Data Exploration, Visualization, and Feature Engineering using R

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Basic plotting systems

1. Base graphics: constructed piecemeal. Conceptually simpler and allows plotting to mirror the thought process.
2. Lattice graphics: entire plots created in a simple function call.
3. ggplot2 graphics: an implementation of the Grammar of Graphics by Leland Wikinson. Combines concepts from both base and lattice graphics. (Need to install ggplot2 library)
4. Fancier and more telling ones.

A list of interactive visualization in R can be found at: http://ouzor.github.io/blog/2014/11/21/interactive-visualizations.html

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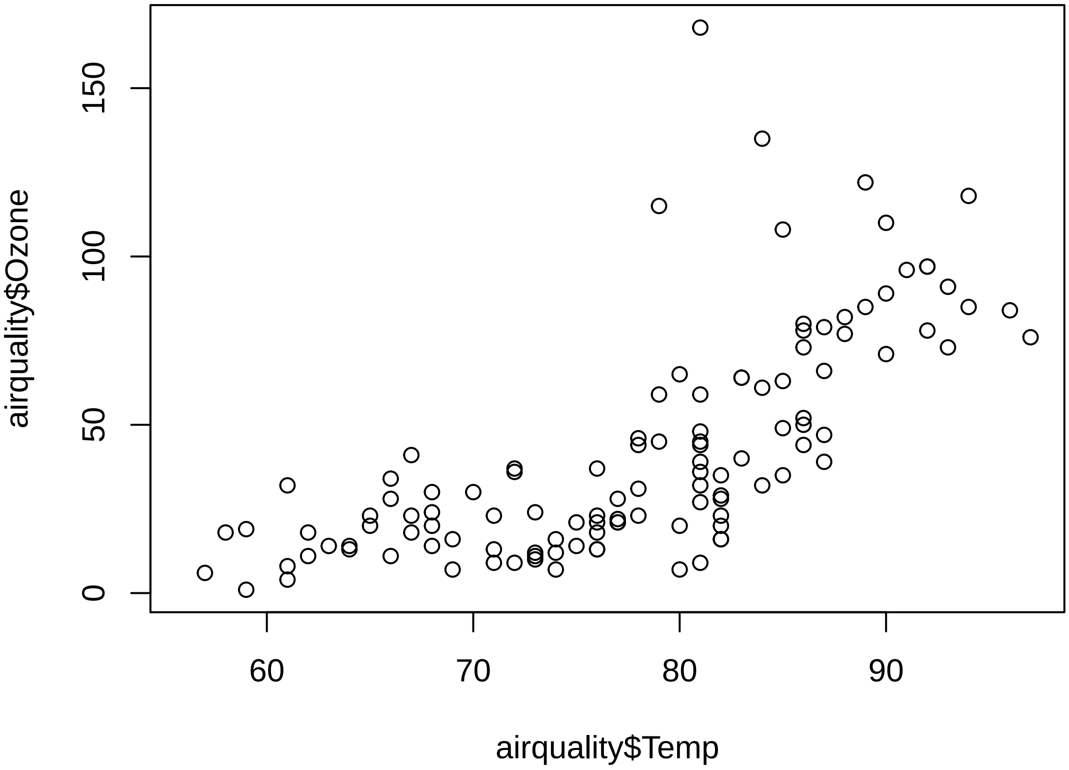
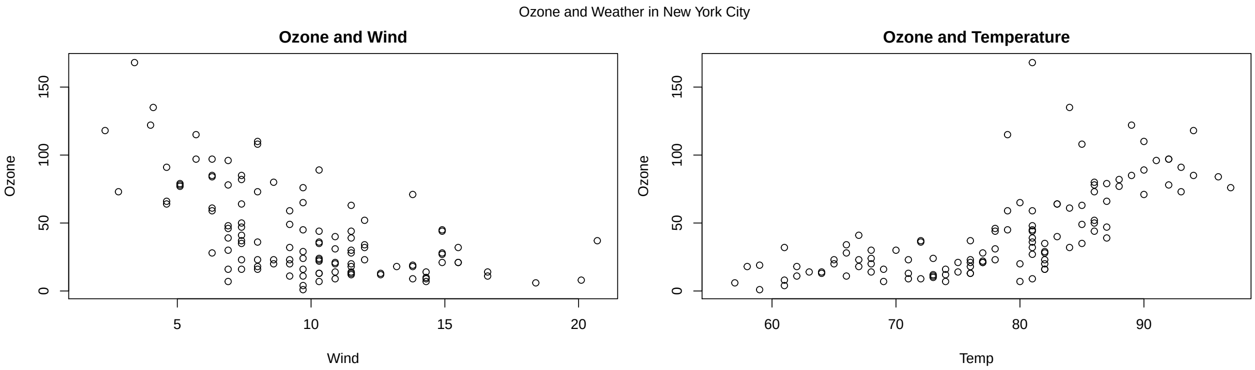
Base plotting system

```
library(datasets)
## scatter plot
plot(x = airquality$Temp, y = airquality$Ozone)
```



