R

Bioinformatics Applications (PLPTH813)

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1/26/2017

Outline

- R introduction
- Data structure
- Data input and output
- Basic graphics
- String operations

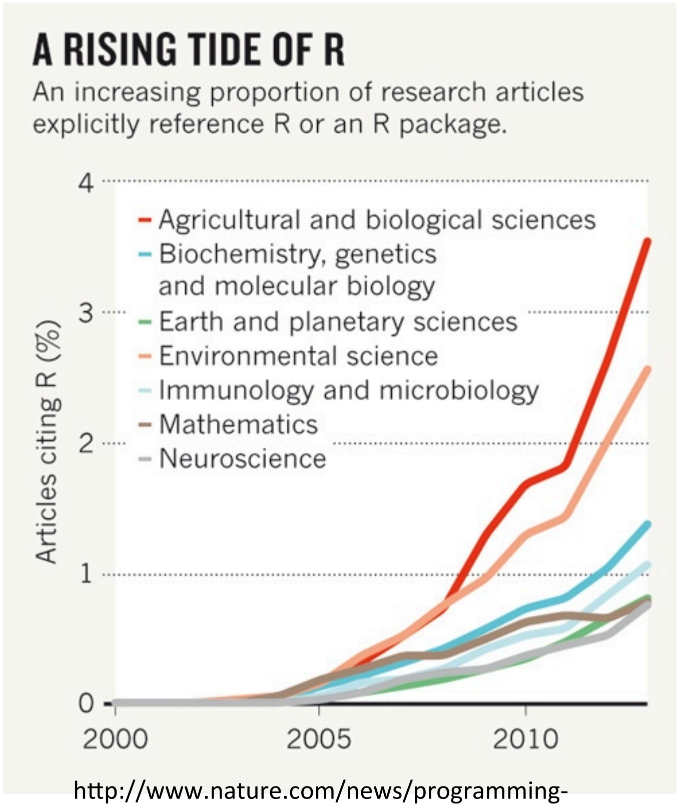
R

- R is a programming language and a cutting-edge tool for data analysis, especially for statistical computing and graphics.

- R is free

- R is powerful. Applications are easily created by writing new **functions**. Functions are usually distributed through **packages**.

- It has great community support.



http://www.nature.com/news/programming-tools-adventures-with-r-1.16609#/rise

www.r-project.org

Example – statistical test

- X^2 test

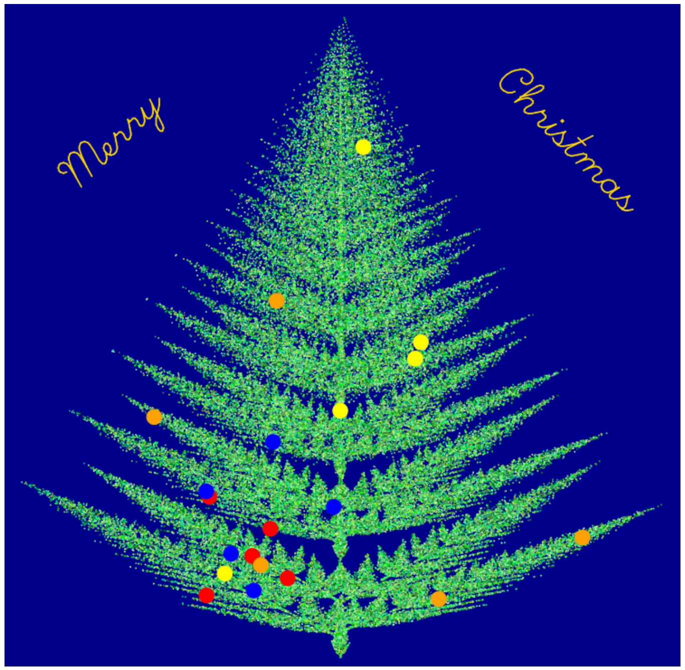
	B	
A	12	36
	24	70

```
d <- c(12, 36, 24, 70)
dm <- matrix(d, nrow=2, byrow=T)
chisq.test(dm)
```

```
data:  dm
X-squared = 0, df = 1, p-value = 1
```

