

# Graphics in R

A. Ardalan  
Statistician & Data Analyst  
[a.ardalan07@gmail.com](mailto:a.ardalan07@gmail.com)

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# Overview of R graphics

## 1. Standard graphics in R

- ▶ The graphics package, as the [base graphics system](#), provides a complete set of functions for creating a wide variety of plots.

[grid system](#):

## 2. Trellis & lattice graphics

- ▶ The techniques were given the name Trellis because: usually results are in a [rectangular array of plots](#).

## 3. Grammar of Graphics ggplot2

- ▶ A powerful approach, based on the [“Grammar of Graphics”](#)

# Expectation Setting

I am assuming the following:

- ▶ You are experienced with R coding - not an expert, but you can hack.
- ▶ You have some statistical knowledge (e.g., what is a histogram or Boxplot).

This is a quick intro to data visualization with R:

- ▶ I will gloss over a lot of things .
- ▶ More in-depth coverage is available via resources I will mention at the end.
- ▶ My goal is to make you excited about graphics in R.
  - ▶ [GitHub URL:][<https://github.com/ArashArd/Graphics-in-R>]

## Prerequisites

- ▶ To follow along you will need the following:
  - ▶ R
  - ▶ RStudio

# Types of more common use Statistical Graphs

## Types of Data (Variables)

### Numeical Variables

- ▶ Estimation and shape of Distribution
  - ▶ Histogram and Density plots
  - ▶ Box-plot
- ▶ Comparisons
  - ▶ Box-plots & Violin plots
- ▶ Associations and finding the structure between variables
  - ▶ Scatter plots
  - ▶ Time series plots
- ▶ Other Advanced Graphic Tools

### Categorical Variables

- ▶ Count and Percentages
  - ▶ Bar charts and Pie charts

### Explore Graphics

# Data Sets Which I am using here

## Titanic Data set

RMS Titanic was a British passenger liner which sank in the North Atlantic Ocean on 15 April 1912 after striking an iceberg. Voyage: from UK to US.

head	pclass	survived	Residence	name	age	sibsp	parch	ticket	fare	cabin	embarked	boat	body	home.dest	Gender
1	3rd	Died	American	Abbing, Mr. Anthony	42	0	0	C.A. 5547	7.55	S					Male
2	3rd	Died	American	Abbott, Master. Eugene Joseph	13	0	2	C.A. 2673	20.25	S				East Providence, RI	Male
3	3rd	Died	American	Abbott, Mr. Rossmore Edward	16	1	1	C.A. 2673	20.25	S			190	East Providence, RI	Male
4	3rd	Survived	American	Abbott, Mrs. Stanton (Rosa Hunt)	35	1	1	C.A. 2673	20.25	S		A		East Providence, RI	Female
5	3rd	Survived	Other	Abelseth, Miss. Karen Marie	16	0	0	348125	7.65	S		16		Norway Los Angeles, CA	Female

## USArrests Data set

Violent Crime Rates by US State

head	Murder	Assault	UrbanPop	Rape
Alabama	13.2	236	58	21.2
Alaska	10.0	263	48	44.5
Arizona	8.1	294	80	31.0
Arkansas	8.8	190	50	19.5
California	9.0	276	91	40.6

## 'mtcars' Data set

Motor Trend Car Road Tests

head	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

# Types of Graphs in R

- ▶ High Level

Some examples of high level graphics functions are:

- ▶ Pie Charts, Bar Charts and Histograms
- ▶ Box-and-Whisker Plots
- ▶ Scatter plots
- ▶ Time Series Plots
- ▶ Surface Plots
- ▶ Other Advanced Plots

- ▶ Low Level

The high-level graphics facilities in R are built on a set of flexible low-level ones. The low level facilities include:

- ▶ Page Layout
- ▶ Setup of Plotting Coordinates
- ▶ Drawing Points and Lines
- ▶ Drawing Polygons and Rectangles
- ▶ Color Management

## graphics package: base graphics system

### 1. **plot**

The '**plot**' function produces an entire graph with a single function call.

It can be useful to access graphics functionality at a **lower level** so that it is possible to create graphs in a much more flexible way.

### 2. **plot.new**

### 3. **plot.window**

- ▶ The functions **plot.new** and **plot.window** are the functions which make it possible to work in this low-level way.
- ▶ **plot.new** is used to **begin a new plot**,
- ▶ **plot.window** is used to **set up coordinate systems**.
- ▶ Neither function does any actual drawing.

# Graphical commands

High level graphical commands create the plot

commands	Type of plots
plot()	Scatter plot, and general plotting
hist()	Histogram
barplot()	Barplot
boxplot()	Boxplot
pairs()	Plots for multivariate data (Matrix scatter plots)
qqnorm()	Normal probability plot

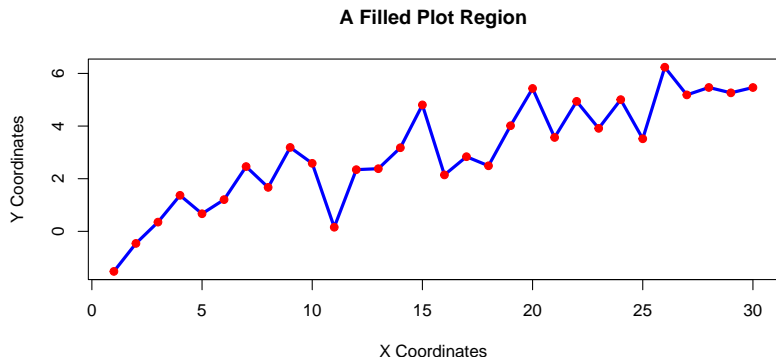
Low level graphical commands add to the plot

commands	Description
points()	Add points
lines()	Add lines
rect()	Add rectangle
text()	Add text
abline()	Add lines
arrows()	Add arrows
segments()	add line segment