Base plotting system

```
## par() function is used to specify global graphics parameters that affect all plots in an R session.
## Type ?par to see all parameters
par(mfrow = c(1, 2), mar = c(4, 4, 2, 1), oma = c(0, 0, 2, 0))
with(airquality, {
    plot(Wind, Ozone, main="Ozone and Wind")
    plot(Temp, Ozone, main="Ozone and Temperature")
    mtext("Ozone and Weather in New York City", outer=TRUE)})
```



Plotting functions (high level)

PHASE ONE: Mount a canvas panel on the easel, and draw the draft. (Initialize a plot.)

- plot(): one of the most frequently used plotting functions in R.
- boxplot(): a boxplot show the distribution of a vector. It is very useful to example the distribution of different variables.
- barplot(): create a bar plot with vertical or horizontal bars.
- hist(): compute a histogram of the given data values.
- pie(): draw a pie chart.

Remember to use ?plot or str(plot), etc. to check the arguments when you want to make more personalized plots. A tutorial of base plotting system with more details: http://bcb.dfci.harvard.edu/~aedin/courses/BiocDec2011/2.Plotting.pdf

Plotting functions (low level)

PHASE TWO: Add more details on your canvas, and make an artwork. (Add more on an existing plot.)

- lines: adds liens to a plot, given a vector of x values and corresponding vector of y values

- points: adds a point to the plot
- text: add text labels to a plot using specified x,y coordinates
- title: add annotations to x,y axis labels, title, subtitles, outer margin
- mtext: add arbitrary text to margins (inner or outer) of plot
- axis: specify axis ticks

Save your artwork

R can generate graphics (of varying levels of quality) on almost any type of display or printing device. Like:

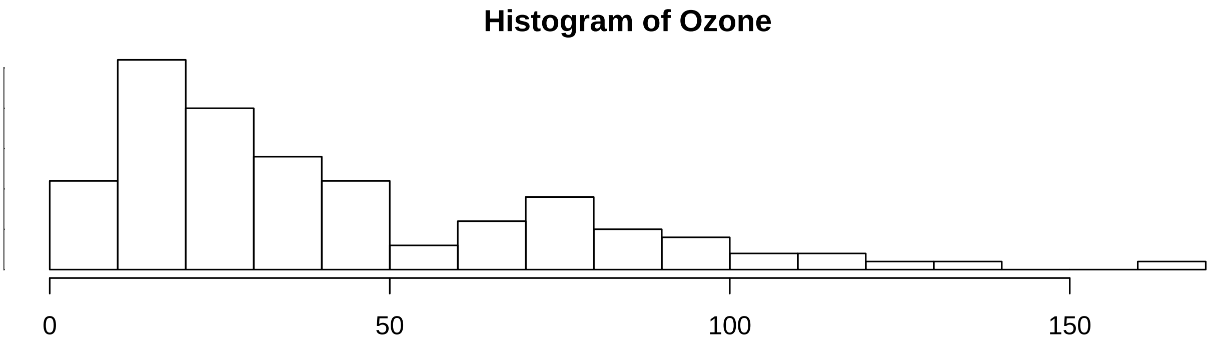
- postscript(): for printing on PostScript printers, or creating PostScript graphics files.
- pdf(): produces a PDF file, which can also be included into PDF files.
- jpeg(): produces a bitmap JPEG file, best used for image plots.

