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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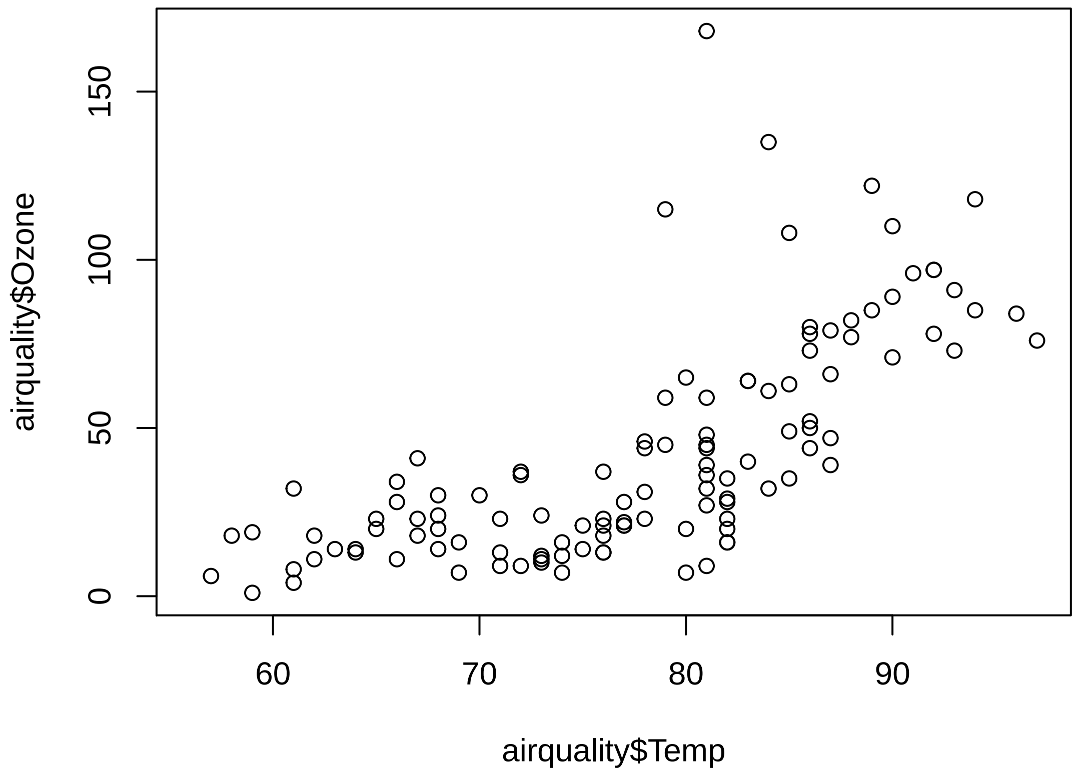
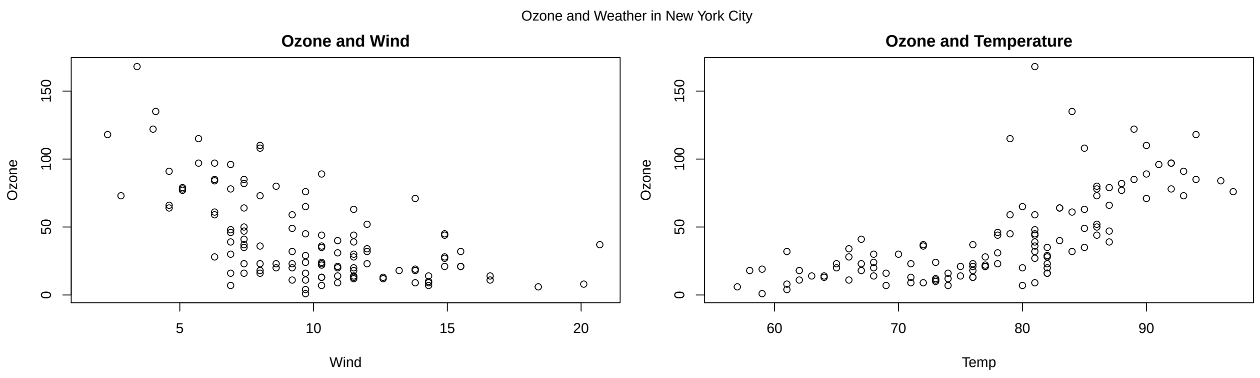
Base plotting system

```r
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:

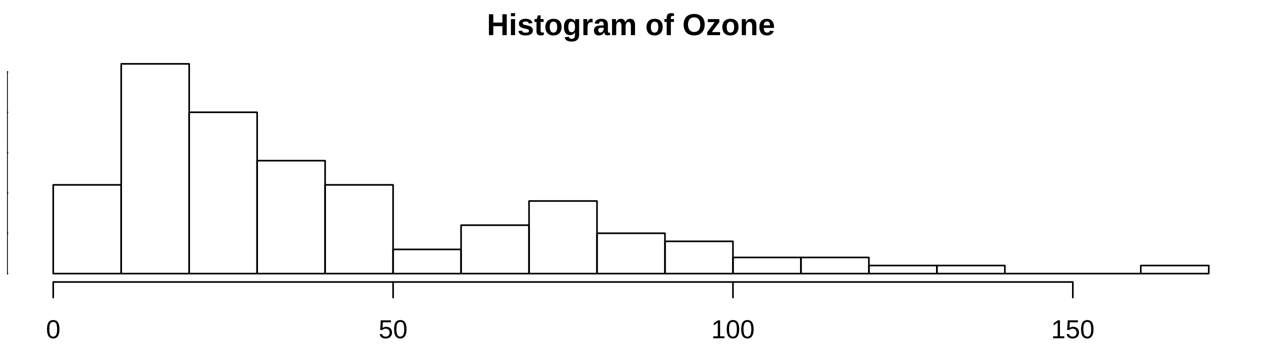
- postscript(): for printing on PostScript printers, or creating PostScript graphics files.
- pdf(): produces a PDF file, which can also be included into PDF files.
- jpeg(): produces a bitmap JPEG file, best used for image plots.

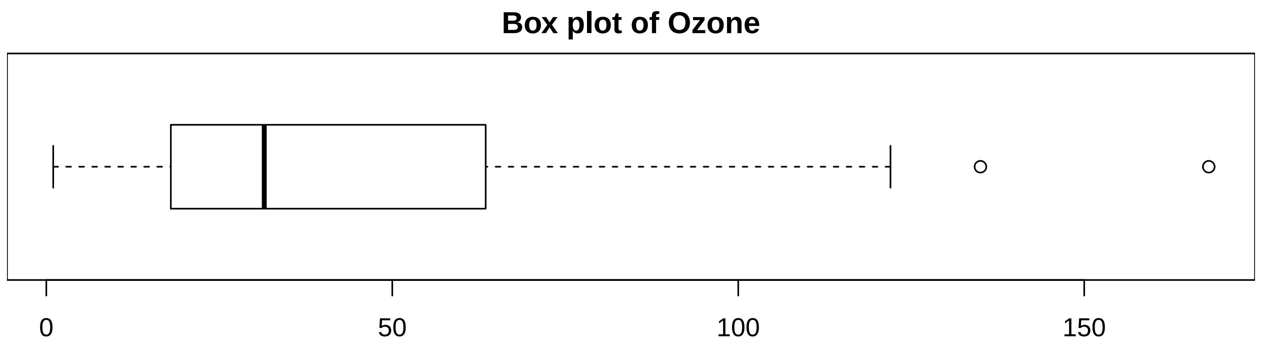
help(Devices) for a list of them all. Simple example:

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

Example: boxplot and hitogram

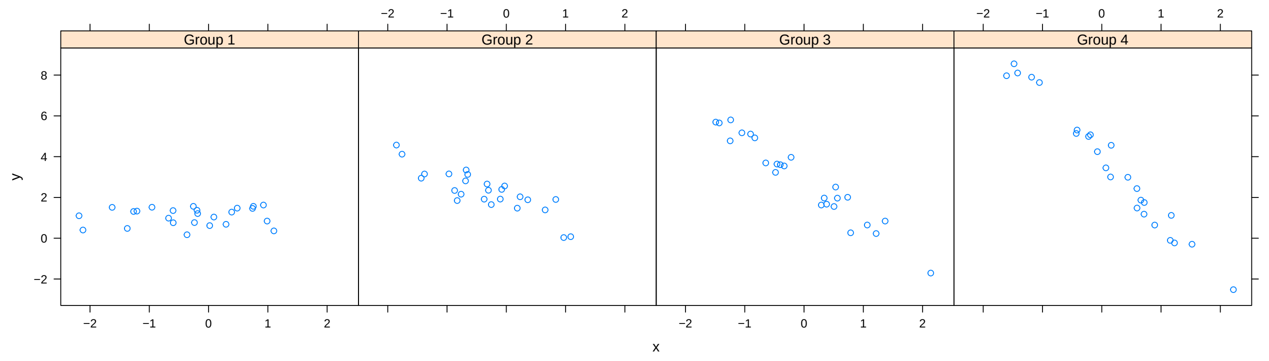
```
## the layout
par(mfrow = c(2, 1), mar = c(2, 0, 2, 0), oma = c(0, 0, 0, 0))
## histogram at the top
hist(airquality$Ozone, breaks=12, main = "Histogram of Ozone")
## box plot below for comparison
boxplot(airquality$Ozone, horizontal=TRUE, main = "Box plot of Ozone")
```





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)
```