# A Simple High-Level Plot

```
x = 1:30 ; y = rnorm(30) + x/5 # Generating x and y: numeric  
  
plot(x = x, y = y, xlim = range(x), ylim = range(y),  
     xlab = "X Coordinates", ylab = "Y Coordinates",  
     main = "A Filled Plot Region", type = 'n')  
lines(x, y, lwd = 3, col = "blue")  
points(x, y, pch = 19, col = "red")
```



## plot function: all in one

The type argument of the plot function

commands	Description
<code>plot(..., type = "p")</code>	points
<code>plot(..., type = "l")</code>	lines
<code>plot(..., type = "b")</code>	points connected by lines
<code>plot(..., type = "o")</code>	lines are over the points
<code>plot(..., type = "h")</code>	vertical lines
<code>plot(..., type = "s")</code>	steps
<code>plot(..., type = "n")</code>	No plotting

Type of the line

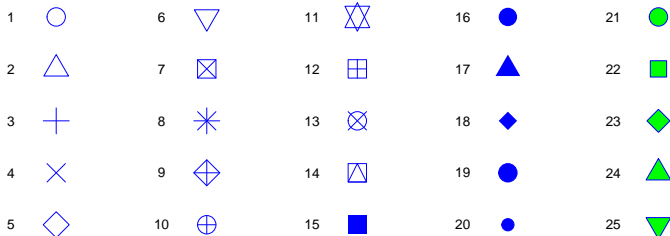
- ▶ `plot(..., type = "l", lty = 1)` # solid (lty: line type)
- ▶ `plot(..., type = "l", lty = 2)` # dashed
- ▶ `plot(..., type = "l", lty = 3)` # dotted
- ▶ `plot(..., type = "l", lty = 4)` # dotdash
- ▶ `plot(..., type = "l", lty = 5)` # longdash

# Point Characters

```
plot.new(); plot.window(xlim = c(4, 26), ylim = c(3, 26) )
```

```
r = rep(1:5 * 5, each = 5); t = rep(5:1 * 5, 5)
points(r, t,
       pch = 1:25,      # Symbol
       cex = 3,         # Size of the symbol
       col = "blue",    # Border color of the symbol
       bg  = "green")   # Background color of the symbol

text(r - 1.5, t, 1:25)
```



# Drawing a Boxplot : Step by Step, using Low-level graphics

```
par(mar = c(2, 2.5, 0, 0)) # Setting the Margins
mydata = rnorm(n = 50, mean = 1, sd = 4); x = mydata; n = length(mydata) # Generating 50 data from Normal

Minx = min(x); Maxx = max(x); Quarts = quantile(x, c(0.25, 0.5, 0.75)) # Finding the min, max and Quartile
SM = c(Minx, Quarts, Maxx); names(SM) = c('Min', paste('Q', 1:3, sep = ''), 'Max') # Summary of data in 5
SM
```

```
##           Min           Q1           Q2           Q3           Max
## -10.2139234  -2.4662382   0.9025534   2.9032375   7.9172575
```

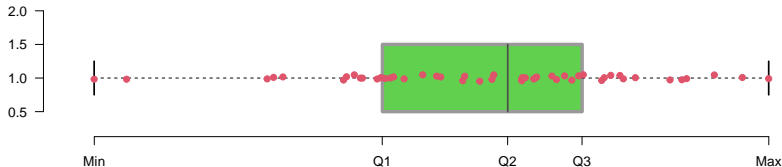
```
plot.new()
plot.window(xlim = c(Minx - 0.15 * sd(x), Maxx + 0.15 * sd(x)), ylim = c(0.2, 2) )

rect(xleft = SM[2], ybottom = 0.5, xright = SM[4], ytop = 1.5, lwd = 4, col = 3, border = "gray60")

segments(x0 = SM[1], y0 = 1, x1 = SM[2], y1 = 1, lty = 'dashed')
segments(x0 = SM[4], y0 = 1, x1 = SM[5], y1 = 1, lty = 'dashed')

segments(SM[1], 0.75, SM[1], 1.25, lwd = 2)
segments(SM[5], 0.75, SM[5], 1.25, lwd = 2)
segments(SM[3], 0.5, SM[3], 1.5, lwd = 2, col = "gray30" )
axis(1, at = round(SM,2), labels = names(SM)); axis(2, las = 2)

points(x = mydata, y = runif(n, 0.95, 1.05), col = 2, pch = 19)
```



# A Histogram : Step by Step, using Low-level graphics

```
par(mar = c(2, 2.5, 2, 0))
```

```
k = 5                                # number of classes or bars
widthx = (Maxx - Minx)/k             # Setting the bin

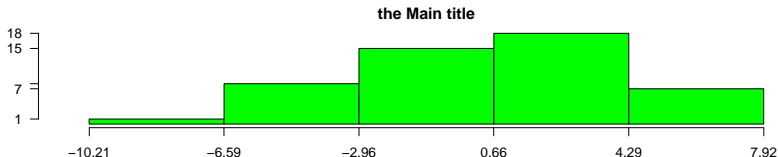
cut_ps = seq(Minx, Maxx, by = widthx) # Setting the cut-points
grx     = cut(x, cut_ps)              # classified the data in groups
(TF     = table(grx))                 # Tabulate the grouped
```

```
## grx
## (-10.2,-6.59] (-6.59,-2.96] (-2.96,0.665] (0.665,4.29] (4.29,7.92]
##           1           8           15           18           7
```

```
plot.new()
plot.window(xlim = c(Minx - 0.15 * sd(x), Maxx + 0.15 * sd(x)), ylim = c(0, max(TF)) )
Hist_col = 'green'
for(i in 1:length(TF))
  polygon(x = rep(cut_ps[i:(i+1)], each = 2), y = c(0, TF[i], TF[i], 0), col = Hist_col)

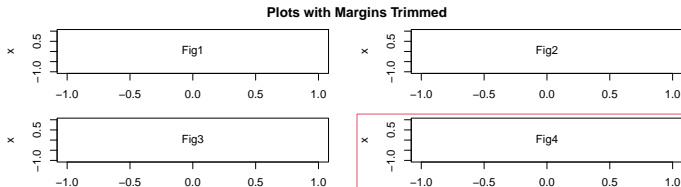
axis(1, at = round(cut_ps, 2)); axis(2, at = TF, las = 2)

title(main = 'the Main title', sub = 'the subtitle', xlab = 'xlab', ylab = 'ylab')
```