Example – Christmas tree

```r
# Christmas tree
L <-  matrix(
  c(0.03,  0,     0  ,  0.1,
    0.85,  0.00,  0.00, 0.85,
    0.8,   0.00,  0.00, 0.8,
    0.2,  -0.08,  0.15, 0.22,
    -0.2,   0.08,  0.15, 0.22,
    0.25, -0.1,   0.12, 0.25,
    -0.2,   0.1,   0.12, 0.2),
  nrow=4)
# ... and each row is a translation vector
B <- matrix(
  c(0, 0,
    0, 1.5,
    0, 1.5,
    0, 0.85,
    0, 0.85,
    0, 0.3,
    0, 0.4),
  nrow=2)

prob = c(0.02, 0.6,.08, 0.07, 0.07, 0.07, 0.07)

# Iterate the discrete stochastic map
N = 1e5 #5  #   number of iterations
x = matrix(NA,nrow=2,ncol=N)
x[,1] = c(0,2)   # initial point
k <- sample(1:7,N,prob,replace=TRUE) # values 1-7

for (i in 2:N)
  x[,i] = crossprod(matrix(L[,k[i]],nrow=2),x[,i-1]) + B[,k[i]] # iterate

# Plot the iteration history
#png('card.png')
par(bg='darkblue',mar=rep(0,4))
plot(x=x[1,],y=x[2,],
     col=grep('green',colors(),value=TRUE),
     axes=FALSE,
     cex=.1,
     xlab='',
     ylab='' )#,pch='.')

bals <- sample(N,20)
points(x=x[1,bals],y=x[2,bals]-.1,
       col=c('red','blue','yellow','orange'),
       cex=2,
       pch=19
)
text(x=-.7,y=8,
     labels='Merry',
     adj=c(.5,.5),
     srt=45,
     vfont=c('script','plain'),
     cex=3,
     col='gold'
)
text(x=0.7,y=8,
     labels='Christmas',
     adj=c(.5,.5),
     srt=-45,
     vfont=c('script','plain'),
     cex=3,
     col='gold'
)
```



R commands, case sensitivity

- **Expression**

Print the value and not save the value in the environment

```
2 + 4
68 * 0.15
```

- **Assignment**

Assign values to a **variable**

```
y <- 2
y = 2
assign("y", 2)
Y <- 2 + 4
```

- **Comments (#)**

Notes/explanation to the scripts, starting with a hashmark ('#'), everything to the end of the line is a comment.

```
y <- 2 + 4  # an example of the assignment
y <- 2 + 4
```

Data structure - vector

A vector is a single entity consisting of an ordered collection of numbers, characters, logical quantities, etc.

- **Numeric vector**

```
x <- c(10.4, 5.6, 3.1, 6.4, 21.7)
sum(x)
y <- 2
2*x + y
```

c(10.4, 5.6, 3.1, 6.4, 21.7)

$\uparrow \qquad \uparrow$

1st 2nd ...

x[2]

- **Logical vector**

```
lv <- c(TRUE, FALSE, TRUE, TRUE)
lv == FALSE
sum(lv)
# The logical operators are <, <=, >, >=, ==, and !=.
# == for exact equality and != for inequality.
x <- c(10.4, 5.6, 3.1, 6.4, 21.7)
lv2 <- x > 10
```

- **Character vectors**

```
cv <- c("a", "b", "c")
cv2 <- paste(cv, 1:3, sep="")
```

- **Missing values: NA, not available**

```
mvv <- c("a", "b", "c", NA)
is.na(mvv)
```

Select a subset and modify a vector

- **Select a subset of a vector**

```
x <- c(4, 5, 7, 3, 9)
x[c(2, 3)]
x[x>10]
x[-c(1,5)]
```

- **Modify a vector**

```
x[3] <- 23.1
x <- c(x, 10.9)
names(x) <- c("a", "b", "c", "d", "e", "f")
```

mode and length of a vector

- **Mode**

Vectors must have their values with the same mode, either numeric, character, logical, or other types.

```
z <- 0:9
is.numeric(z)
digits <- as.character(z) # convert to character
d <- as.integer(digits) # convert to integer
```

- **Length**

```
length(z)
length(z) <- 5  # retain just the first 5 values
```

factor

Definition: A factor is a vector object used to specify a discrete classification (grouping) of the components of other vectors with the same length.