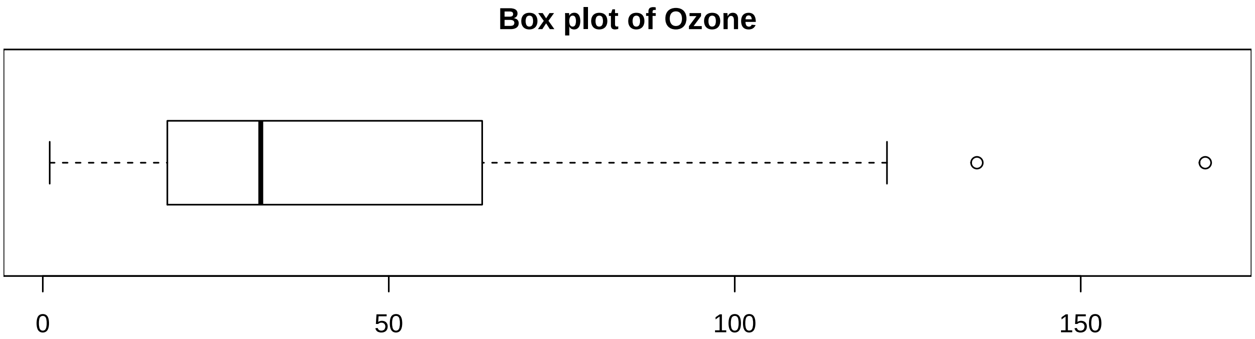
help(Devices) for a list of them all. Simple example:

```
## png(filename = 'plot1.png', width = 480, height = 480, units = 'px')
## plot(x, y)
## dev.off()
```

Example: boxplot and hitogram

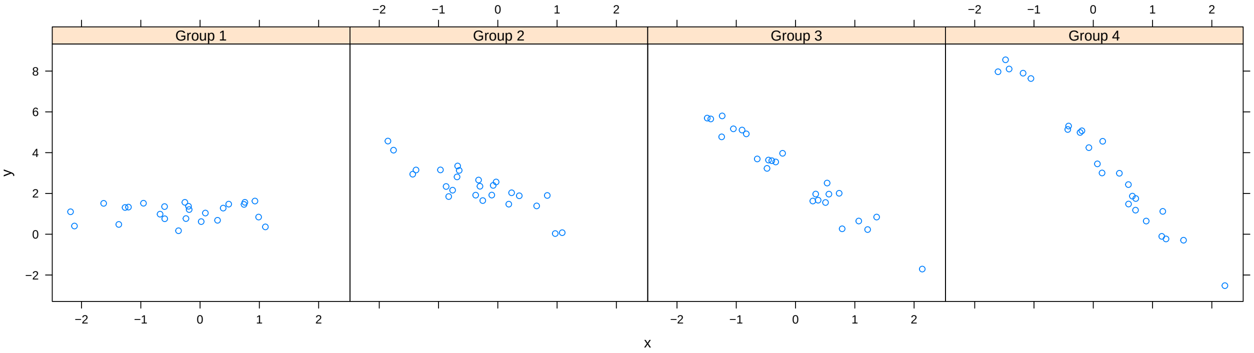
```r
## the layout
par(mfrow = c(2, 1), mar = c(2, 0, 2, 0), oma = c(0, 0, 0, 0))
## histogram at the top
hist(airquality$Ozone, breaks=12, main = "Histogram of Ozone")
## box plot below for comparison
boxplot(airquality$Ozone, horizontal=TRUE, main = "Box plot of Ozone")
```