# Control graphical parameters by par function 1

```
par(mfrow = c(2, 2)) # a 2*2 array of figures and combine plots
par(mar = c(3, 4, 0.3, 2.1)) # The size of margins
par(oma = c(3, 4, 2, 4)) # The size of outer margins
x = c(-1, 1)
plot(x, x, type = "n"); text(0, 0, 'Fig1')
plot(x, x, type = "n"); text(0, 0, 'Fig2')
plot(x, x, type = "n"); text(0, 0, 'Fig3')
plot(x, x, type = "n"); text(0, 0, 'Fig4');
box("figure", col = 2)
title(main = "Plots with Margins Trimmed", outer = TRUE)
box(which = 'outer', col = 'blue', lty = "dashed")
```

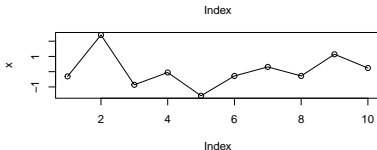
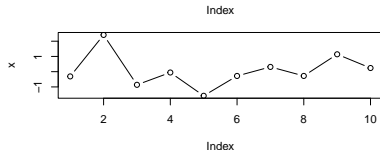
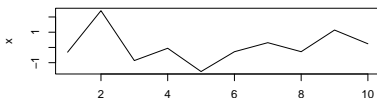
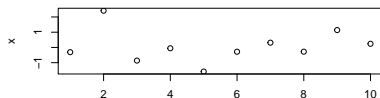


## Control graphical parameters by par function 2

```
par(mfrow = c(2, 2)) # a 2*2 array of figures
par(mar = c(5.1, 4.1, 0.1, 2.1)) # The size of margins
par(oma = c(0, 0, 4, 0)) # The size of outer margins

x = rnorm(10)
plot(x, type = "p"); plot(x, type = "l")
plot(x, type = "b"); plot(x, type = "o")
title(main = "Plots with Margins Trimmed", outer = TRUE)
```

Plots with Margins Trimmed

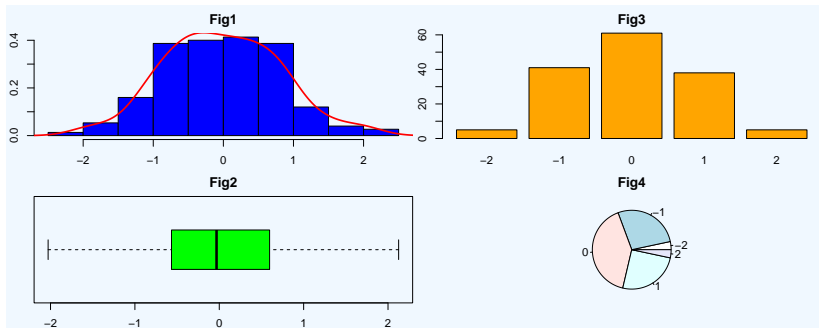


# Control graphical parameters by par function 3

```
x = rnorm(n = 150, mean = 0, sd = 0.8)

par(mfcol = c(2, 2)) # Two rows, two columns
par(mar = c(2.1, 2.1, 2.1, 0.1))
par(bg = "aliceblue") # Aliceblue background color

hist(x, probability = TRUE, col = 'blue', main = "Fig1") # Top left
lines(density(x), col = "red", lwd = 2) # Add a line graph
boxplot(x, col = 'green', main = "Fig2", horizontal = TRUE) # Bottom left
barplot(table(round(x)), col = 'orange', main = "Fig3") # Top right
pie(table(round(x)), main = "Fig4") # Bottom right
```





# Plots and coordinates

```
# Cartesian coordinates
```

```
x = 1:30
```

```
y = rnorm(30) + x/5
```

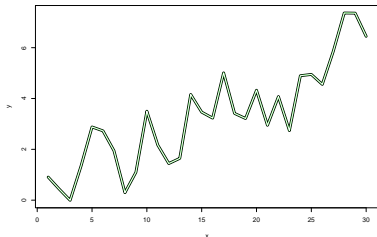
```
plot(x, y, type = "n")
```

```
# add 3 lines
```

```
lines(x, y, lwd = 7)
```

```
lines(x, y, lwd = 4,  
      col = "green4")
```

```
lines(x, y, lwd = 1,  
      col = "white")
```



```
# polar coordinate
```

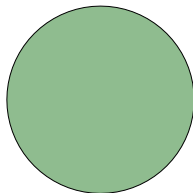
```
th = seq(0, 2*pi, length = 73)[1:72]
```

```
x = cos(th); y = sin(th)
```

```
plot.new()
```

```
plot.window(xlim = c(-1,1),  
            ylim = c(-1,1),  
            asp = 1)
```

```
polygon(x, y,  
        col = "darkseagreen")
```



## More on par function

R graphics are controlled by use of the par function. par makes it possible to control low-level graphics by querying and setting a large set of graphical parameters. Graphical parameters control many features such as:

- ▶ the layout of figures on the device
- ▶ the size of the margins around plots
- ▶ the colours, sizes and typefaces of text
- ▶ the colour and texture of lines
- ▶ the style of axis to be used
- ▶ the orientation of axis labels

```
names(par())
```

```
## [1] "xlog"      "ylog"      "adj"       "ann"       "ask"       "bg"
## [7] "bty"       "cex"       "cex.axis"  "cex.lab"   "cex.main"  "cex.sub"
## [13] "cin"       "col"       "col.axis"  "col.lab"   "col.main"  "col.sub"
## [19] "cra"       "crt"       "csi"       "cxy"       "din"       "err"
## [25] "family"    "fg"        "fig"       "fin"       "font"      "font.axis"
## [31] "font.lab"  "font.main" "font.sub"  "lab"       "las"       "lend"
## [37] "lheight"   "ljoin"     "lmitre"    "lty"       "lwd"       "mai"
## [43] "mar"       "mex"       "mfcol"     "mfg"       "mfrow"     "mgp"
## [49] "mkh"       "new"       "oma"       "omd"       "omi"       "page"
## [55] "pch"       "pin"       "plt"       "ps"        "pty"       "smo"
## [61] "srt"       "tck"       "tcl"       "usr"       "xaxp"      "xaxs"
## [67] "xaxt"      "xpd"       "yaxp"      "yaxs"      "yaxt"      "ylbias"
```

# Background color

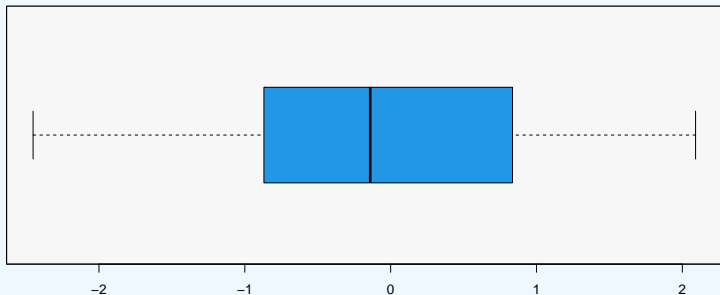
```
set.seed(2); x <- rnorm(100)

par(bg = "aliceblue") # Aliceblue background color

plot.new(); plot.window(xlim = range(x), ylim = c(0.5, 1.5))

rect(par("usr")[1], par("usr")[3],
     par("usr")[2], par("usr")[4],
     col = "#f7f7f7") # Change the plot region color

boxplot(x, col = 4, horizontal = T, add = T) # Create your plot
```



## More Flexible Layouts: layout 1

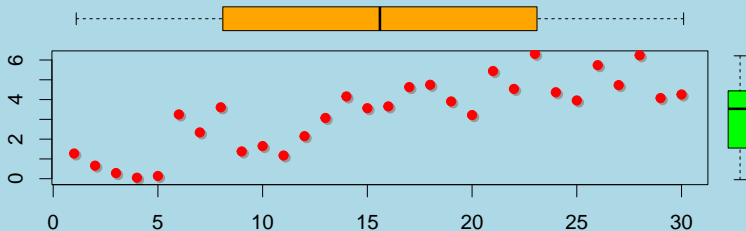
```
layout(rbind(c(0,4,4,0),  
             c(0,2,0,0),  
             c(0,1,3,0),  
             c(0,0,0,0)),  
       height = c(1cm(2), 1cm(2), 1, 1cm(2)),  
       width  = c(1cm(2), 1, 1cm(2), 1cm(1)))  
layout.show(4)  
box("outer", lty = "dotted")
```



# More Flexible Layouts: layout 2

```
layout(rbind(c(0,4,4,0),  
             c(0,2,0,0),  
             c(0,1,3,0),  
             c(0,0,0,0)),  
       height = c(lcm(2), lcm(2), 1, lcm(2)),  
       width = c(lcm(2), 1, lcm(2), lcm(1)))  
  
par(mar = rep(0, 4), cex = 1.5, bg = 'lightblue') # setting the parameters  
x = 1:30  
y = rnorm(30) + x/5  
plot(x+0.1, y-0.1, pch = 19, col = 'gray60'); points(x, y, pch = 19, col = 'red') # First figure  
boxplot(x, horizontal = TRUE, col = 'orange', axes = FALSE) # Second figure  
boxplot(y, col = 'green', axes = FALSE) # Third figure  
plot.new(); plot.window(xlim = c(0, 1), ylim = c(0, 1)) # Forth figure  
text(.5, 0.25, "An Enhanced Scatterplot", cex = 1.5, font = 2)
```

## An Enhanced Scatterplot



# Trellis and Lattice

- ▶ R also provides an implementation of Trellis plots via the package `lattice` by Deepayan Sarkar, on the basis of the “Grid” graphics system written by Paul Murrell of Auckland.
- ▶ Trellis plots embody a number of design principles and these principles are evident in a number of new plot types in Trellis and in the default choice of colors, symbol shapes, and line styles provided by Trellis plots.
- ▶ Trellis plots provide a feature known as multipanel conditioning, which creates multiple plots by splitting the data being plotted according to the levels of other variables.

## Why lattice system?

- ▶ The default appearance of the `lattice` plots is superior in some areas. The default colors and the default data symbols have been deliberately chosen to make it **easy to distinguish**.
- ▶ The arrangement of plot components is **more automated** in `lattice`. It is usually not necessary to set figure margins manually.
- ▶ Legends can be automatically generated by the `lattice` system.
- ▶ The output from `lattice` functions is grid output, so many powerful grid features are **available for annotating, editing, and saving the graphics output**.