- **factor = regular vector + Levels**

```
state <- c("tas", "sa", "qld", "nsw",
           "nsw", "nt", "wa", "wa",
           "qld", "vic", "nsw", "vic")
statef <- factor(state)
> statef
[1] tas sa qld nsw nsw nt wa wa qld vic nsw vic
Levels: nsw nt qld sa tas vic wa
> levels(statef)
[1] "nsw" "nt" "qld" "sa" "tas" "vic" "wa"
```

```
state2 <- as.character(statef)
```

array and matrix

- array: 2 or more dimensions of data
- matrix: a special array with two dimensions

```
num <- 1:25
numm <- matrix(num, nrow=5, byrow=T)
nrow(numm)
dim(numm)
```

matrices can be built up by using the functions cbind() and rbind():

cbind() forms matrices by binding together matrices horizontally, or column-wise
rbind() vertically, or row-wise.

Note: the result of rbind() or cbind() always has matrix status

data.frame

name	age	>30?	gender
Josh	23	FALSE	male
Rose	35	TRUE	female
Jone	18	FALSE	male
Molly	21	FALSE	female
Lisa	36	TRUE	female

- **Data frame**

A data frame may be regarded as a matrix with columns possibly of differing modes and attributes. The data of a matrix are of the same type or mode.

- **Making data frames**

```
df <- data.frame(name=c("Josh", "rose"), age=c(23, 35))
```

- **Working with data frames**

```
> df$name
[1] Josh rose
Levels: Josh rose
> df[, 1]
[1] Josh rose
Levels: Josh rose
```

```
> df[[1]]
[1] Josh rose
Levels: Josh rose
> df[1]
  name
1 Josh
2 rose
```

```
head(df); tail(df); summary(df); str(df)
```

list

A list is an object consisting of an ordered collection of objects.

- **Objects can be any types or modes**

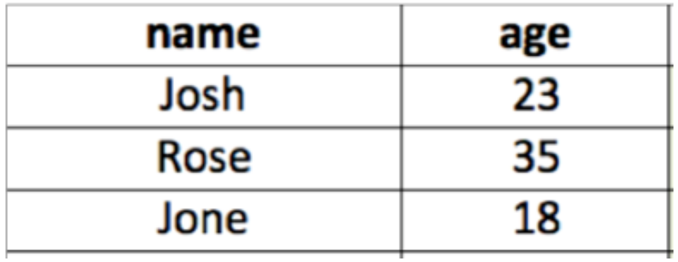
```
lst <- list(name="Fred", wife="Mary", nkids=3, kid.ages=c(4,7,9))


> lst[1]  # sublist
$name
[1] "Fred"

> lst[[1]] # first element in the list
[1] "Fred"

> lst$name # the element named “name”
[1] "Fred”
```

Problem

```
df <- data.frame(name=c("Josh", "rose", "John"),
age=c(23, 35, 18))
```

What are the values of

df[2, 1]
df[3, 2]
df[2]
df[, 2]



name	age
Josh	23
Rose	35
Jone	18

What is the difference between the last two?

Data import

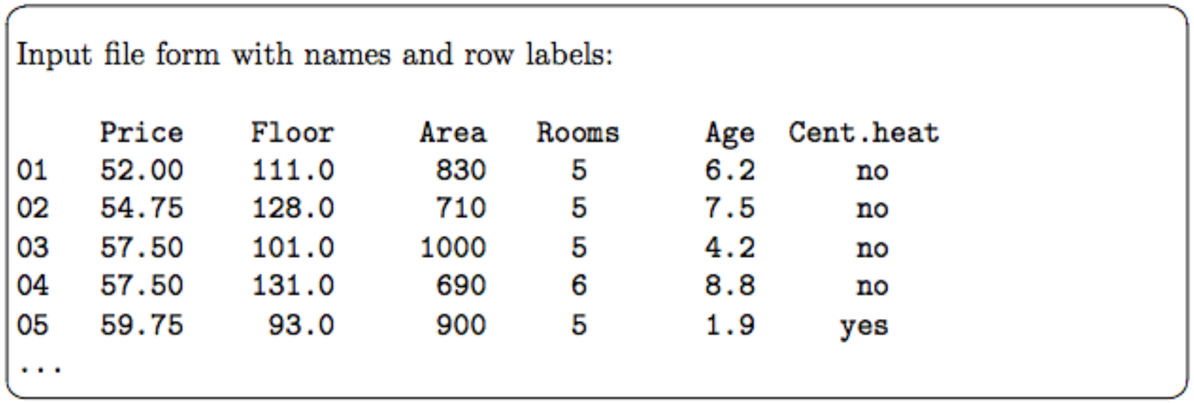
- **scan()**: to read data from a file to a vector or list

```
cat("lisa Jone", "28 21", file = "hrdb.txt", sep = "\n")
hr <- scan("hrdb.txt", what=character())
hr
"lisa" "Jone" "28"   "21"
```