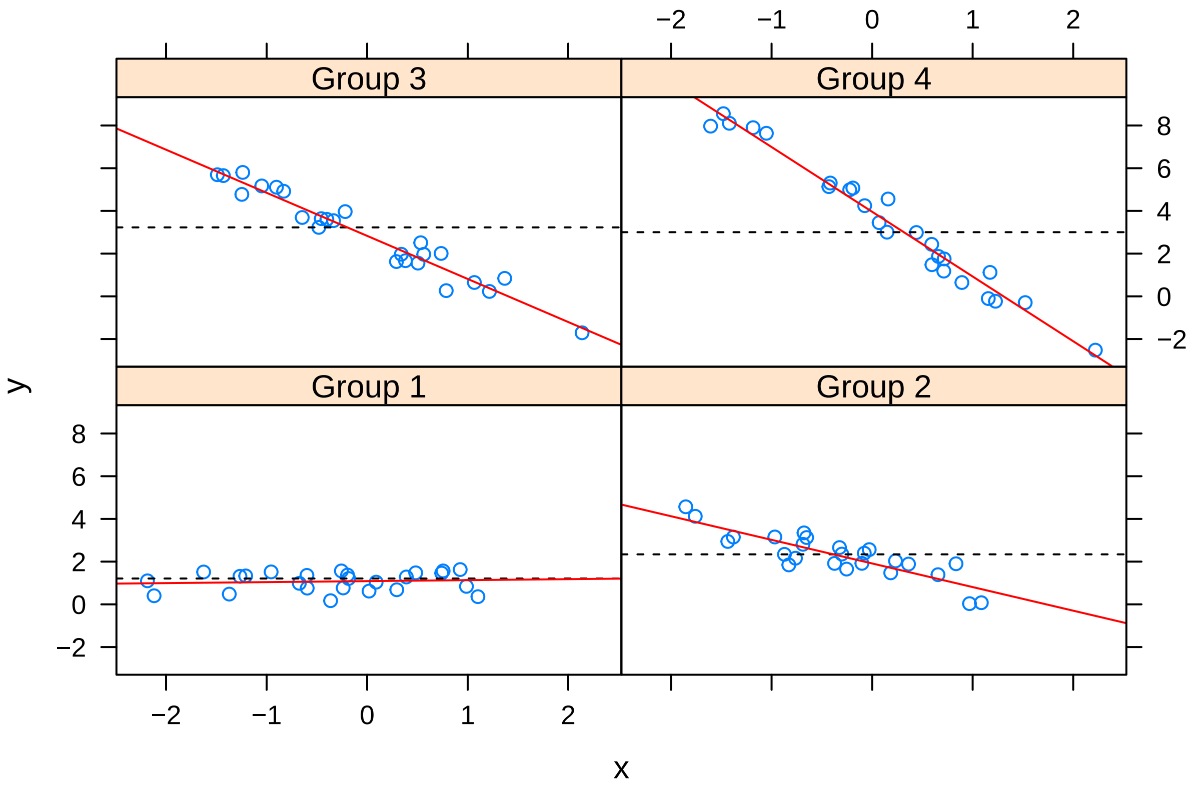


Lattice plotting system

Want more on the plot? Customize the panel funciton:

```r
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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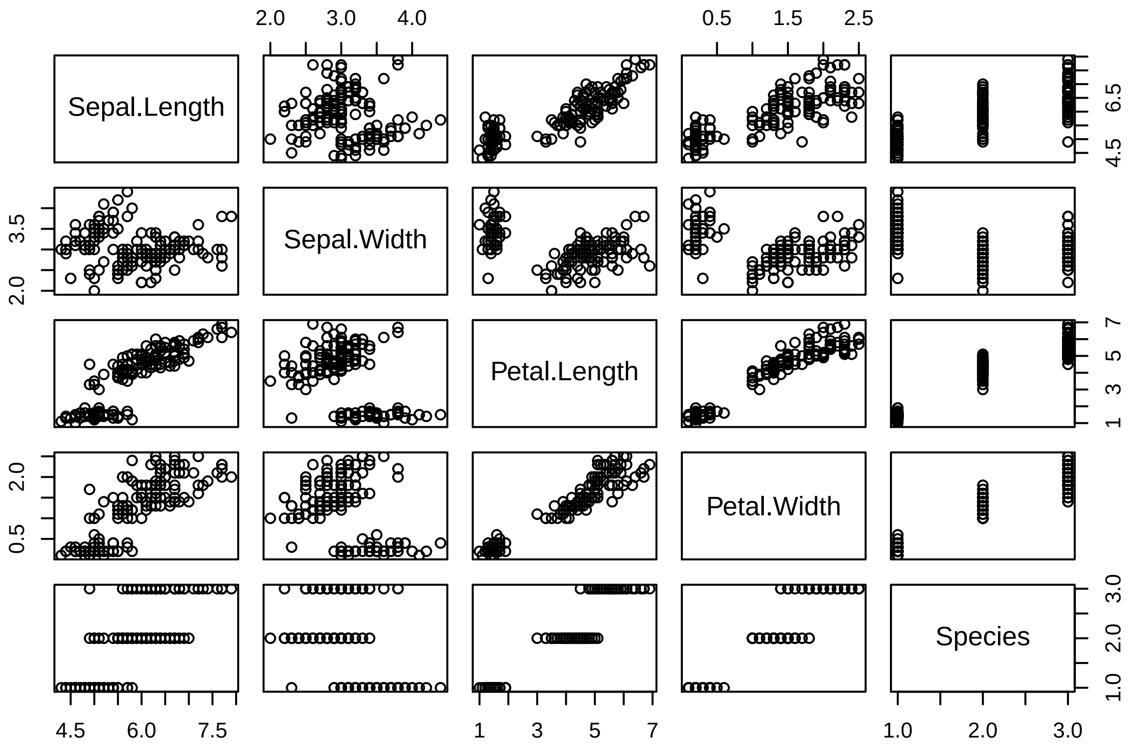
Very useful when we want a lot...

```
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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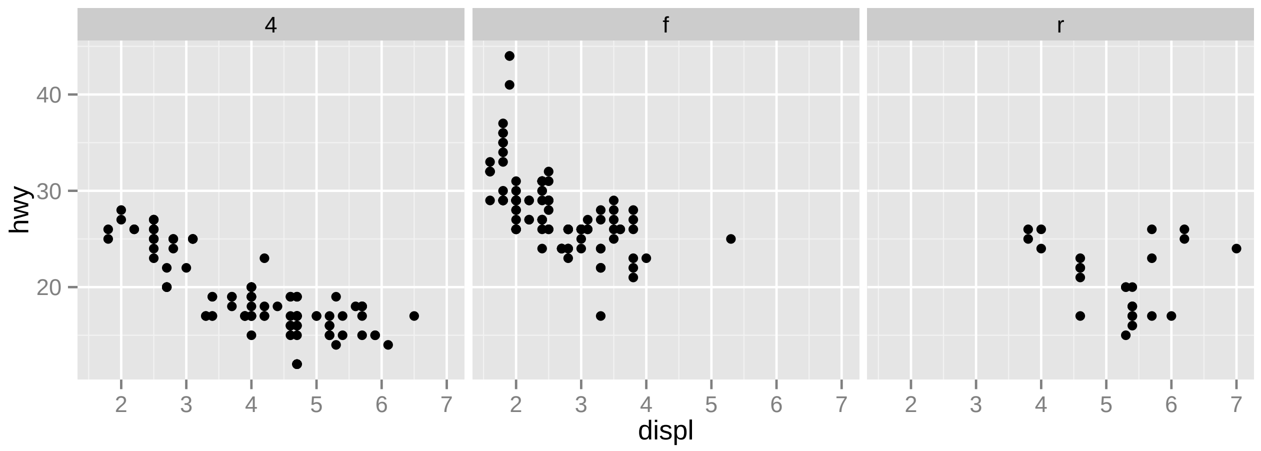
qplot function