# The lattice system structure in R

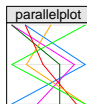
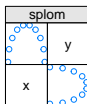
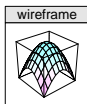
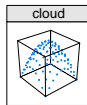
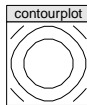
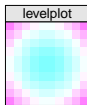
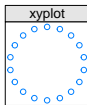
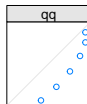
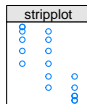
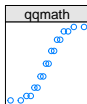
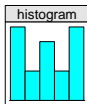
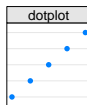
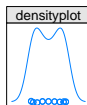
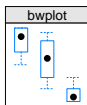
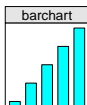
```
graph_type(formula, data = )
```

formula	description
~ y	Some univariate plot (boxplot, histogram, boxplot, ...)
~ y   A	Univariate, separate panels for levels of factor A
~ y   z	Univariate, cutting z into discrete ranges
y ~ x	Bivariate
y ~ x   A	Bivariate, separate panels for levels of A
y ~ x   A + B	Multiple conditioning variables
y1 + y2 ~ x1 + x2	Multiple Y and X variables

graph_type	description	graph_type	description
barchart	bar chart	bwplot	boxplot
cloud	3D scatterplot	contourplot	3D contour plot
densityplot	kernal density plot	dotplot	dotplot
histogram	histogram	levelplot	3D level plot
spiom	scatterplot matrix	stripplot	strip plots
xvplot	scatterplot	wireframe	3D wireframe

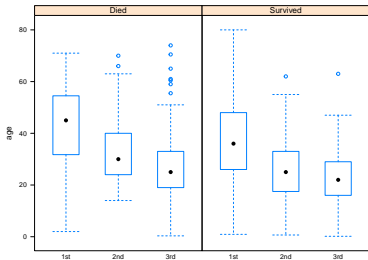


# Types of the the lattice system

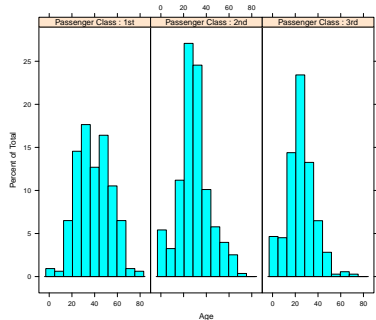


# Histogram and Box-Wishker plot in lattice

```
bwplot(age~pclass | survived,  
       data = Titanic )
```



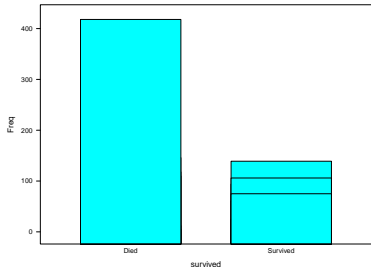
```
# Condition on Passenger Class & Gender  
histogram(~ age | pclass,  
          data = Titanic,  
          layout = c(3,1),  
          strip = strip.custom(  
            strip.names = TRUE,  
            var.name =  
              "Passenger Class"),  
          xlab = "Age")
```



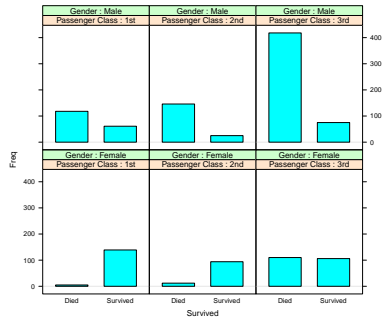
# Barchart

```
surv.tab = xtabs(~survived +  
                pclass +  
                Gender,  
                data = Titanic)  
surv.df = as.data.frame(surv.tab)
```

```
# In barchart you need Freq ~ X  
barchart(Freq ~ survived,  
         data = surv.df,  
         xlab = "survived")
```



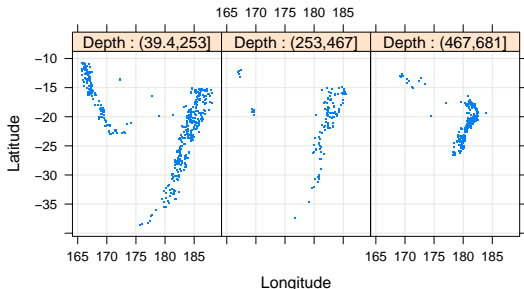
```
# Condition on Passenger Class & Gender  
barchart(  
  Freq ~ survived | pclass * Gender,  
  data = surv.df, origin = 0,  
  strip = strip.custom(  
    strip.names = TRUE,  
    var.name =  
    c("Passenger Class", "Gender")),  
  xlab = "Survived")
```



... columns

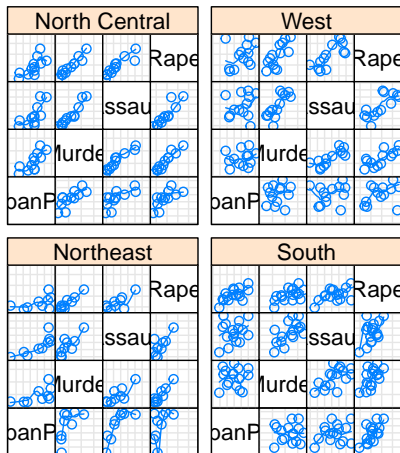
## xyplot: Scatter plot in lattice

```
library(lattice)
xyplot(lat ~ long | cut(depth, 3),
       data = quakes, aspect = "iso", pch = ".", cex = 2,
       type = c("p", "g"), xlab = "Longitude", ylab="Latitude",
       strip = strip.custom(strip.names = TRUE,
                             var.name = "Depth"))
```



## splom: Scatter Plot Matrix

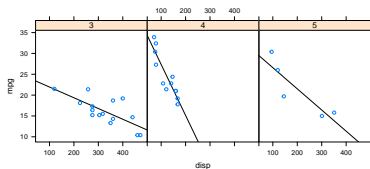
```
splom(~USArrests[c(3, 1, 2, 4)] | state.region,  
      pscales = 0, type = c("g", "p", "smooth"),  
      layout = c(2,2))
```



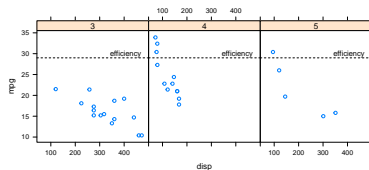
Scatter Plot Matrix

# panel function in lattice

```
xyplot(mpg ~ disp | factor(gear),  
       data = mtcars,  
       layout=c(3, 1), aspect=1,  
  
       panel = function(x, y, ...) {  
         panel.lmline(x, y)  
         panel.xyplot(x, y, ...)  
       })
```



```
xyplot(mpg ~ disp | factor(gear),  
       data=mtcars,  
       layout=c(3, 1), aspect = 1,  
       panel = function(...) {  
         panel.xyplot(...)  
         panel.abline(h = 29, lty = "dashed")  
         panel.text(470,29.5, "efficiency",  
                   adj = c(1, 0), cex= 0.9)  
       })
```



# Most common used panels

A selection of predefined panel functions for adding graphical output to the panels of lattice plots.