- **read.table()**: to read a data frame (table) directly

read.delim, read.csv

```
d <- read.table(data)
```



Input file form with names and row labels:

	Price	Floor	Area	Rooms	Age	Cent.heat
01	52.00	111.0	830	5	6.2	no
02	54.75	128.0	710	5	7.5	no
03	57.50	101.0	1000	5	4.2	no
04	57.50	131.0	690	6	8.8	no
05	59.75	93.0	900	5	1.9	yes
...						

Data export

- **write.table()** or **write.csv()**

```
## To write a tab-delimited file:
x <- data.frame(a = "pi", b = pi)
write.table(x, file="foo.txt", sep="\t", row.names=FALSE)

## and to read this file back into R one needs
read.table("foo.txt")

## Alternatively
write.csv(x, file = "foo.csv”, row.names=FALSE)
read.csv("foo.csv")
```

Outline

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- Data structure
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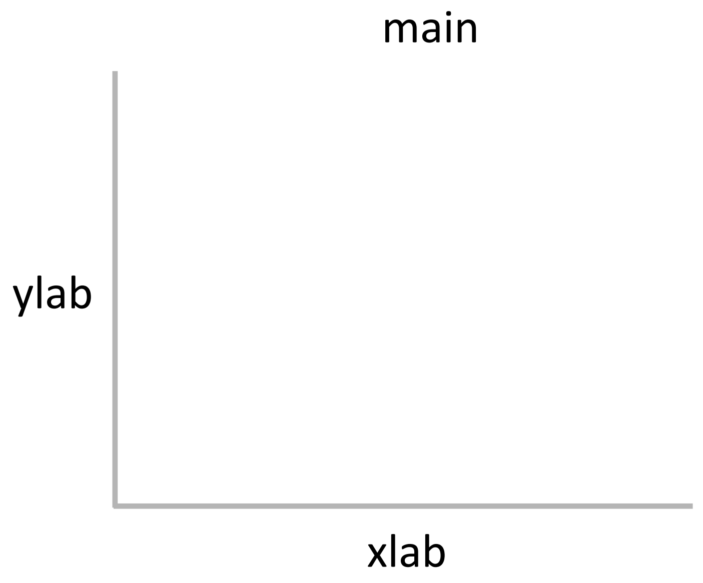
- Basic graphics
- String operations

Basic graphics

- **plot(); points(); lines(); abline(); text(); legend()**

High-level plot: create a new plot

```
plot(x, y, xlab, ylab, main, …)
```

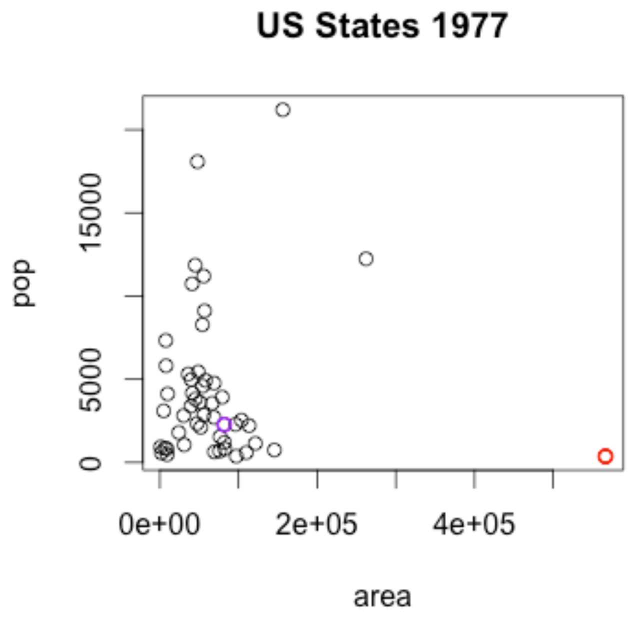


Low-level plot: add to an existing plot

```
# add points
points(x, y)

# add lines
lines(x, y)

# add horizontal or vertical lines
abline(h, v)

# add text or legend
text()
legend()
```