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)
```



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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

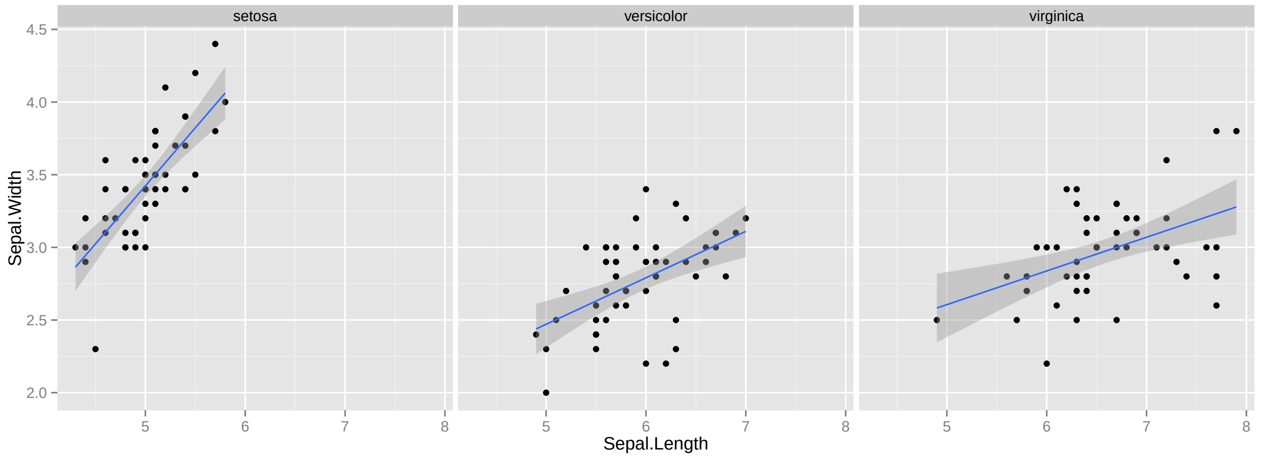
```r
library(ggplot2) ## need to install and load this library
g <- ggplot(iris, aes(Sepal.Length, Sepal.Width)) ## this would not show you add plot
```

---

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)
```



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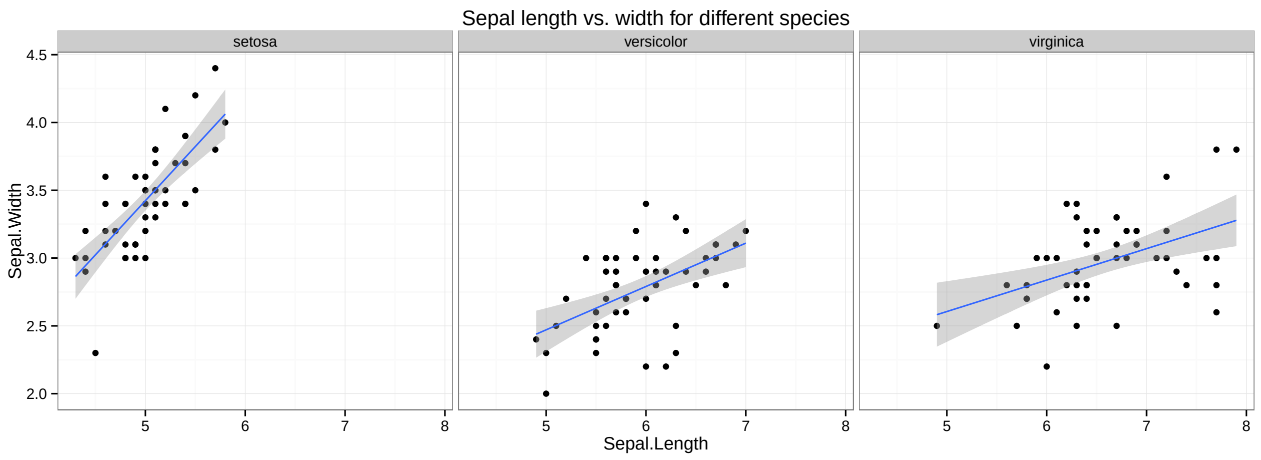
ggplot function

- 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/

Titanic tragedy data

Reading RAW training data

- Download the data set "Titanic_train.csv" from https://raw.githubusercontent.com/datasciencedojo/datasets/master/Titanic_train.csv
- Set working directory of R to the directory of the file using setwd()

```
titanic = read.csv('Titanic_train.csv')
```

Look at the first few rows

What would be some good features to consider here?

```
options(width = 110)
head(titanic)
```

```
##   PassengerId Survived Pclass                                                Name    Sex Age SibSp Pa
## 1           1        0      3                             Braund, Mr. Owen Harris   male  22     1
## 2           2        1      1 Cumings, Mrs. John Bradley (Florence Briggs Thayer) female  38     1
## 3           3        1      3                              Heikkinen, Miss. Laina female  26     0
## 4           4        1      1        Futrelle, Mrs. Jacques Heath (Lily May Peel) female  35     1
## 5           5        0      3                            Allen, Mr. William Henry   male  35     0
## 6           6        0      3                                    Moran, Mr. James   male  NA     0
##             Ticket    Fare Cabin Embarked
## 1        A/5 21171  7.2500              S
## 2         PC 17599 71.2833   C85        C
## 3 STON/O2. 3101282  7.9250              S
## 4           113803 53.1000  C123        S
## 5           373450  8.0500              S
## 6           330877  8.4583              Q
```

What is the data type of each column?

```
sapply(titanic,class)
```

```
## PassengerId    Survived      Pclass        Name         Sex         Age       SibSp       Parch     
##   "integer"   "integer"   "integer"    "factor"    "factor"   "numeric"   "integer"   "integer"    "
##        Fare       Cabin    Embarked 
##   "numeric"    "factor"    "factor"
```

Converting class label to a factor

```
titanic$Survived = factor(titanic$Survived, labels=c("died", "survived"))
titanic$Embarked = factor(titanic$Embarked, labels=c("unkown", "Cherbourg", "Queenstown", "Southampton"
sapply(titanic,class)
```

```
## PassengerId    Survived      Pclass        Name         Sex         Age       SibSp       Parch
##   "integer"    "factor"   "integer"    "factor"    "factor"   "numeric"   "integer"   "integer"    "
##        Fare       Cabin    Embarked
##   "numeric"    "factor"    "factor"
```

```
str(titanic$Survived)
```

```
##  Factor w/ 2 levels "died","survived": 1 2 2 2 1 1 1 1 2 2 ...
```

```
str(titanic$Sex)
```

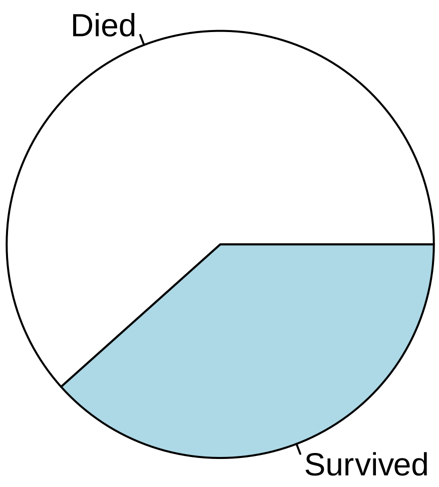
```
##  Factor w/ 2 levels "female","male": 2 1 1 1 2 2 2 2 1 1 ...
```

Class distribution - PIE Charts

```
survivedTable = table(titanic$Survived)
survivedTable
```

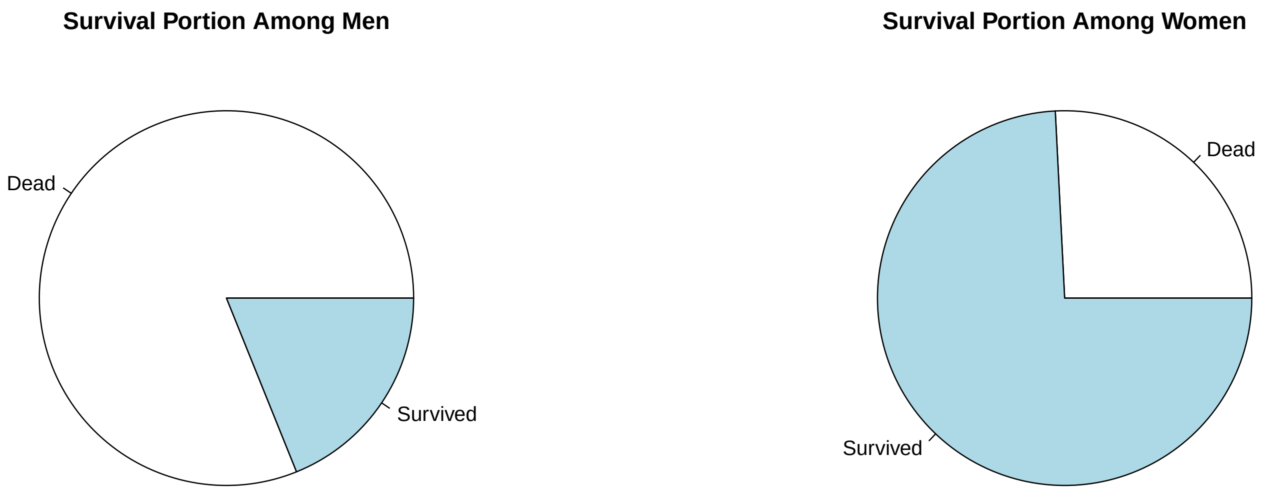
```
##
##     died survived
##      549      342
```

```
par(mar = c(0, 0, 0, 0), oma = c(0, 0, 0, 0))
pie(survivedTable,labels=c("Died","Survived"))
```



