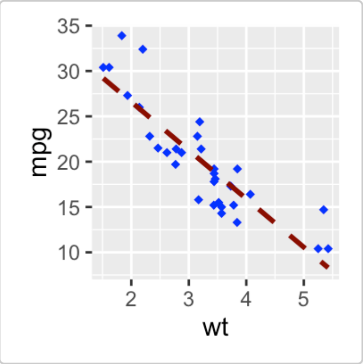


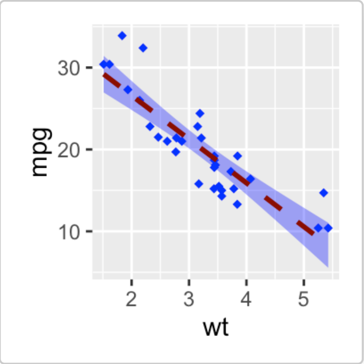
Change the appearance of points and lines

This section describes how to change :

- the color and the shape of points
- the line type and color of the regression line
- the fill color of the confidence interval

```
# Change the point colors and shapes
# Change the line type and color
ggplot(mtcars, aes(x=wt, y=mpg)) +
  geom_point(shape=18, color="blue")+
  geom_smooth(method=lm, se=FALSE, linetype="dashed",
             color="darkred")
# Change the confidence interval fill color
ggplot(mtcars, aes(x=wt, y=mpg)) +
  geom_point(shape=18, color="blue")+
  geom_smooth(method=lm,  linetype="dashed",
             color="darkred", fill="blue")
```





Note that a transparent color is used, by default, for the confidence band. This can be changed by using the argument *alpha* : *geom_smooth(fill="blue", alpha=1)*

Read more on point shapes : ggplot2 point shapes

Read more on line types : ggplot2 line types

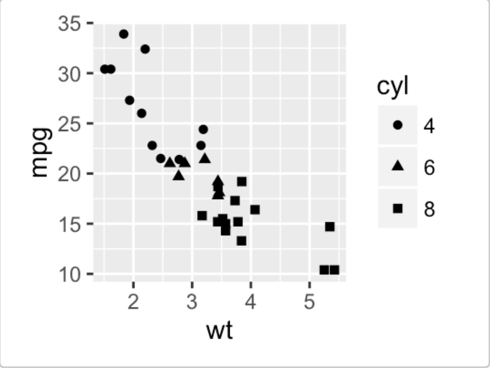
Scatter plots with multiple groups

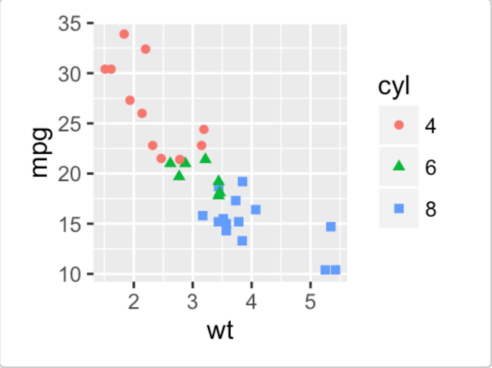
This section describes how to change point colors and shapes automatically and manually.

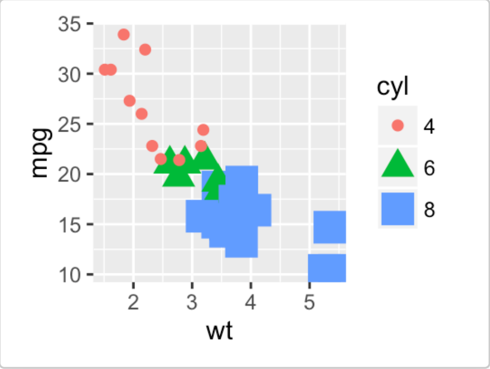
Change the point color/shape/size automatically

In the R code below, point shapes, colors and sizes are controlled by the levels of the factor variable *cyl* :

```
# Change point shapes by the levels of cyl
ggplot(mtcars, aes(x=wt, y=mpg, shape=cyl)) +
  geom_point()
# Change point shapes and colors
ggplot(mtcars, aes(x=wt, y=mpg, shape=cyl, color=cyl)) +
  geom_point()
# Change point shapes, colors and sizes
ggplot(mtcars, aes(x=wt, y=mpg, shape=cyl, color=cyl, size=cyl)) +
  geom_point()
```