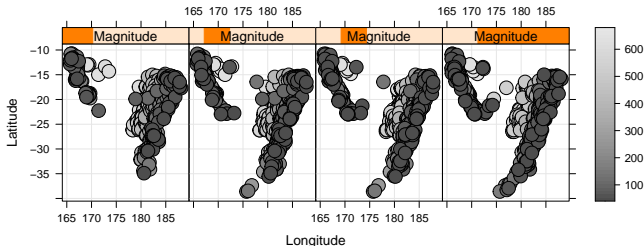
Function	Description
<code>panel.points()</code>	Draw data symbols at locations (x, y)
<code>panel.lines()</code>	Draw lines between locations (x, y)
<code>panel.segments()</code>	Draw line segments between (x0, y0) and (x1, y1)
<code>panel.arrows()</code>	Draw line segments and arrowheads to the end(s)
<code>panel.polygon()</code>	Draw one or more polygons with vertices (x, y)
<code>panel.text()</code>	Draw text at locations (x, y)
<code>panel.abline()</code>	Draw a line with intercept a and slope b
<code>panel.curve()</code>	Draw a function given by expr
<code>panel.rug()</code>	Draw axis ticks at x- or y-locations
<code>panel.grid()</code>	Draw a (gray) reference grid
<code>panel.loess()</code>	Draw a loess smooth through (x, y)
<code>panel.violin()</code>	Draw one or more violin plots
<code>panel.smoothScatter()</code>	Draw a smoothed 2D density of (x, y)

# panel

```
depth.col = gray.colors(100)[cut(quakes$depth, 100, label = FALSE)]
depth.ord = rev(order(quakes$depth))
quakes$Magnitude=equal.count(quakes$mag,4); quakes$color=depth.col; quakes.ordered=quakes[depth.ord,]
depth.breaks = do.breaks(range(quakes.ordered$depth), 50)

xyplot(lat ~ long | Magnitude, data = quakes.ordered,
       aspect = "iso", groups = color, cex = 2, col = "black",
       panel = function(x, y, groups, ..., subscripts) {
         fill <- groups[subscripts]
         panel.grid(h = -1, v = -1)
         panel.xyplot(x, y, pch = 21, fill = fill, ...)},

       legend = list(right = list(fun = draw.colorkey, args =
                                   list(key = list(col = gray.colors, at = depth.breaks)))),
       xlab = "Longitude", ylab = "Latitude")
```





# Grammar of Graphics: ggplot2 1

Leland Wilkinson's [Grammar of Graphics](#) provides another completely different paradigm for producing statistical plots and this approach to plotting has been implemented for R by Hadley Wickham's ggplot2 package.

- ▶ One advantage of this package is that it makes it possible to create a very wide variety of plots from a relatively small set of fundamental components.
- ▶ The ggplot2 package also has a feature called facetting, which is similar to lattice's multipanel plots.

# Grammar of Graphics: ggplot2 2

Every graph can be described as a combination of

- ▶ **data**: a data frame: **quantitative, categorical**;
- ▶ **aesthetic**: **mapping** of variables into visual properties: **x, y, size, color, ...**
- ▶ **geometric** objects (“geom”): **points, lines, areas, arrows, ...**
- ▶ **layers**: graph elements combined with “+”
  - ▶ **coordinate** system (“coord”): **Cartesian, polar, log, map,**

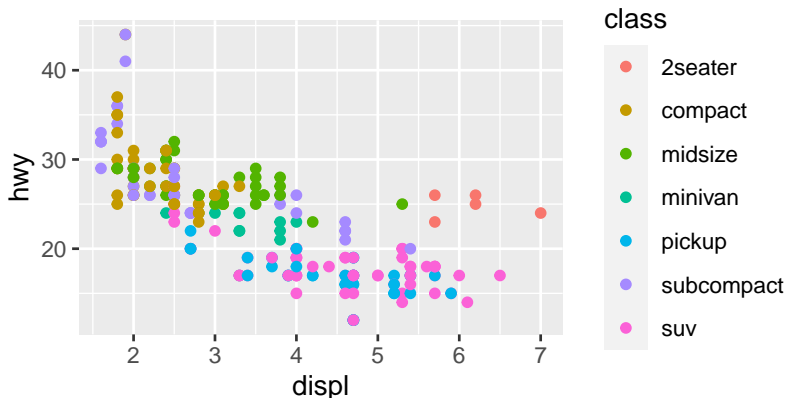
And some more

- ▶ **statistical** transformations (“stat”) – data summaries: **mean, sd, binning & counting, ...**
- ▶ **scales**: **legends, axes**
- ▶ **position** adjustments: **jitter, dodge, stack, ...**
- ▶ **faceting**: **small multiples or conditioning to break a plot**

## ggplot 1

```
ggplot(data = <DATA>) +  
  <GEOM_FUNCTION>(mapping = aes(<MAPPINGS>))
```

```
ggplot(data = mpg) +  
  geom_point(mapping =  
    aes(x = displ, y = hwy, color = class))
```