Is Sex a good predictor?

```r
male = titanic[titanic$Sex=="male",]
female = titanic[titanic$Sex=="female",]
par(mfrow = c(1, 2), mar = c(0, 0, 2, 0), oma = c(0, 1, 0, 1))
pie(table(male$Survived),labels=c("Dead","Survived"),  main="Survival Portion Among Men")
pie(table(female$Survived),labels=c("Dead","Survived"), main="Survival Portion Among Women")
```



Is Age a good predictor?

```r
Age <- titanic$Age; summary(Age)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's 
##    0.42   20.12   28.00   29.70   38.00   80.00     177
```

How about summary segmented by **survival**

```r
summary(titanic[titanic$Survived=="0",]$Age)
```

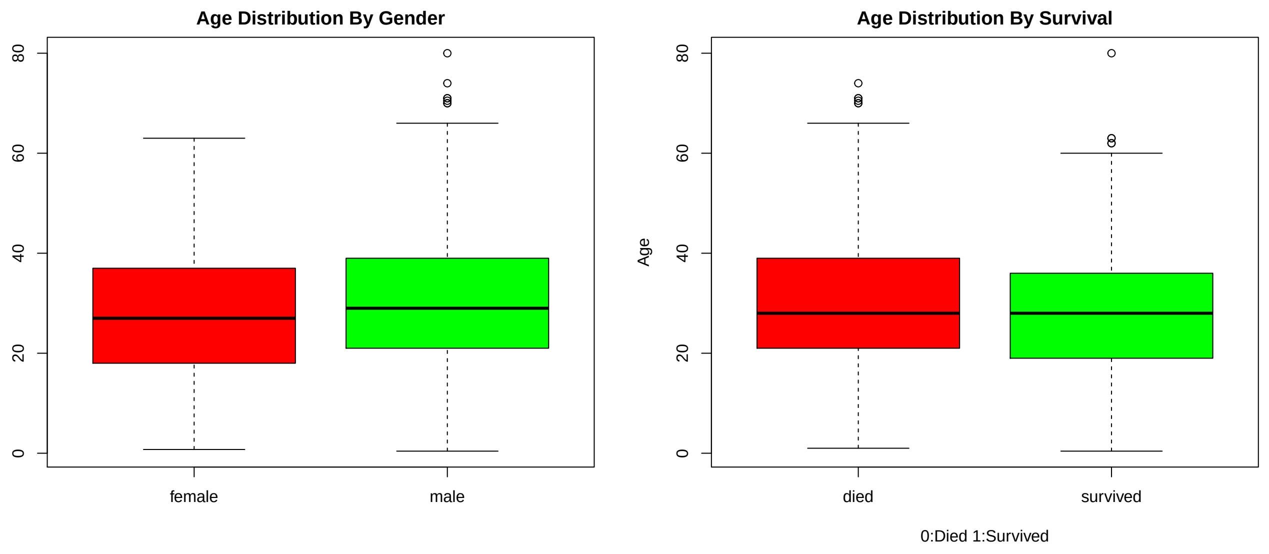
```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max. 
##
```

```r
summary(titanic[titanic$Survived=="1",]$Age)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max. 
##
```

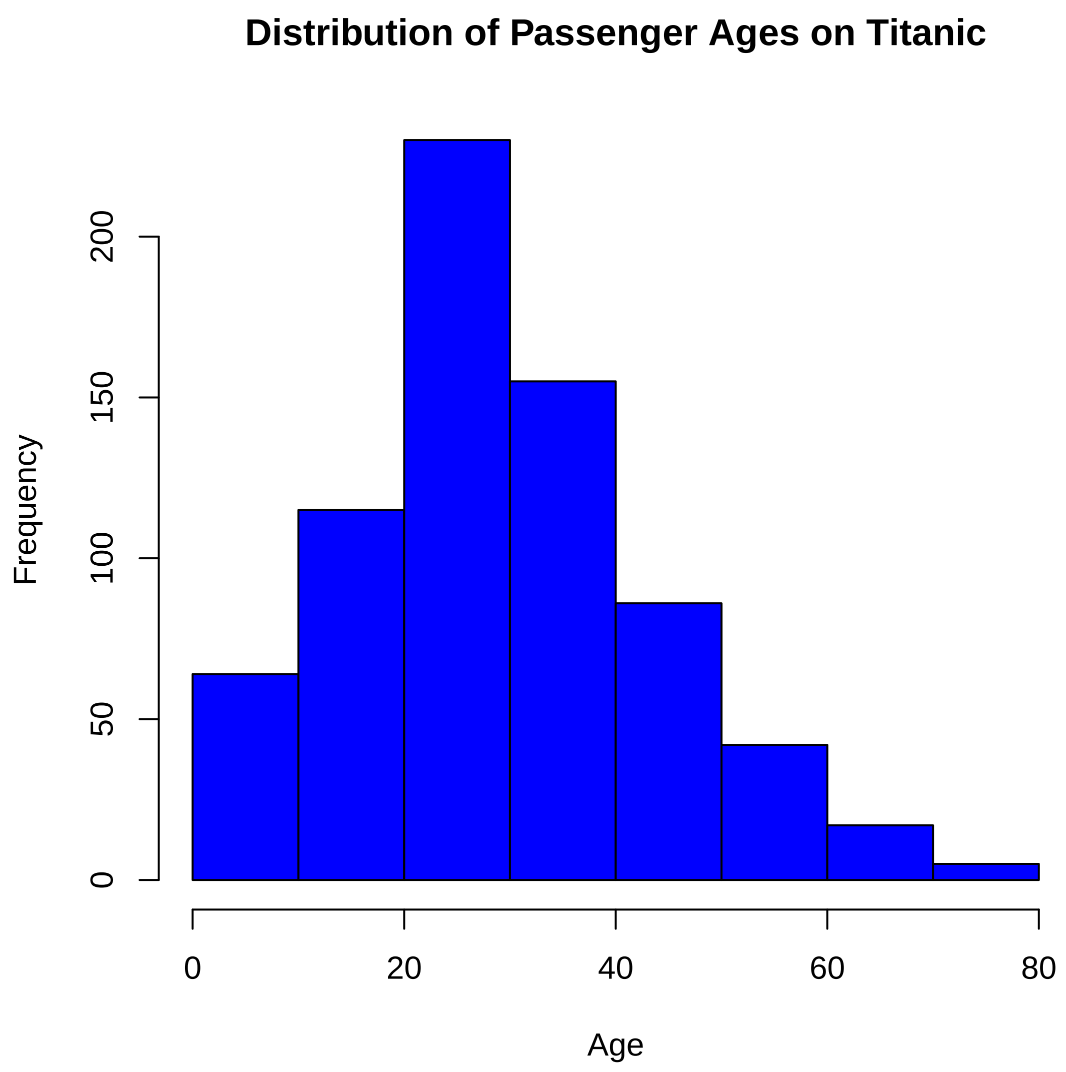
Age distribution by Survival and Sex

```r
par(mfrow = c(1, 2), mar = c(4, 4, 2, 2), oma = c(1, 1, 1, 1))
boxplot(titanic$Age~titanic$Sex, main="Age Distribution By Gender",col=c("red","green"))
boxplot(titanic$Age~titanic$Survived, main="Age Distribution By Survival",col=c("red","green"),
        xlab="0:Died 1:Survived",ylab="Age")
```



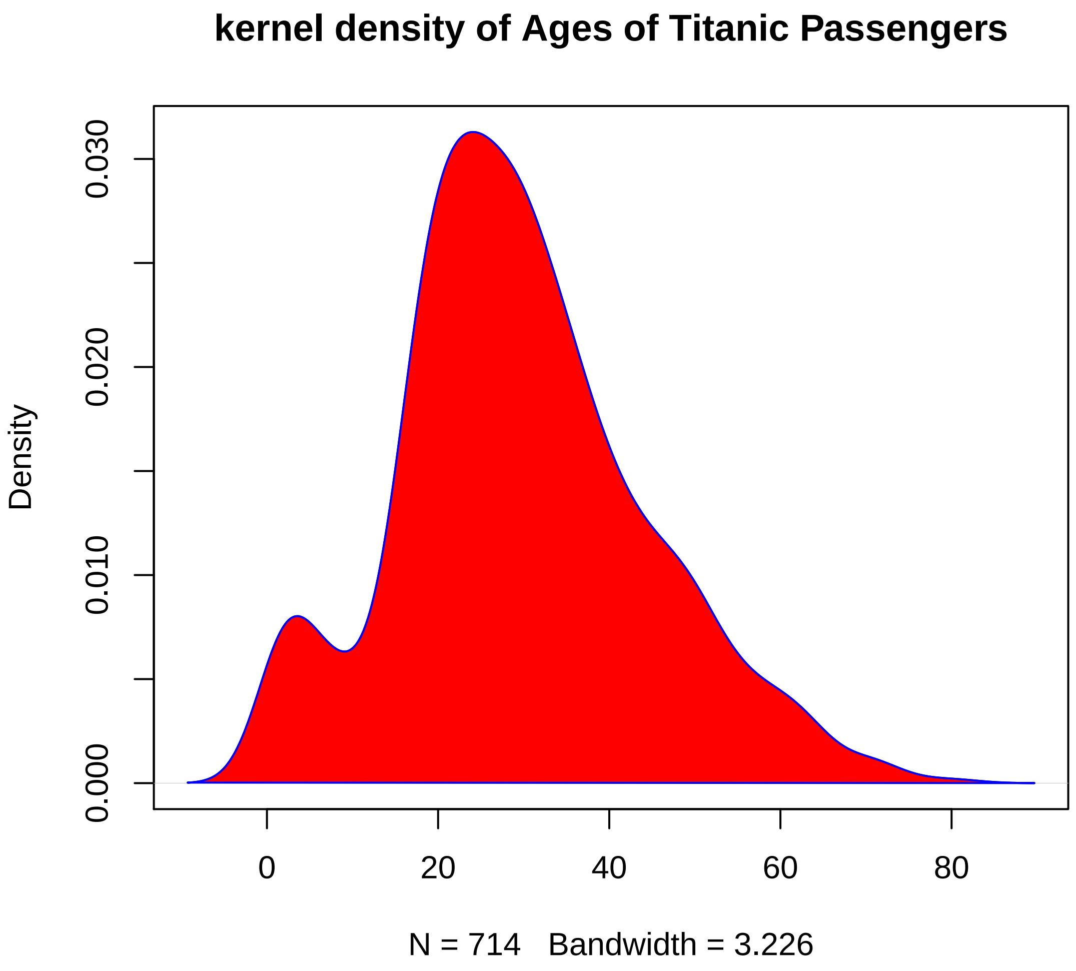
Histogram of Age

```r
hist(Age, col="blue", xlab="Age", ylab="Frequency",
     main = "Distribution of Passenger Ages on Titanic")
```