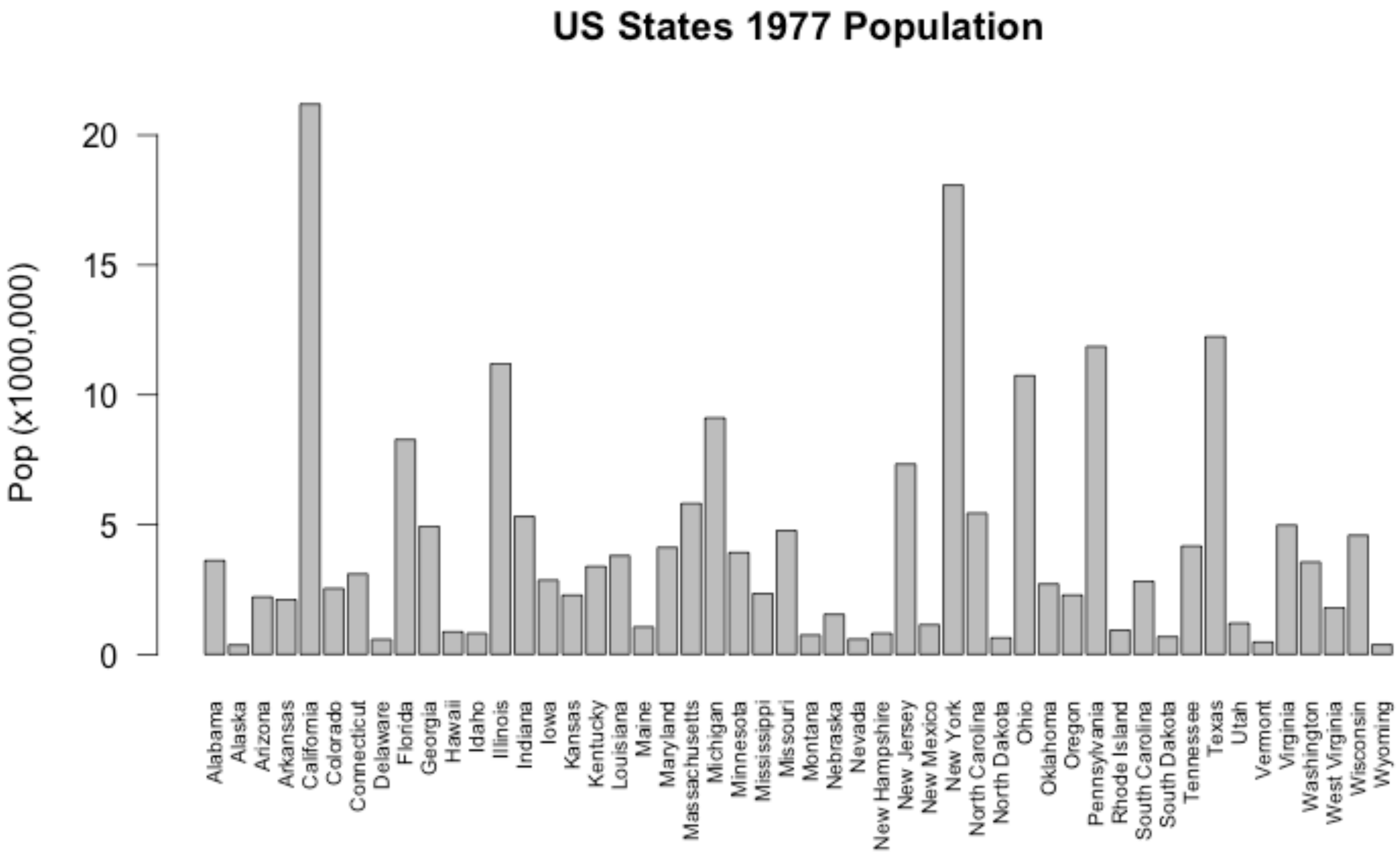
Scatter plot

```
# data
area <- state.x77[, "Area"]
pop <- state.x77[, "Population"]

# scatter plot
plot(area, pop, main="US States 1977")

# label points
state.max.area <- which.max(area)
points(area[state.max.area],
       pop[state.max.area],
       col="red", lwd=2)

points(area["Kansas"], pop["Kansas"],
       col="purple", lwd=2)
```