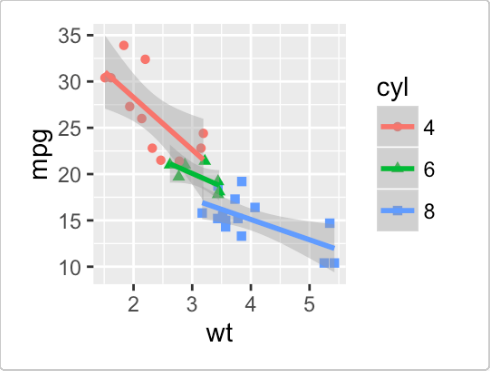


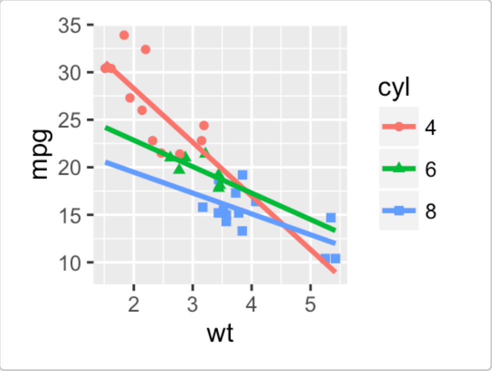


Add regression lines

Regression lines can be added as follow :

```
# Add regression lines
ggplot(mtcars, aes(x=wt, y=mpg, color=cyl, shape=cyl)) +
  geom_point() +
  geom_smooth(method=lm)
# Remove confidence intervals
# Extend the regression lines
ggplot(mtcars, aes(x=wt, y=mpg, color=cyl, shape=cyl)) +
  geom_point() +
  geom_smooth(method=lm, se=FALSE, fullrange=TRUE)
```

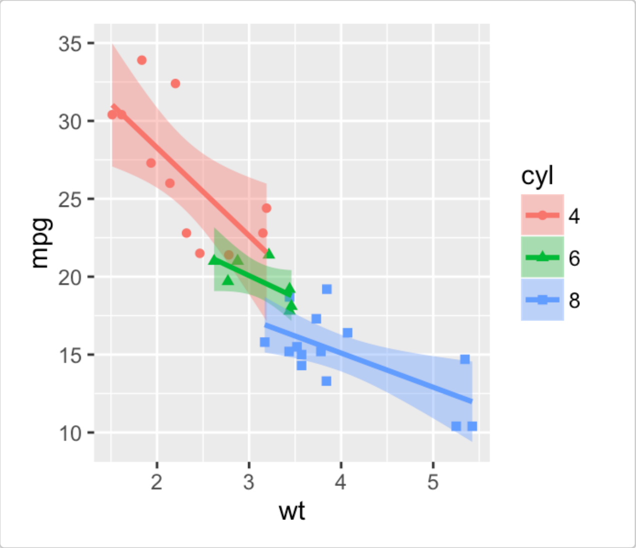




⚠ Note that, you can also change the line type of the regression lines by using the aesthetic *linetype = cyl*.

The fill color of confidence bands can be changed as follow :

```
ggplot(mtcars, aes(x=wt, y=mpg, color=cyl, shape=cyl)) +
  geom_point() + 
  geom_smooth(method=lm, aes(fill=cyl))
```



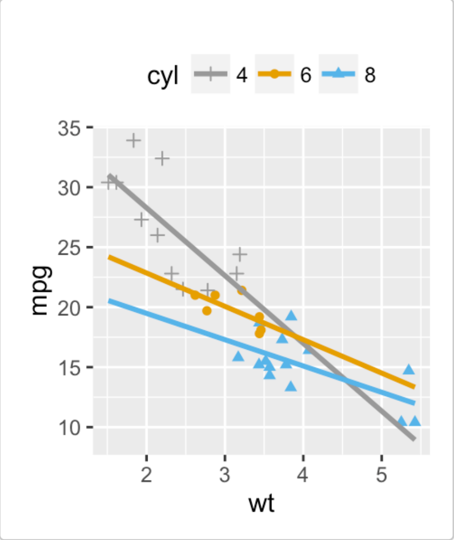
Change the point color/shape/size manually

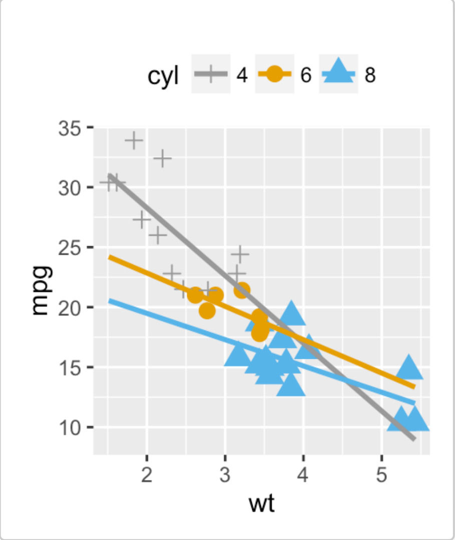
The functions below are used :

- *scale_shape_manual()* for point shapes
- *scale_color_manual()* for point colors
- *scale_size_manual()* for point sizes

```
# Change point shapes and colors manually
ggplot(mtcars, aes(x=wt, y=mpg, color=cyl, shape=cyl)) +
  geom_point() + 
  geom_smooth(method=lm, se=FALSE, fullrange=TRUE)+
  scale_shape_manual(values=c(3, 16, 17))+ 
  scale_color_manual(values=c('#999999','#E69F00', '#56B4E9'))+
  theme(legend.position="top")

# Change the point sizes manually
ggplot(mtcars, aes(x=wt, y=mpg, color=cyl, shape=cyl))+
  geom_point(aes(size=cyl)) + 
  geom_smooth(method=lm, se=FALSE, fullrange=TRUE)+
  scale_shape_manual(values=c(3, 16, 17))+ 
  scale_color_manual(values=c('#999999','#E69F00', '#56B4E9'))+
  scale_size_manual(values=c(2,3,4))+
  theme(legend.position="top")
```