Lattice plotting system

```
library(lattice) # need to load the lattice library
set.seed(10) # set the seed so our plots are the same
x <- rnorm(100)
f <- rep(1:4, each = 25) # first 25 elements are 1, second 25 elements are 2, ...
y <- x + f - f * x+ rnorm(100, sd = 0.5)
f <- factor(f, labels = c("Group 1", "Group 2", "Group 3", "Group 4"))
# first 25 elements are in Group 1, second 25 elements are in Group 2, ...
xyplot(y ~ x | f)
```

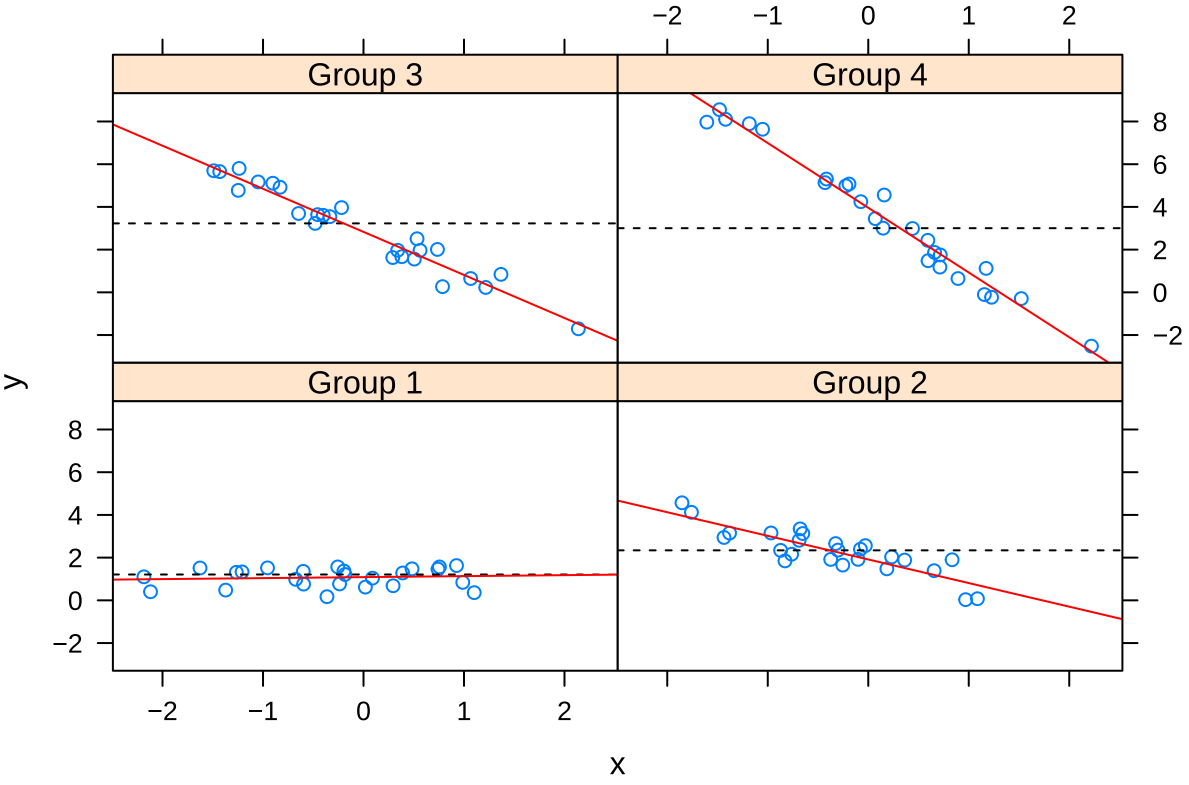


Lattice plotting system

Want more on the plot? Customize the panel funciton:

```
xyplot(y ~ x | f, panel = function(x, y, ...) {
    # call the default panel function for xyplot
    panel.xyplot(x, y, ...)
    # adds a horizontal line at the median
    panel.abline(h = median(y), lty = 2)
    # overlays a simple linear regression line
    panel.lmline(x, y, col = 2)
})
```