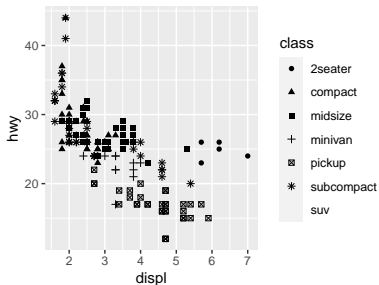
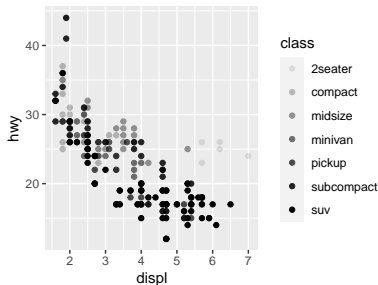
## # ggplot 2

*# Left*

```
ggplot(data = mpg) +  
  geom_point(mapping =  
    aes(x = displ, y = hwy, alpha = class))
```

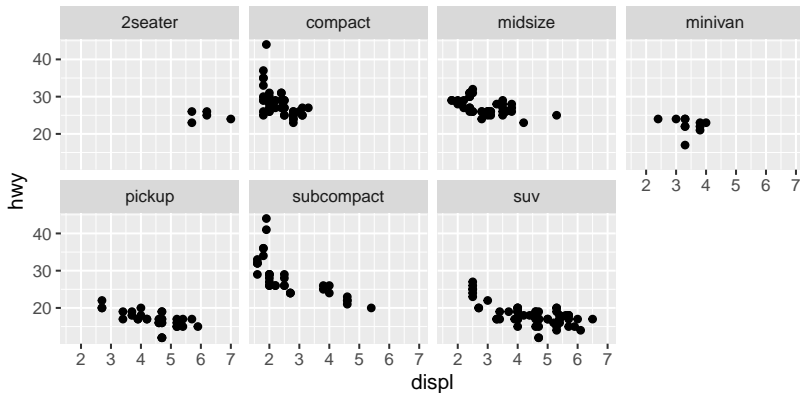
*# Right*

```
ggplot(data = mpg) +  
  geom_point(mapping =  
    aes(x = displ, y = hwy, shape = class))
```



## facet

```
ggplot(data = mpg) +  
  geom_point(mapping = aes(x = displ, y = hwy)) +  
  facet_wrap(~ class, nrow = 2)
```



# geom\_bar 1

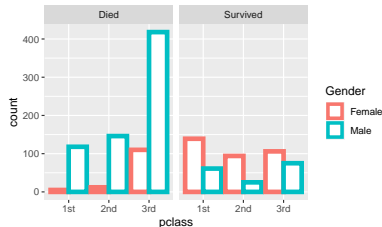
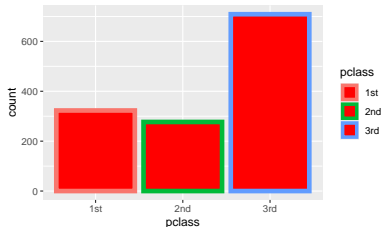
*#Left*

```
ggplot(data = Titanic) +  
  geom_bar(mapping = aes(x = pclass, colour = pclass),  
           fill = 'red',  
           lwd = 2)
```

*# Right*

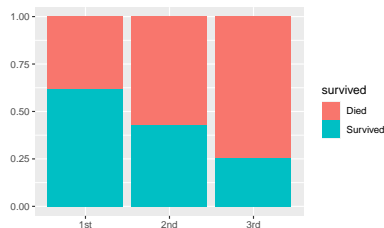
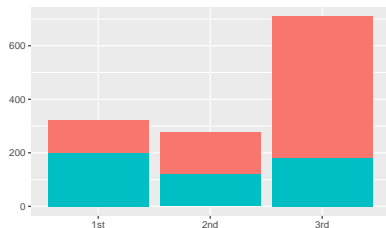
```
ggplot(data = Titanic,  
       mapping = aes(x= pclass, colour= Gender, fill= pclass))+  
  geom_bar(lwd = 2, fill = "white", position = "dodge") +  
  facet_wrap(~ survived)
```

*# position can be 'dodge' and fill, 'stack' is the default for b*



## geom\_bar 2

```
dplot = ggplot(Titanic, aes(pclass, fill = survived)) +  
  xlab(NULL) + ylab(NULL) + theme(legend.position = "none")  
  
# position stack is the default for bars, so `geom_bar()`  
# is equivalent to `geom_bar(position = "stack")`.  
#Left  
dplot + geom_bar() +  
  theme(plot.background = element_rect(fill = "lightblue"))  
# Right  
dplot + geom_bar(position = "fill") +  
  theme(legend.position = "right") # the default
```



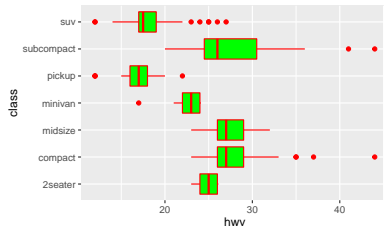
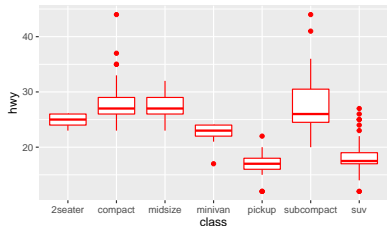
## geom\_box

*#Left*

```
ggplot(data = mpg, mapping = aes(x = class, y = hwy)) +  
  geom_boxplot(col = 'red')
```

*#Right*

```
ggplot(data = mpg, mapping = aes(x = class, y = hwy)) +  
  geom_boxplot(col = 'red', fill = 'green') +  
  coord_flip()
```





# map

```
library(maps); library(tidyverse)
```

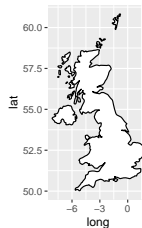
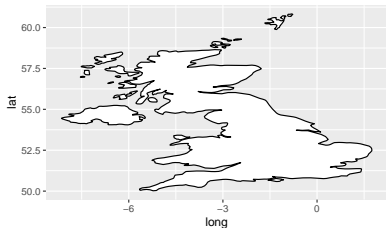
```
UK <- map_data("world") %>% filter(region=="UK")
```