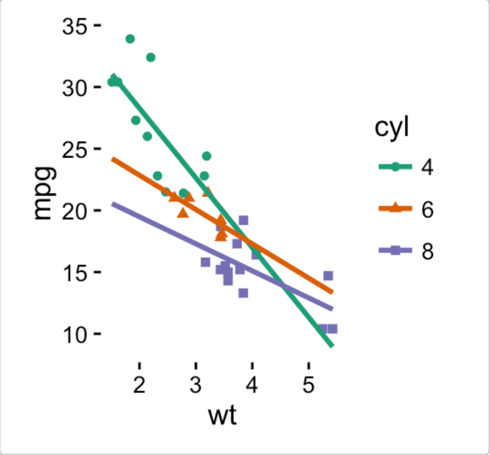


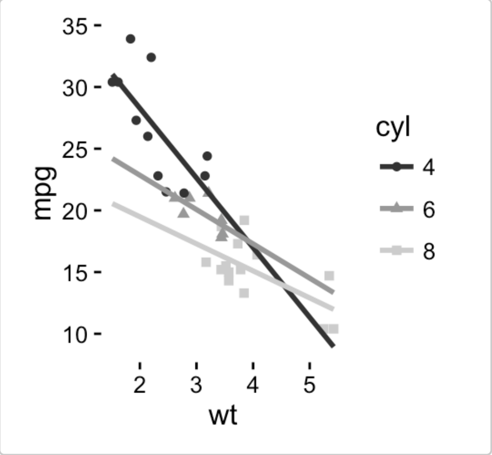


It is also possible to *change manually point and line colors* using the functions :

- *scale_color_brewer()* : to use color palettes from *RColorBrewer* package
- *scale_color_grey()* : to use grey color palettes

```
p <- ggplot(mtcars, aes(x=wt, y=mpg, color=cyl, shape=cyl)) +
  geom_point() +
  geom_smooth(method=lm, se=FALSE, fullrange=TRUE)+
  theme_classic()
# Use brewer color palettes
p+scale_color_brewer(palette="Dark2")
# Use grey scale
p + scale_color_grey()
```





Read more on ggplot2 colors here : ggplot2 colors

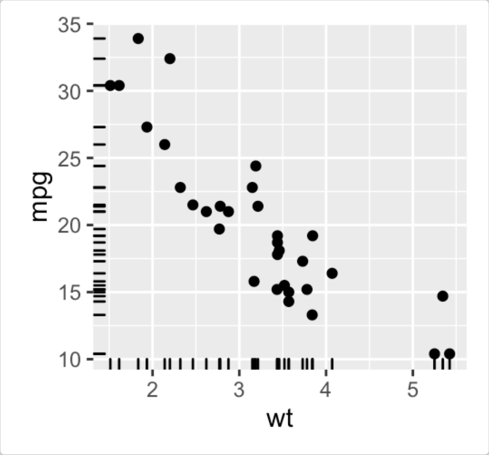
Add marginal rugs to a scatter plot

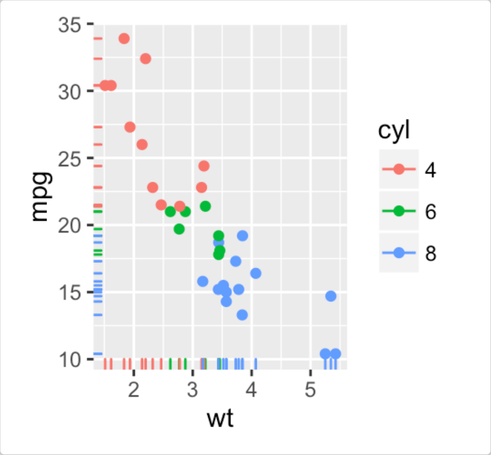
The function **geom_rug()** can be used :

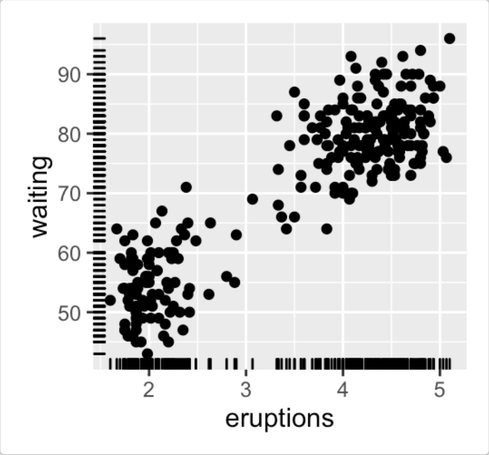
```
geom_rug(sides ="bl")
```

sides : a string that controls which sides of the plot the rugs appear on. Allowed value is a string containing any of "trbl", for top, right, bottom, and left.

```
# Add marginal rugs
ggplot(mtcars, aes(x=wt, y=mpg)) +
  geom_point() + geom_rug()
# Change colors
ggplot(mtcars, aes(x=wt, y=mpg, color=cyl)) +
  geom_point() + geom_rug()
# Add marginal rugs using faithful data
ggplot(faithful, aes(x=eruptions, y=waiting)) +
  geom_point() + geom_rug()
```