Lattice plotting system



Lattice plotting system

Plotting functions * xyplot(): main function for creating scatterplots * bwplot(): box and whiskers plots (box plots) * histogram(): histograms * stripplot(): box plot with actual points * dotplot(): plot dots on "violin strings" * splom(): scatterplot matrix (like pairs() in base plotting system) * levelplot()/contourplot(): plotting image data

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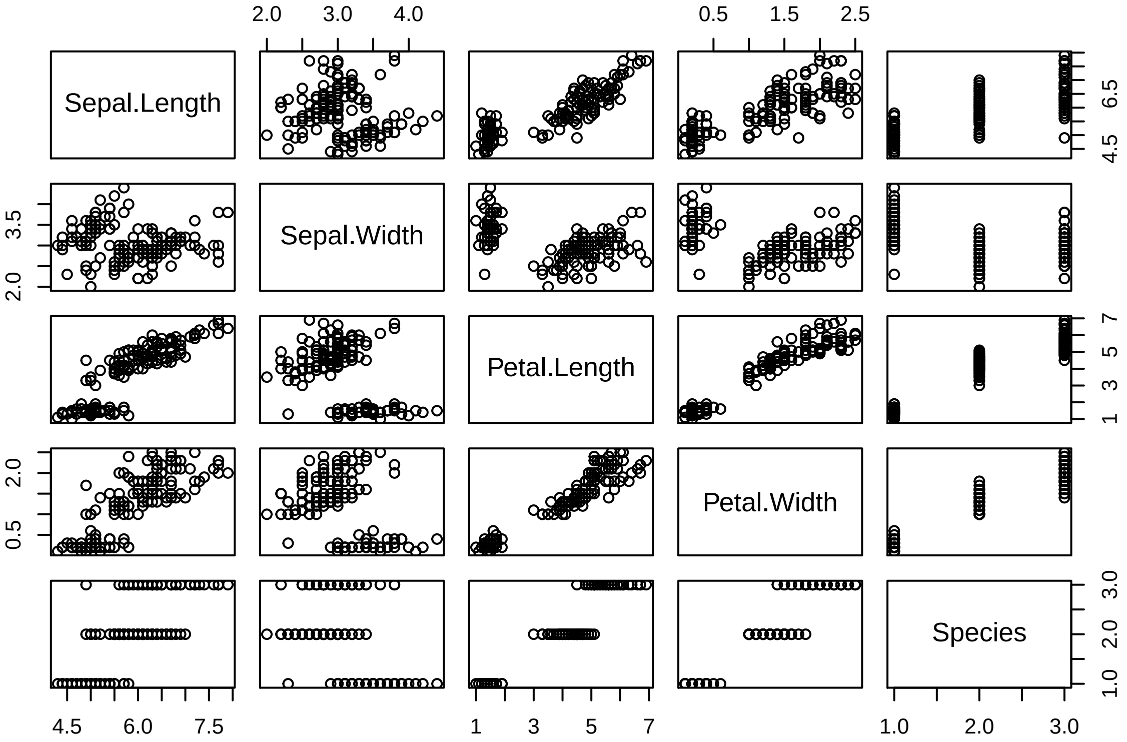
Very useful when we want a lot…

```r
pairs(iris) ## iris is a data set in R
```