*#Left*

```
ggplot(UK, aes(long, lat, group = group)) +  
  geom_polygon(fill = "white", colour = "black")
```

*#Right*

```
ggplot(UK, aes(long, lat, group = group)) +  
  geom_polygon(fill = "white", colour = "black") +  
  coord_quickmap()
```



## map 2

*# Get a data frame with longitude, latitude, and size of bubbles*

```
library(ggmap)
```

```
UK_city <- world.cities %>% filter(country.etc == "UK")
```

```
ggplot(data = UK) +
```

```
  geom_polygon(aes(x=long, y = lat, group = group),  
               fill="grey", alpha=0.3) +
```

```
  geom_point(data = UK_city, aes(x=long, y=lat)) +
```

```
  theme_void() + ylim(50,59) + coord_map()
```

*# Second graphic with names of the 10 biggest cities*

```
ggplot(data = UK) +
```

```
  geom_polygon(aes(x=long, y = lat, group = group),  
               fill="grey", alpha=0.3) +
```

```
  geom_point(UK_city, aes(x=long, y=lat, alpha=pop)) +
```

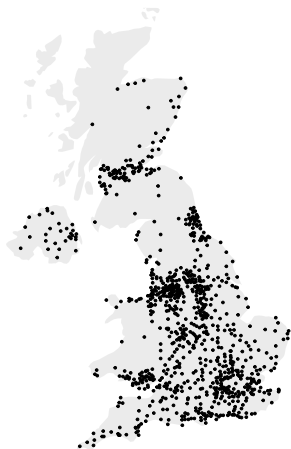
```
  geom_text_repel(UK_city %>% arrange(pop) %>% tail(10),  
                  aes(x=long, y=lat, label=name), size=5) +
```

```
  geom_point(UK_city %>% arrange(pop) %>% tail(10),  
              aes(x=long, y=lat), color="red", size=3) +
```

```
  theme_void() + ylim(50,59) + coord_map() +
```

```
  theme(legend.position="none")
```

## map 3



## map 4

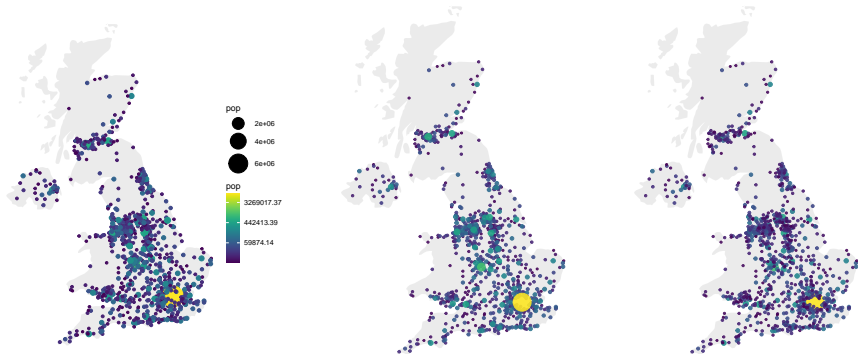
```
# viridis package for the color palette
library(viridis)

# Left: use size and color
ggplot() +
  geom_polygon(data = UK, aes(x=long, y = lat, group = group), fill="grey", alpha=0.3) +
  geom_point( data=UK_city, aes(x=long, y=lat, size=pop, color=pop)) +
  scale_size_continuous(range=c(1,12)) +
  scale_color_viridis(trans="log") +
  theme_void() + ylim(50,59) + coord_map()
```

```
# Center: reorder your dataset first! Big cities appear later = on top
UK_city %>%
  arrange(pop) %>%
  mutate( name=factor(name, unique(name))) %>%
  ggplot() +
    geom_polygon(data = UK, aes(x=long, y = lat, group = group), fill="grey", alpha=0.3) +
    geom_point( aes(x=long, y=lat, size=pop, color=pop), alpha=0.9) +
    scale_size_continuous(range=c(1,12)) +
    scale_color_viridis(trans="log") +
    theme_void() + ylim(50,59) + coord_map() + theme(legend.position="none")
```

```
# Right: just use arrange(desc(pop)) instead
UK_city %>%
  arrange(desc(pop)) %>%
  mutate( name=factor(name, unique(name))) %>%
  ggplot() +
    geom_polygon(data = UK, aes(x=long, y = lat, group = group), fill="grey", alpha=0.3) +
    geom_point( aes(x=long, y=lat, size=pop, color=pop), alpha=0.9) +
    scale_size_continuous(range=c(1,12)) +
    scale_color_viridis(trans="log") +
    theme_void() + ylim(50,59) + coord_map() + theme(legend.position="none")
```

## map 4\_2



# Resources

- ▶ Paul Murrell, R Graphics, 3rd Ed
  - ▶ [R Code:][ <https://www.stat.auckland.ac.nz/~paul/RG3e/>]
- ▶ Hadley Wickham, ggplot2: Elegant graphics for data analysis, 2nd Ed. [ggplot2](https://ggplot2.tidyverse.org/reference/index.html#plot-basics)  
<https://ggplot2.tidyverse.org/reference/index.html#plot-basics>
- ▶ Winston Chang, R Graphics Cookbook: Practical Recipes for Visualizing Data [R Graphics Cookbook](#)
- ▶ Antony Unwin, Graphical Data Analysis with R
  - ▶ [R code:][<http://www.gradaanwr.net/>]

## Useful online resouses

- ▶ [R CHARTS](#)
- ▶ [Topic in Computational Data Analysis and Graphics](#)
- ▶ [Lattice: Multivariate Data Visualization with R - Figures and Code](#)
- ▶ [Data Visualization in R](#)