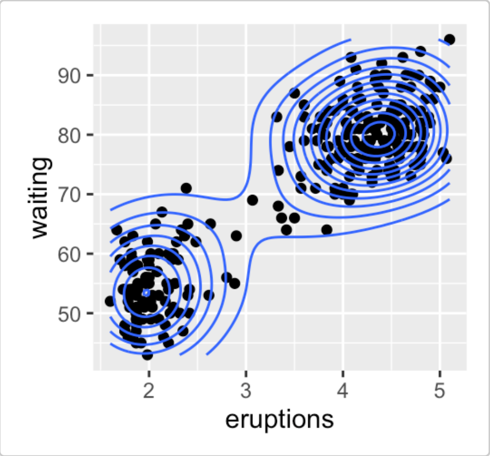


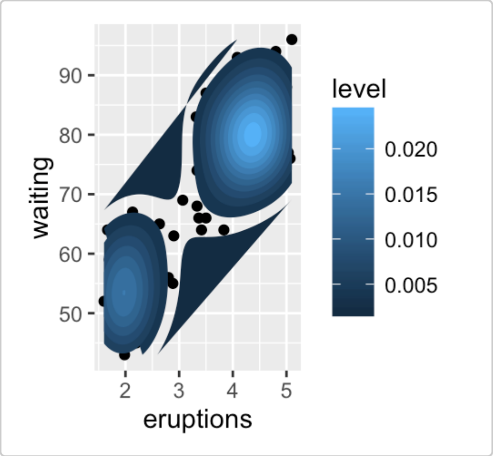
Scatter plots with the 2d density estimation

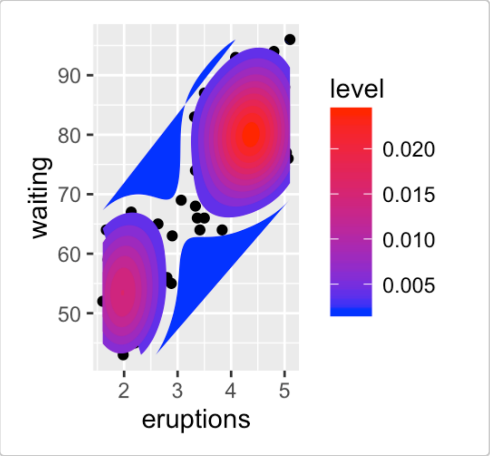
The functions **geom_density_2d()** or **stat_density_2d()** can be used :

```
# Scatter plot with the 2d density estimation
sp <- ggplot(faithful, aes(x=eruptions, y=waiting)) +
  geom_point()
sp + geom_density_2d()
```

```
# Gradient color
sp + stat_density_2d(aes(fill = ..level..), geom="polygon")
# Change the gradient color
sp + stat_density_2d(aes(fill = ..level..), geom="polygon")+
  scale_fill_gradient(low="blue", high="red")
```





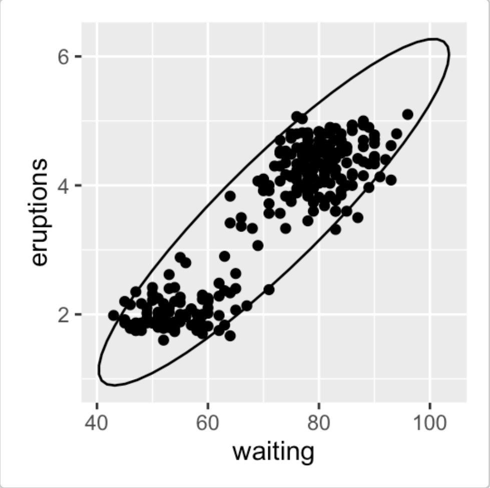


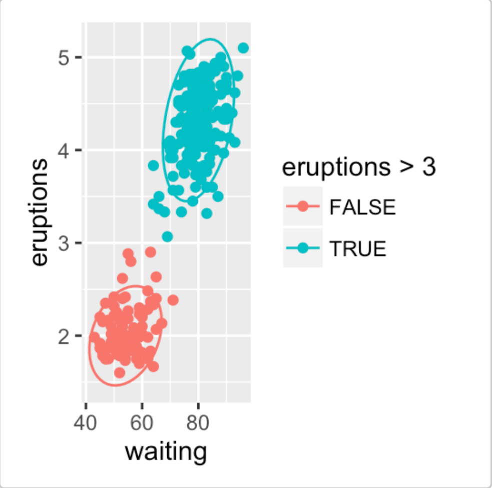
Read more on ggplot2 colors here : ggplot2 colors

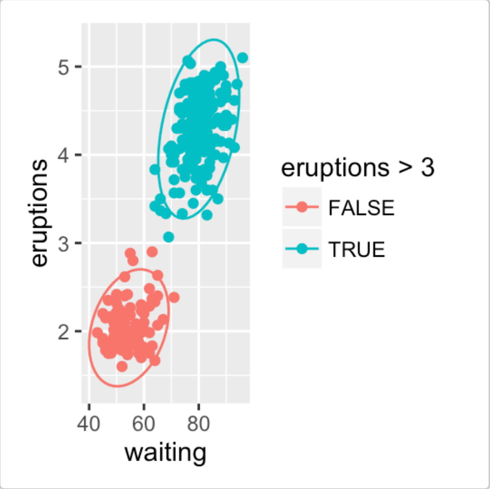
Scatter plots with ellipses

The function **stat_ellipse()** can be used as follow:

```
# One ellipse arround all points
ggplot(faithful, aes(waiting, eruptions))+
  geom_point()+
  stat_ellipse()
# Ellipse by groups
p <- ggplot(faithful, aes(waiting, eruptions, color = eruptions > 3))+
  geom_point()
p + stat_ellipse()
# Change the type of ellipses: possible values are "t", "norm", "euclid"
p + stat_ellipse(type = "norm")
```