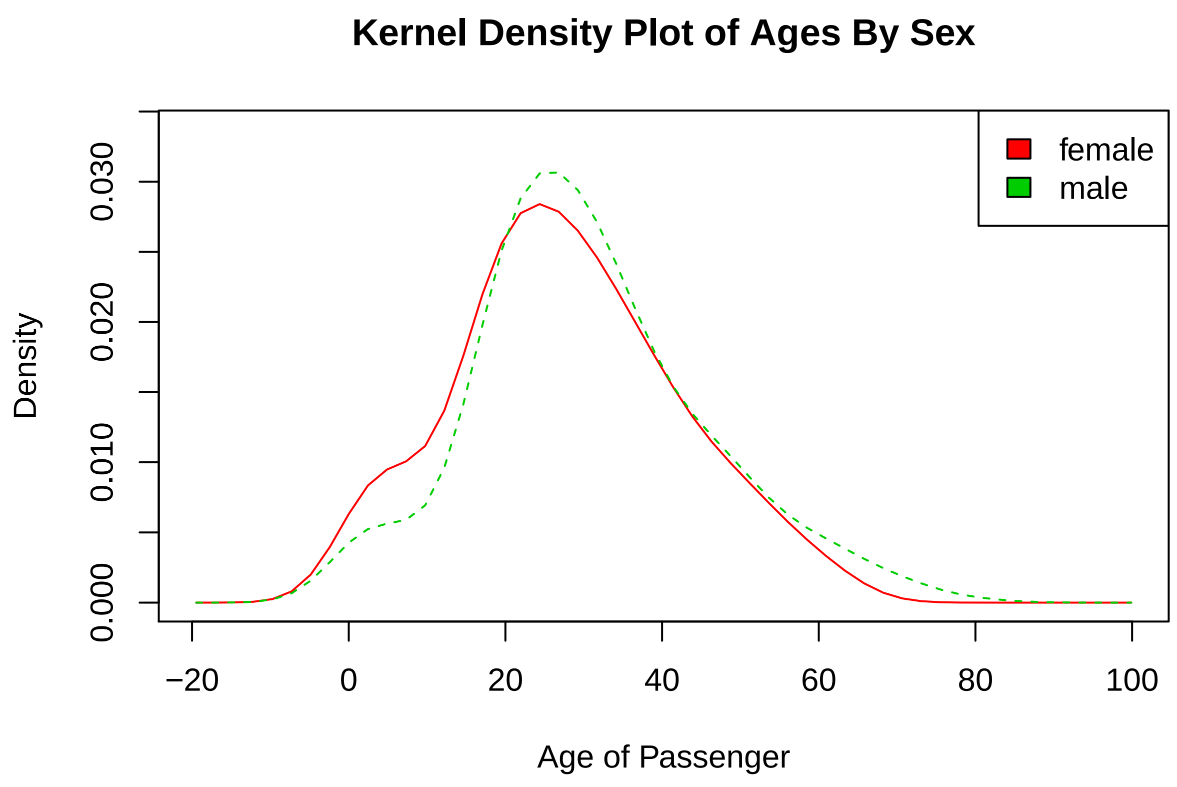
Kernel density plot of age

```r
d = density(na.omit(Age)) # density(Age) won't work, need to omit all NAs
plot(d, main = "kernel density of Ages of Titanic Passengers")
polygon(d, col="red", border="blue")
```

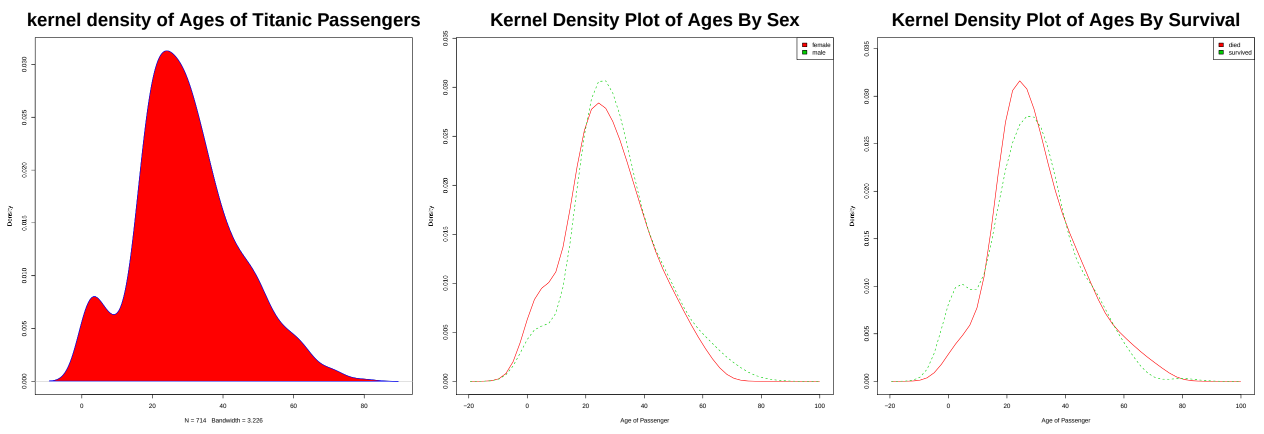


Comparison of density plots of Age with different Sex

```
## Package 'sm', version 2.2-5.4: type help(sm) for summary information
```



Did Age have an impact on survival?