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ggplot2

- An implementation of the Grammar of Graphics by Leland Wikinson
- Written by Hadley Wickham (while he was a graduate student as lowa State)
- A "third" graphics system for R (along with base and lattice)
  Available from CRAN via install.packages()
  web site: http://ggplot2.org (better documentation)
- Grammar of graphics represents the abstraction of graphics ideas/objects
  Think "verb", "noun", "adjective" for graphics
  "Shorten" the distance from mind to page
- Two main functions:
  qplot() hides what goes on underneath, which is okay for most operations **ggplot()** is the core function and very flexible for doing this qplot() cannot do

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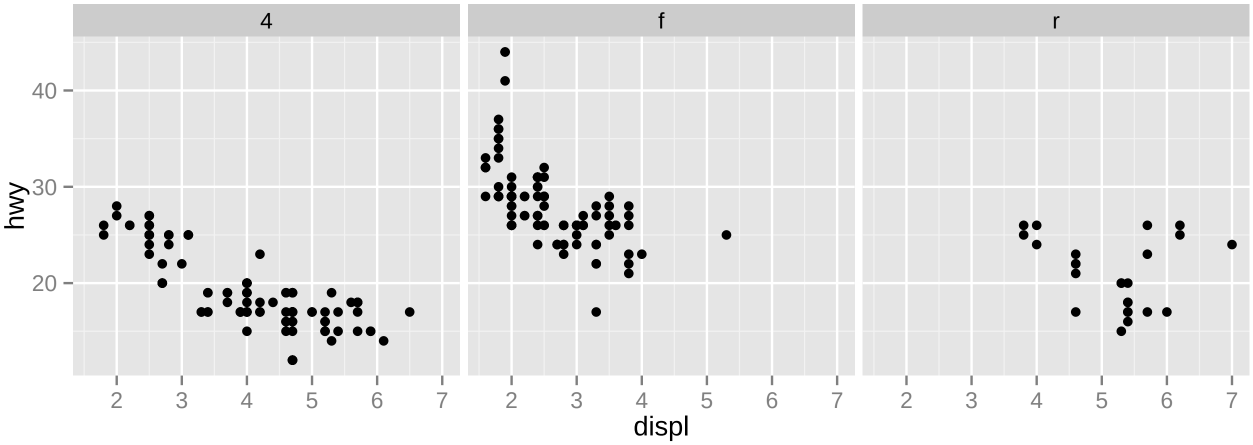
qplot function

The qplot() function is the analog to plot() but with many build-in features
Syntax somewhere in between base/lattice
Difficult to be customized (don't bother, use full ggplot2 power in that case)

```r
library(ggplot2) ## need to install and load this library
qplot(displ, hwy, data = mpg, facets = .~drv)
```



ggplot function

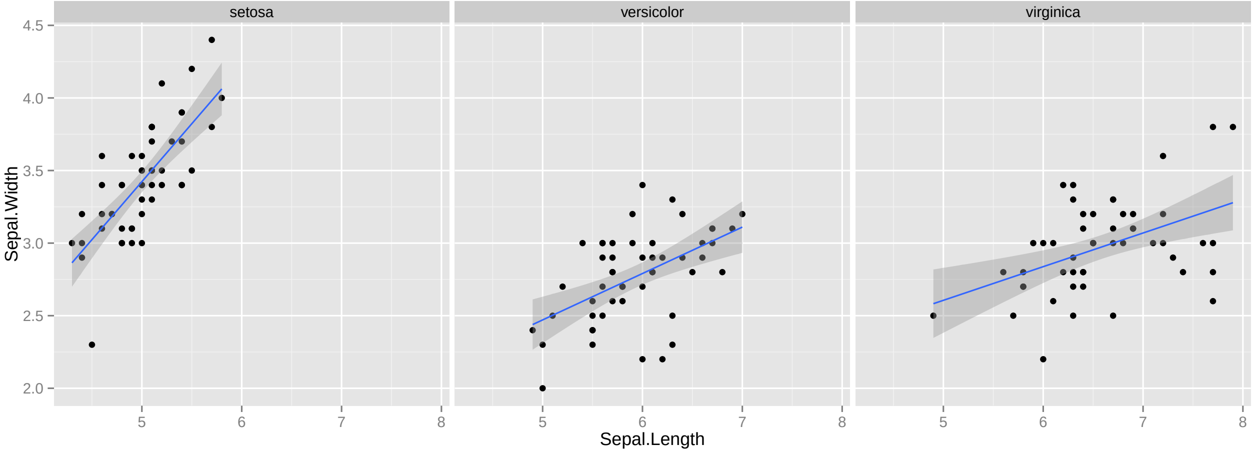
When building plots in ggplot2 (ggplot, rather than using qplot)
The "artist's palette" model may be the closest analogy
Plots are built up in layers
Step I: Input the data
noun: the data

```r
library(ggplot2) ## need to install and load this library
g <- ggplot(iris, aes(Sepal.Length, Sepal.Width)) ## this would not show you add plot
```