Scatter plots with rectangular bins

The number of observations is counted in each bins and displayed using any of the functions below :

- **geom_bin2d()** for adding a heatmap of 2d bin counts
- **stat_bin_2d()** for counting the number of observation in rectangular bins
- **stat_summary_2d()** to apply function for 2D rectangular bins

The simplified formats of these functions are :

```
plot + geom_bin2d(...)
plot+stat_bin_2d(geom=NULL, bins=30)
plot + stat_summary_2d(geom = NULL, bins = 30, fun = mean)
```

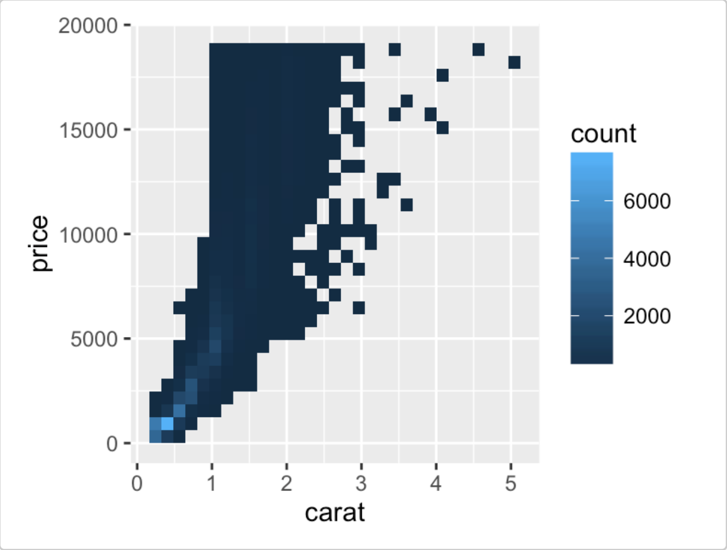
- **geom** : geometrical object to display the data
- **bins** : Number of bins in both vertical and horizontal directions. The default value is 30
- **fun** : function for summary

The data sets *diamonds* from ggplot2 package is used :

```
head(diamonds)
```

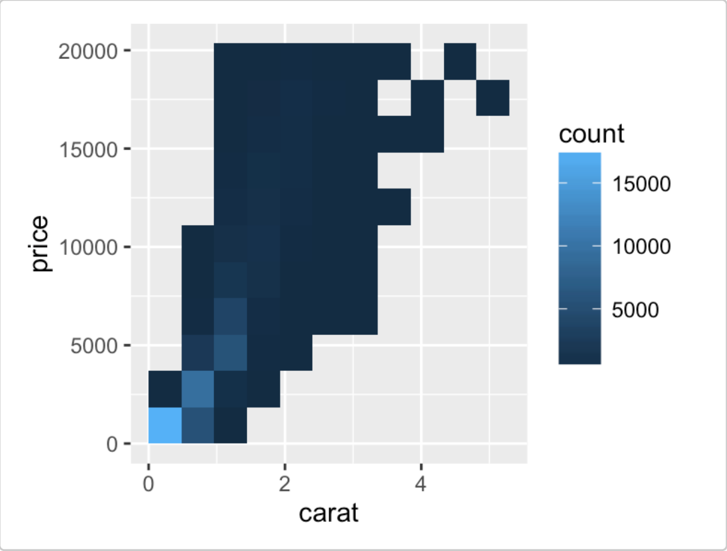
```
##   carat       cut color clarity depth table price    x    y    z
## 1  0.23     Ideal     E     SI2  61.5    55   326 3.95 3.98 2.43
## 2  0.21   Premium     E     SI1  59.8    61   326 3.89 3.84 2.31
## 3  0.23      Good     E     VS1  56.9    65   327 4.05 4.07 2.31
## 4  0.29   Premium     I     VS2  62.4    58   334 4.20 4.23 2.63
## 5  0.31      Good     J     SI2  63.3    58   335 4.34 4.35 2.75
## 6  0.24 Very Good     J    VVS2  62.8    57   336 3.94 3.96 2.48
```

```
# Plot
p <- ggplot(diamonds, aes(carat, price))
p + geom_bin2d()
```



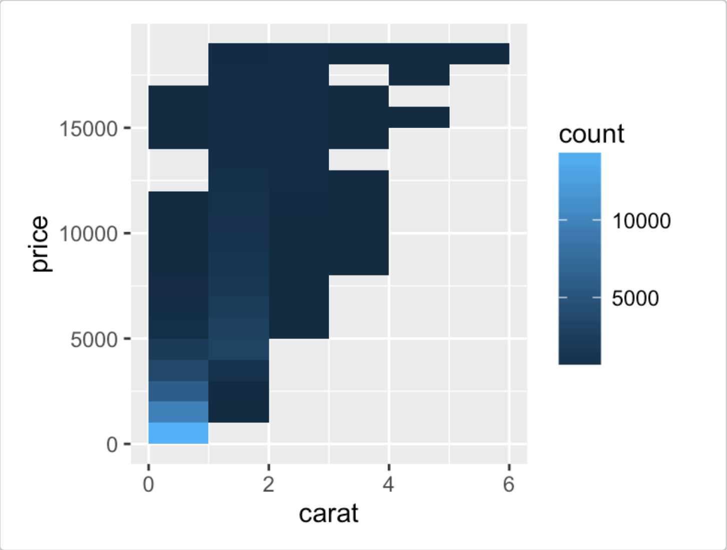
Change the number of bins :

```
# Change the number of bins
p + geom_bin2d(bins=10)
```