Create categorical groupings: Adult vs Child

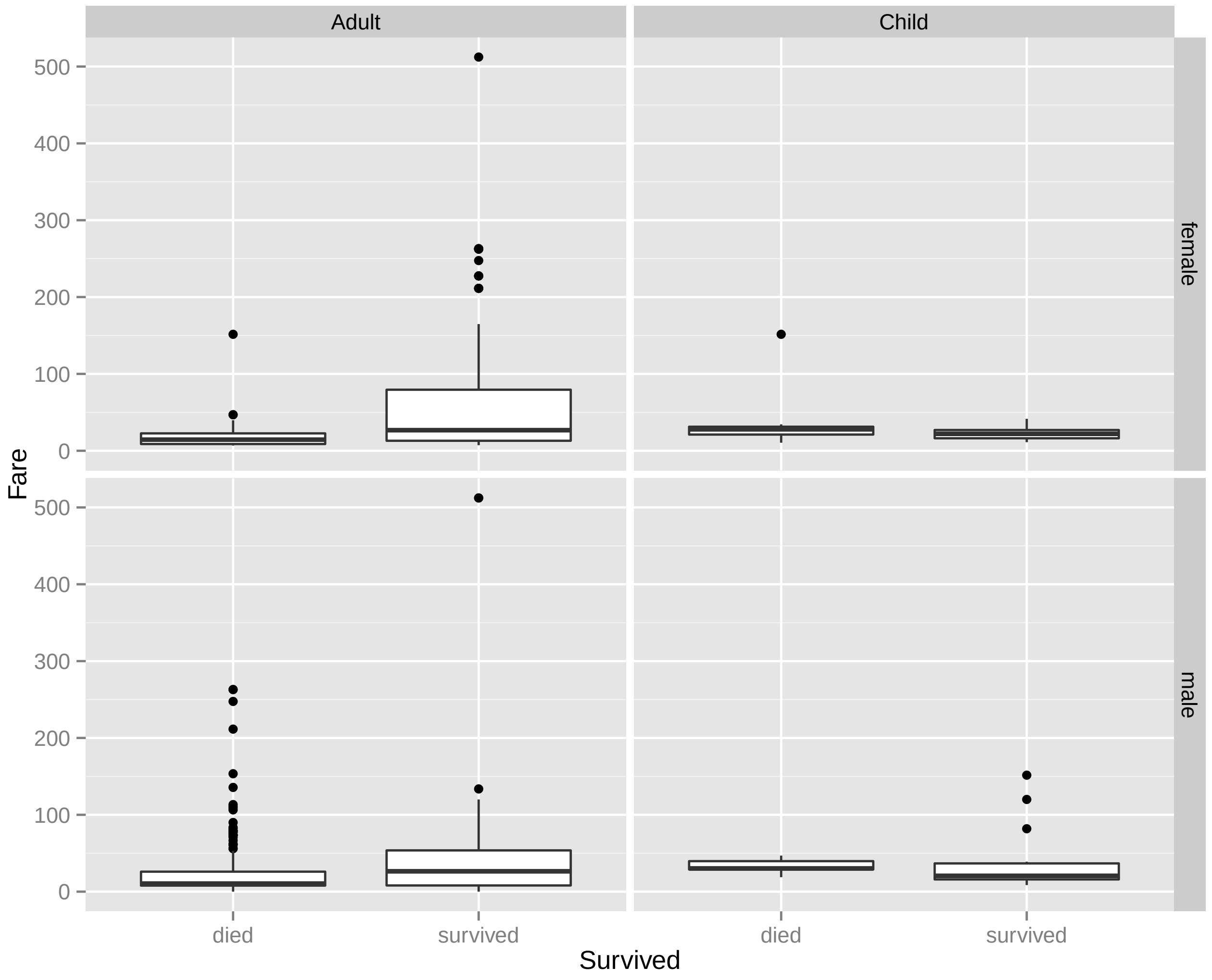
An example of **feature engineering**!

```
## Multi dimensional comparison
Child <- titanic$Age # Isolating age.
```

```
## Now we need to create categories: NA = Unknown, 1 = Child, 2 = Adult
## Every age below 13 (exclusive) is classified into age group 1
Child[Child<13] <- 1
## Every child 13 or above is classified into age group 2
Child[Child>=13] <- 2
```

```
# Use labels instead of 0's and 1's
Child[Child==1] <- "Child"
Child[Child==2] <- "Adult"
# Appends the new column to the titanic dataset
titanic_with_child_column <- cbind(titanic, Child)
# Removes rows where age is NA
titanic_with_child_column <- titanic_with_child_column[!is.na(titanic_with_child_column$Child),]
```

Fare matters?



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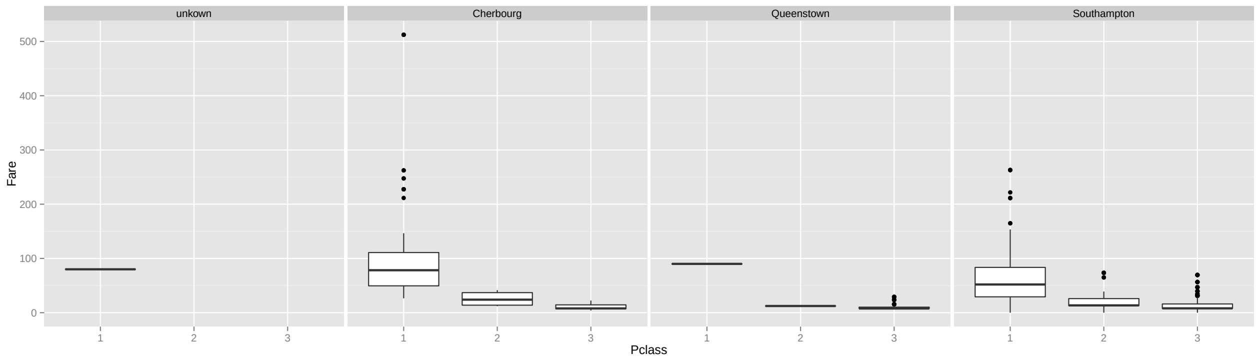
How about fare, ship class, port embarkation?



Diamond data

Overview of the diamond data

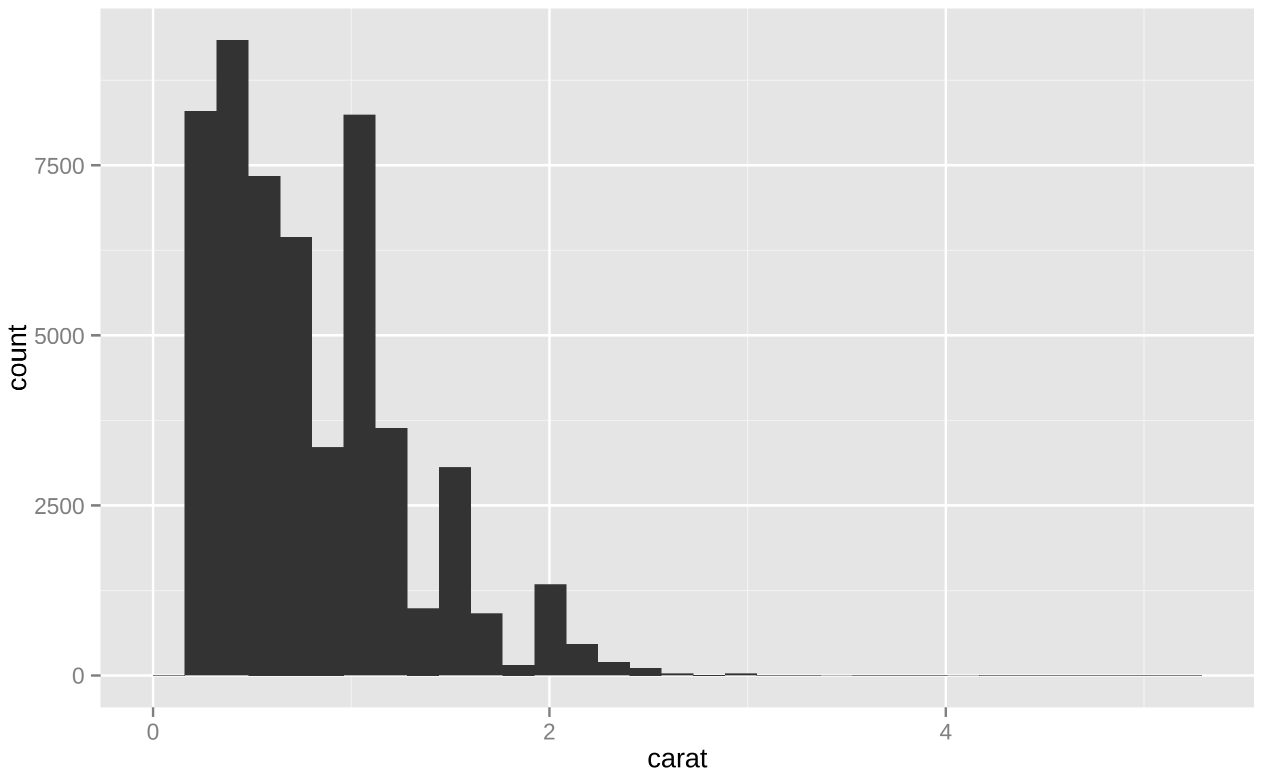
```
data(diamonds) # loading diamonds data set
head(diamonds, 16) # first few rows of diamond data set
```

```
##    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
## 7   0.24 Very Good     I    VVS1  62.3    57   336 3.95 3.98 2.47
## 8   0.26 Very Good     H     SI1  61.9    55   337 4.07 4.11 2.53
## 9   0.22      Fair     E     VS2  65.1    61   337 3.87 3.78 2.49
## 10  0.23 Very Good     H     VS1  59.4    61   338 4.00 4.05 2.39
## 11  0.30      Good     J     SI1  64.0    55   339 4.25 4.28 2.73
## 12  0.23     Ideal     J     VS1  62.8    56   340 3.93 3.90 2.46
## 13  0.22   Premium     F     SI1  60.4    61   342 3.88 3.84 2.33
## 14  0.31     Ideal     J     SI2  62.2    54   344 4.35 4.37 2.71
## 15  0.20   Premium     E     SI2  60.2    62   345 3.79 3.75 2.27
## 16  0.32   Premium     E      I1  60.9    58   345 4.38 4.42 2.68
```