ggplot function

- Step II: Add layers
  adjective: describe the type of plot you will produce.

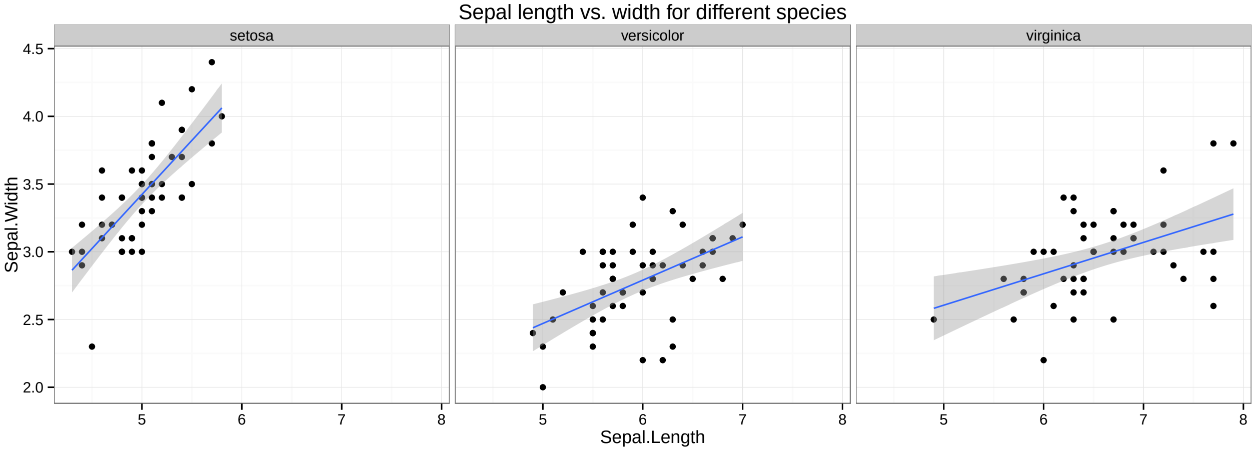
```r
g + geom_point() + geom_smooth(method = "lm") + facet_grid(. ~ Species)
```



ggplot function

- Step III: Add metadata and annotation
  adjective: control the mapping between data and aesthetics.

```
g <- g + geom_point() + geom_smooth(method = "lm") + facet_grid(. ~ Species)
g + ggtitle("Sepal length vs. width for different species") + theme_bw() ## verb
```



Great documentation

Great **documentation** of ggplot with all functions in **step II** and **III** and demos:
http://docs.ggplot2.org/current/

Interactive visualization in R - rCharts

- What is rCharts?
  Is an R package to create, customize and publish interactive javascript visualizations from R using a familiar lattice style plotting interface.

- What rCharts can make and how?
  Quick start at: http://ramnathv.github.io/rCharts/

- A list of interactive visualization in R can be found at:
  http://ouzor.github.io/blog/2014/11/21/interactive-visualizations.html