Or specify the width of bins :

```
# Or specify the width of bins
p + geom_bin2d(binwidth=c(1, 1000))
```



Scatter plot with marginal density distribution plot

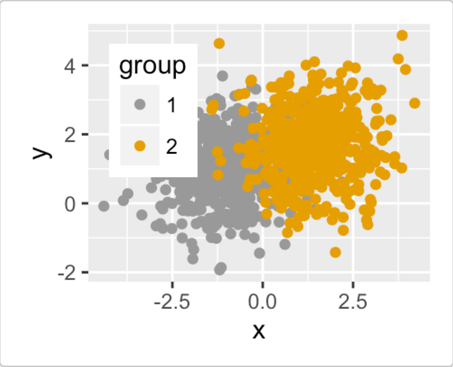
Step 1/3. Create some data :

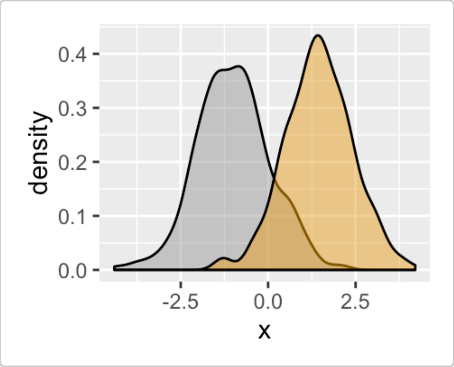
```
set.seed(1234)
x <- c(rnorm(500, mean = -1), rnorm(500, mean = 1.5))
y <- c(rnorm(500, mean = 1), rnorm(500, mean = 1.7))
group <- as.factor(rep(c(1,2), each=500))
df <- data.frame(x, y, group)
head(df)
```

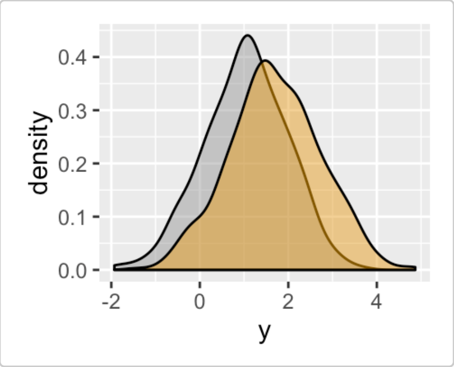
```
##             x          y group
## 1 -2.20706575 -0.2053334     1
## 2 -0.72257076  1.3014667     1
## 3  0.08444118 -0.5391452     1
## 4 -3.34569770  1.6353707     1
## 5 -0.57087531  1.7029518     1
## 6 -0.49394411 -0.9058829     1
```

Step 2/3. Create the plots :

```
# scatter plot of x and y variables
# color by groups
scatterPlot <- ggplot(df,aes(x, y, color=group)) +
  geom_point() +
  scale_color_manual(values = c('#999999','#E69F00')) +
  theme(legend.position=c(0,1), legend.justification=c(0,1))
scatterPlot
# Marginal density plot of x (top panel)
xdensity <- ggplot(df, aes(x, fill=group)) + 
  geom_density(alpha=.5) + 
  scale_fill_manual(values = c('#999999','#E69F00')) + 
  theme(legend.position = "none")
xdensity
# Marginal density plot of y (right panel)
ydensity <- ggplot(df, aes(y, fill=group)) + 
  geom_density(alpha=.5) + 
  scale_fill_manual(values = c('#999999','#E69F00')) + 
  theme(legend.position = "none")
ydensity
```







Create a blank placeholder plot :

```
blankPlot <- ggplot()+geom_blank(aes(1,1))+
  theme(plot.background = element_blank(), 
   panel.grid.major = element_blank(),
   panel.grid.minor = element_blank(), 
   panel.border = element_blank(),
   panel.background = element_blank(),
   axis.title.x = element_blank(),
   axis.title.y = element_blank(),
   axis.text.x = element_blank(), 
   axis.text.y = element_blank(),
   axis.ticks = element_blank()
     )
```