Histogram of carat

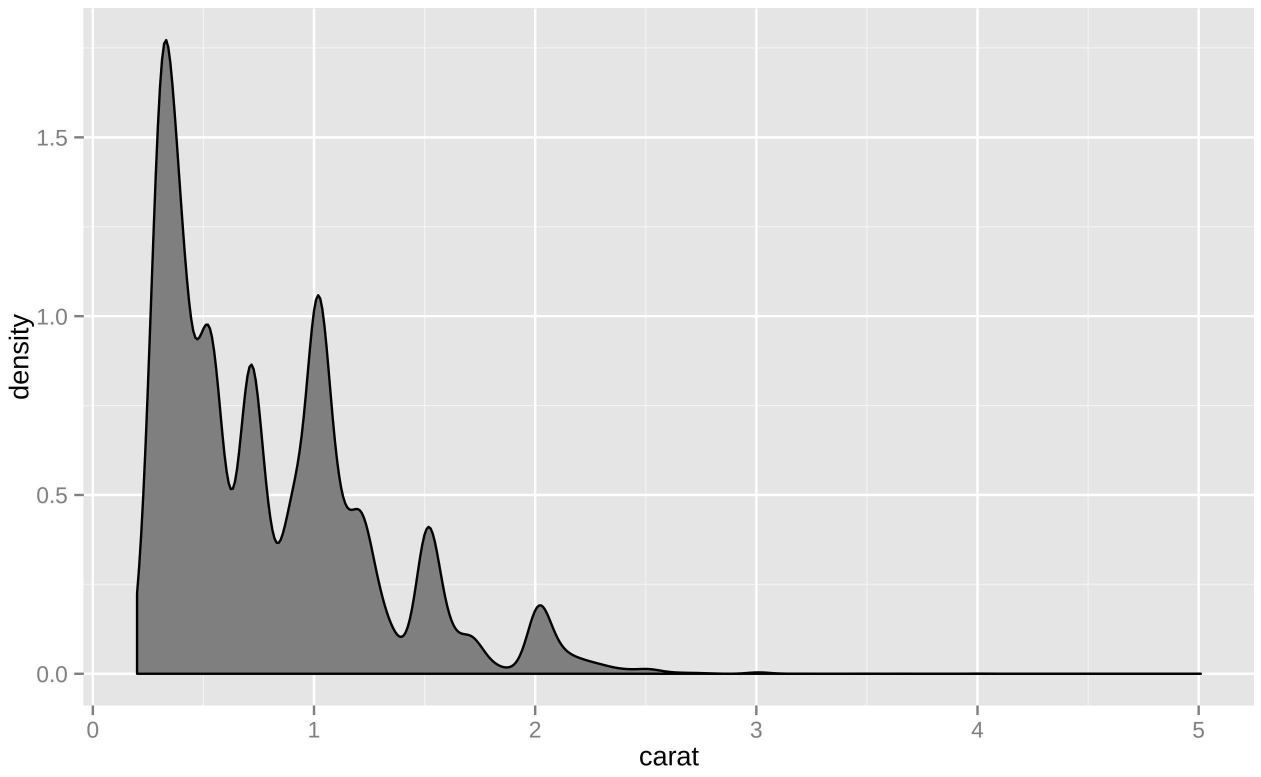
```r
library(ggplot2)
ggplot(data=diamonds) + geom_histogram(aes(x=carat))
```

```
## stat_bin: binwidth defaulted to range/30. Use 'binwidth = x' to adjust this.
```



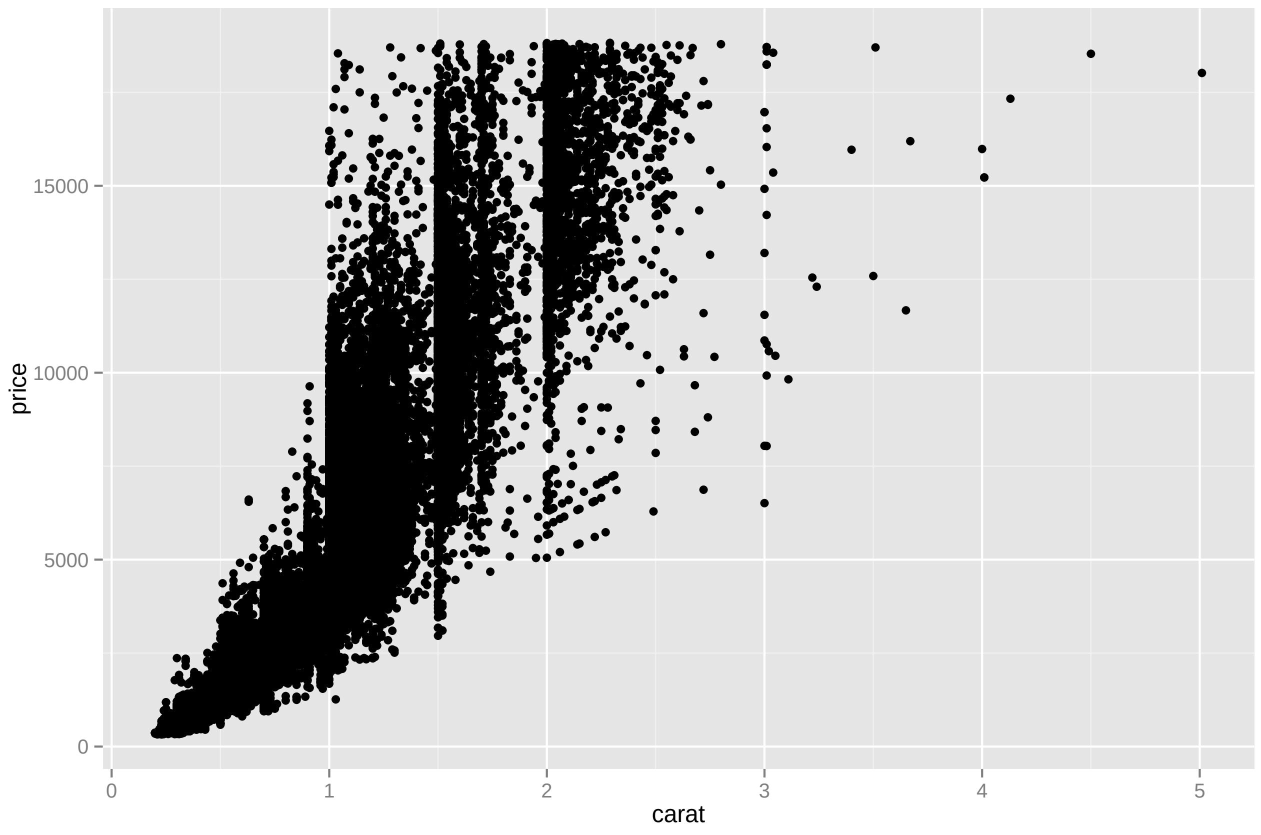
Density plot of carat

```r
ggplot(data=diamonds) +
geom_density(aes(x=carat),fill="gray50")
```



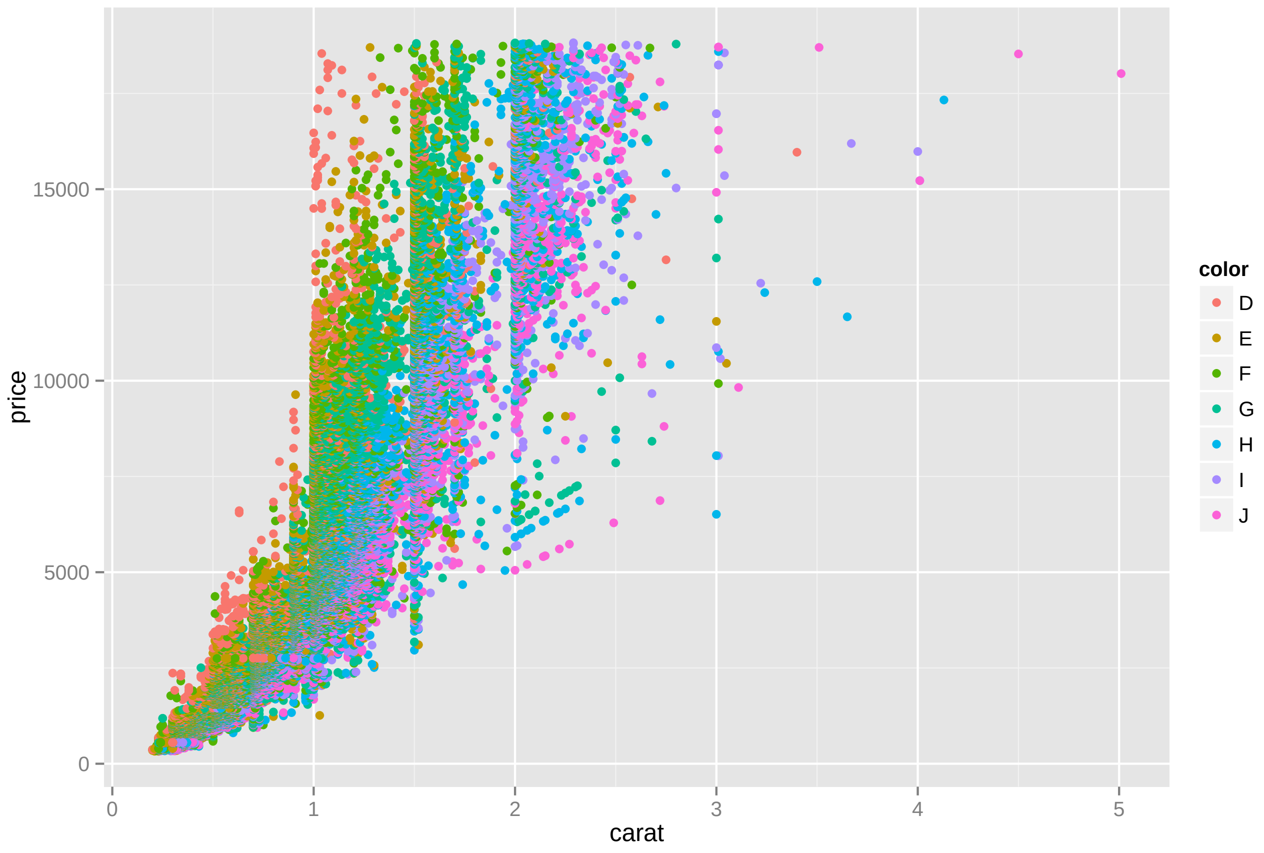
Scatter plots (carat vs. price)

```r
ggplot(diamonds, aes(x=carat,y=price)) + geom_point()
```