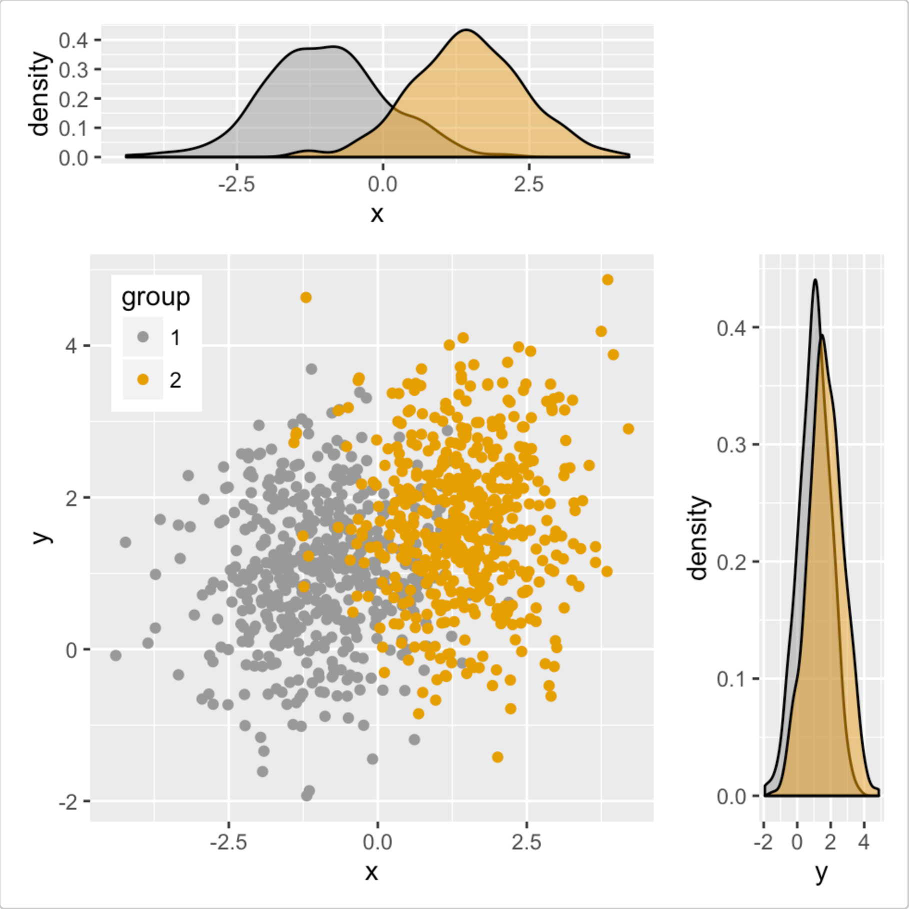
Step 3/3. Put the plots together:

To put multiple plots on the same page, the package **gridExtra** can be used. Install the package as follow :

```
install.packages("gridExtra")
```

Arrange ggplot2 with adapted height and width for each row and column :

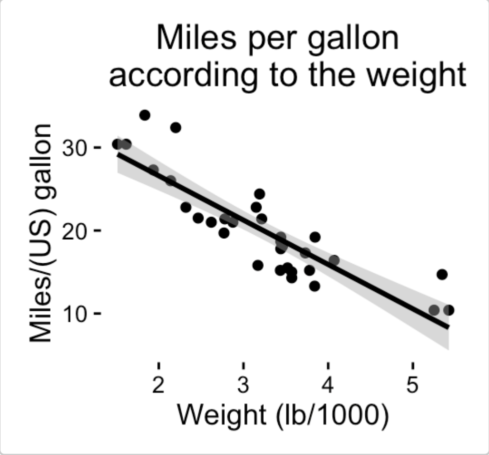
```
library("gridExtra")
grid.arrange(xdensity, blankPlot, scatterPlot, ydensity,
        ncol=2, nrow=2, widths=c(4, 1.4), heights=c(1.4, 4))
```

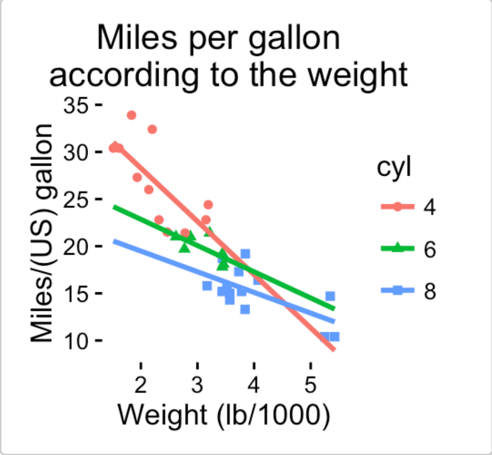


Read more on how to arrange multiple ggplots in one page : ggplot2 - Easy way to mix multiple graphs on the same page

Customized scatter plots

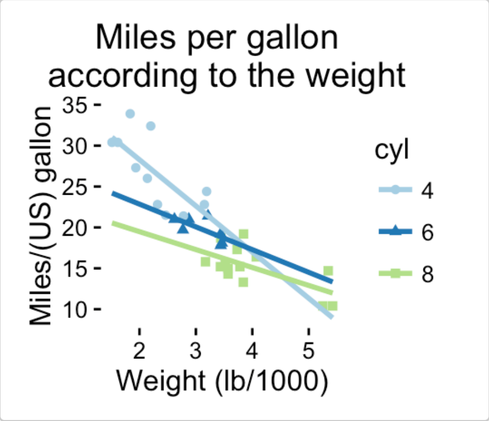
```
# Basic scatter plot
ggplot(mtcars, aes(x=wt, y=mpg)) +
  geom_point()+
  geom_smooth(method=lm, color="black")+
  labs(title="Miles per gallon \n according to the weight",
       x="Weight (lb/1000)", y = "Miles/(US) gallon")+
  theme_classic()
# Change color/shape by groups
# Remove confidence bands
p <- ggplot(mtcars, aes(x=wt, y=mpg, color=cyl, shape=cyl)) +
  geom_point()+
  geom_smooth(method=lm, se=FALSE, fullrange=TRUE)+
  labs(title="Miles per gallon \n according to the weight",
       x="Weight (lb/1000)", y = "Miles/(US) gallon")
p + theme_classic()
```

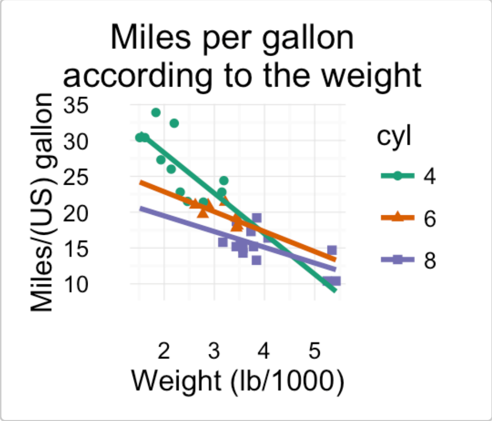


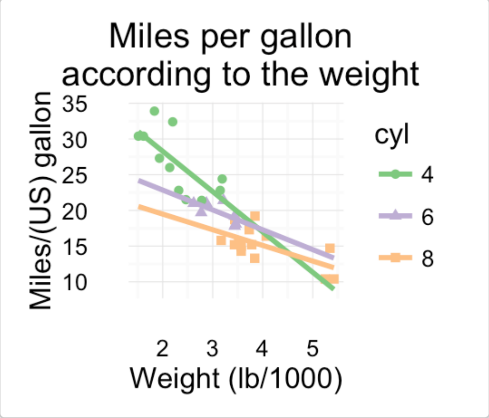


Change colors manually :

```
# Continuous colors
p + scale_color_brewer(palette="Paired") + theme_classic()
# Discrete colors
p + scale_color_brewer(palette="Dark2") + theme_minimal()
# Gradient colors
p + scale_color_brewer(palette="Accent") + theme_minimal()
```







Read more on ggplot2 colors here : ggplot2 colors

Infos

⚠ This analysis has been performed using **R software** (ver. 3.2.4) and **ggplot2** (ver. 2.1.0)

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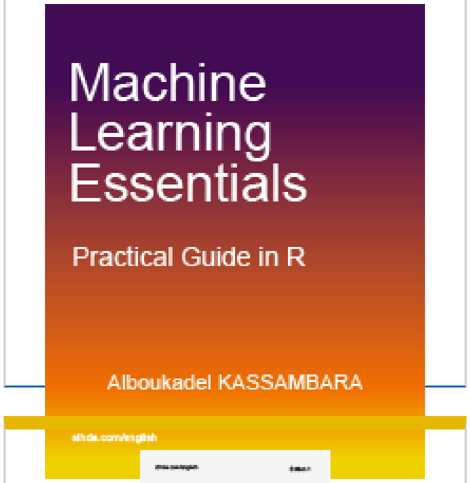

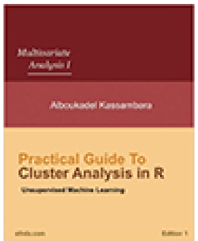
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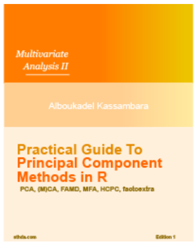
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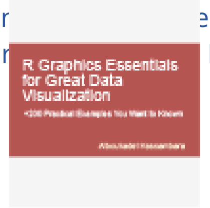

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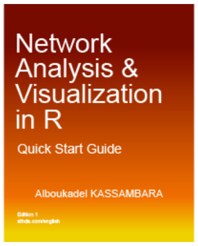

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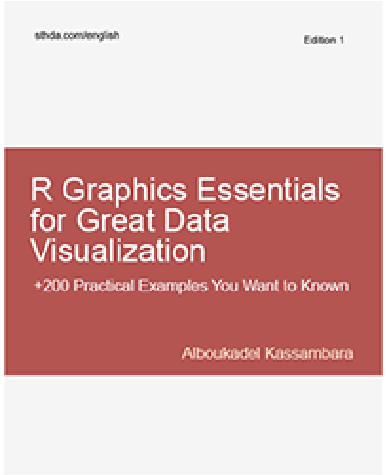

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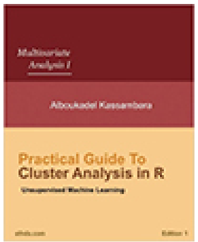

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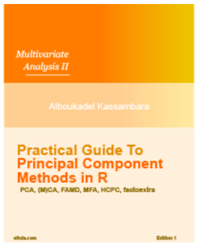

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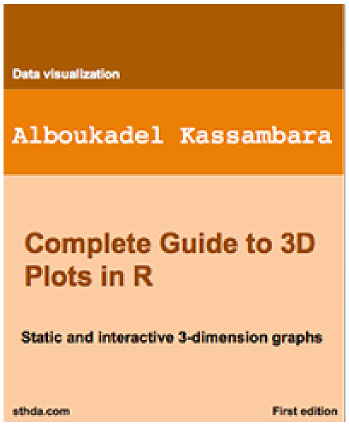

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