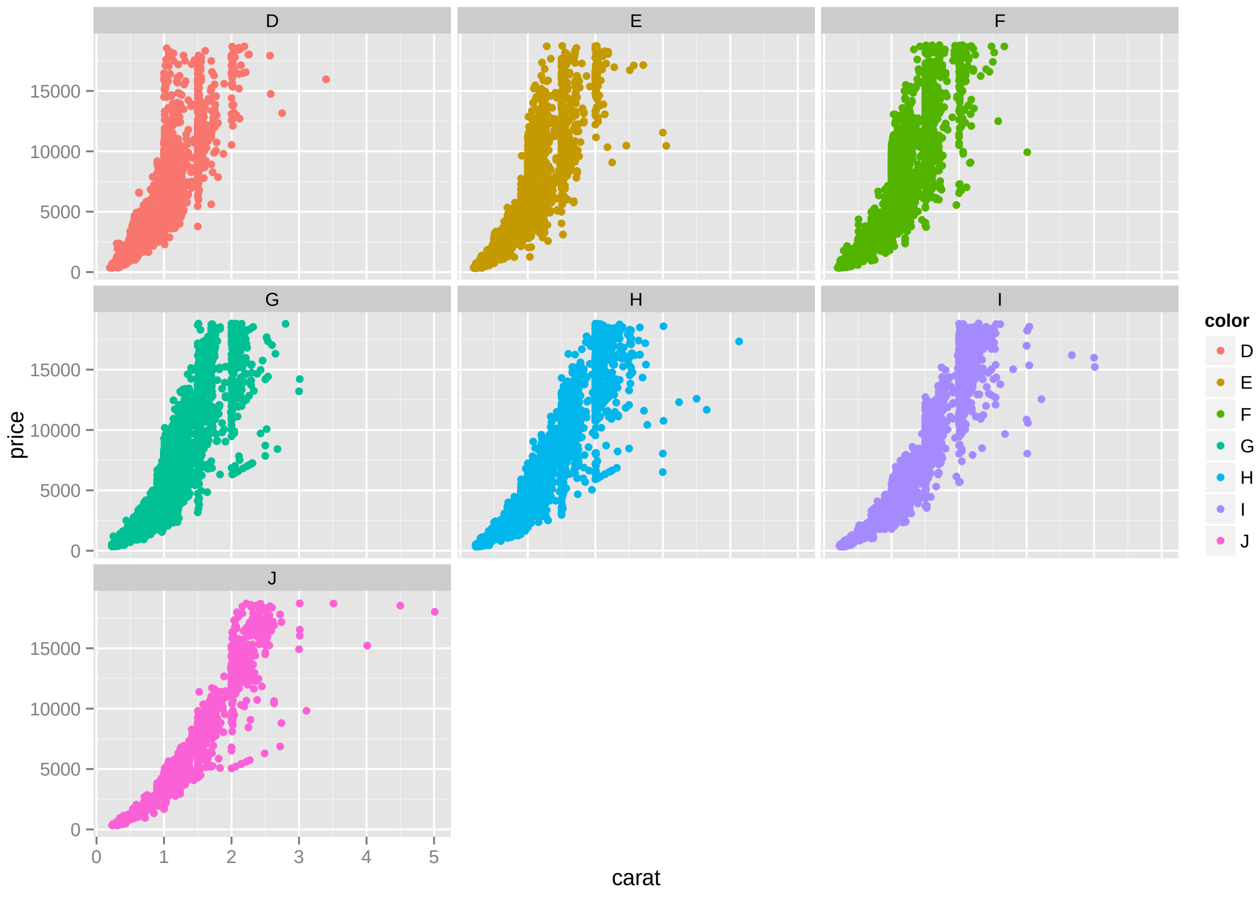
Carat with colors

```
g = ggplot(diamonds, aes(x=carat, y=price)) # saving first layer as variable
g + geom_point(aes(color=color)) # rendering first layer and adding another layer
```

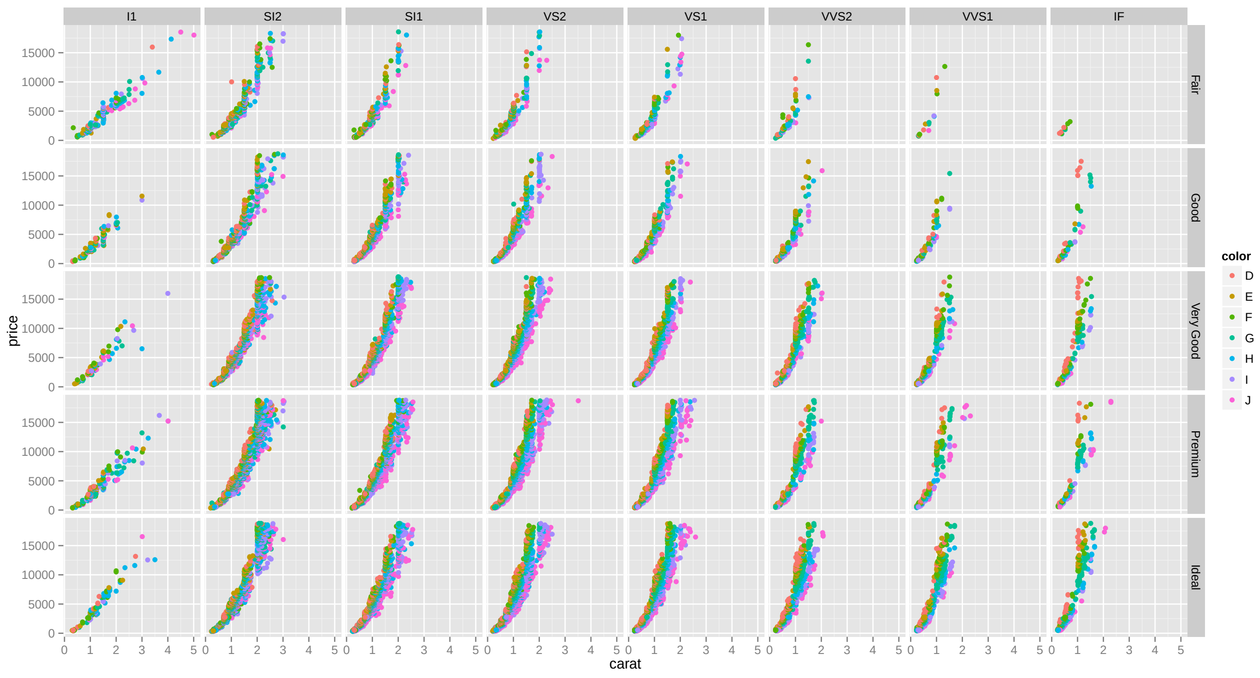


Carat with colors (more details)

```
g + geom_point(aes(color=color)) + facet_wrap(~color)
```



Let's consider cut and clarity



Your trun!

What is your knowledge of diamond's price after exploring this data?

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

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Tell your story - R Markdown

- R Markdown is an authoring format that enables easy creation of dynamic documents, presentations, and reports from R.
- It combines the core syntax of markdown (an easy-to-write plain text format) with embedded R code chunks that are run so their output can be included in the final document.
- Many available output formats including HTML, PDF, and MS Word
- **Installation**
  Use RStudio: already installed
  Outside of RStudio: install.packages("rmarkdown"). A recent version of pandoc (>= 1.12.3) is also required. See https://github.com/rstudio/rmarkdown/blob/master/PANDOC.MD to install it.

Check out Markdown first

> Markdown is a markup language with plain text formatting syntax designed so that it can be converted to HTML and many other formats using a tool by the same name.

One minute you get the point, and always check the cheat sheets
https://github.com/adam-p/markdown-here/wiki/Markdown-Cheatsheet#lists

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Then, R Markdown sample code

Download the template:
https://github.com/datasciencedojo/datasets/blob/master/rmarkdownd_template.Rmd

R Markdown

- YAML header
- Edit Markdown, and R chunks
- Run!
  RStudio: knitr button
  Command line: render("file.Rmd")

Cheat sheet of rmarkdown:
http://www.rstudio.com/wp-content/uploads/2015/02/rmarkdown-cheatsheet.pdf

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Present your story of Titanic!

Use * Titanic data * Plotting functions in R * R Markdown template * **The heart of data explorer**

to write your story of Titanic…

Hope this is inspiring :)

Titanic