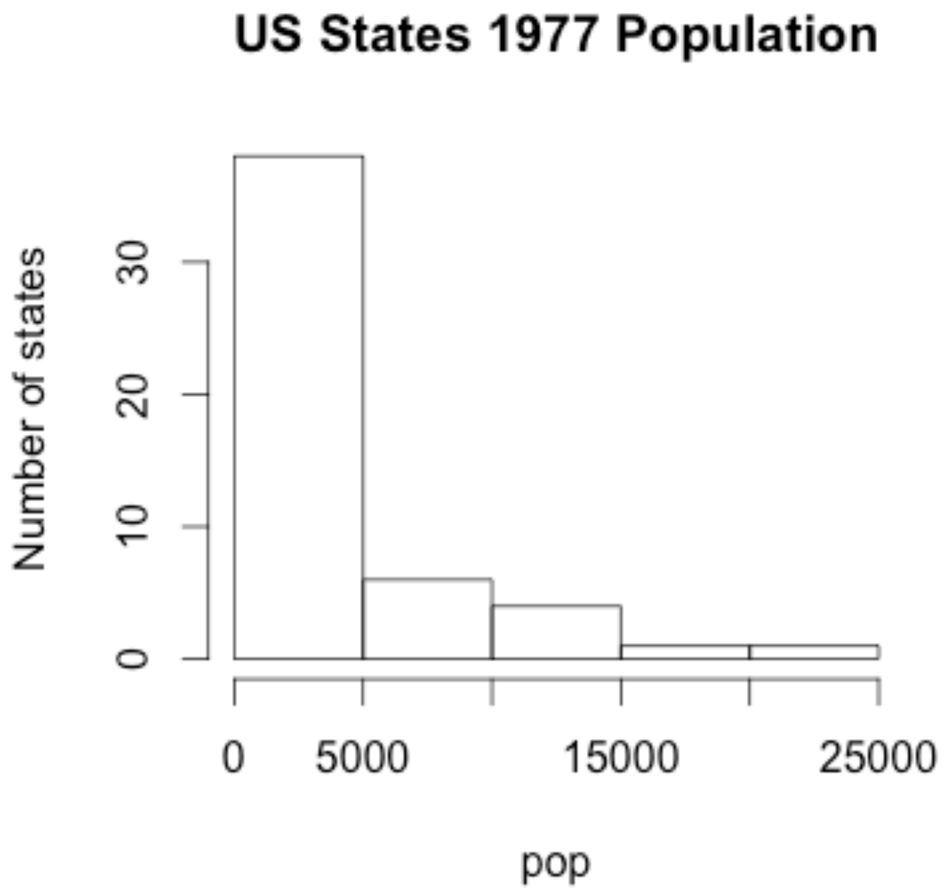
Barplot

```
barplot(pop/1000, las=2, cex.names=0.65, ylab="Pop (x1000,000)",
        main="US States 1977 Population")
```



Histogram

```
hist(pop, ylab="Number of states", main="US States 1977 Population")
```



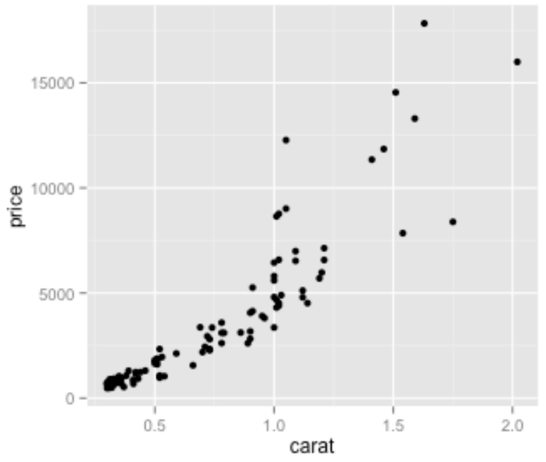
ggplot2 - an easy plotting package

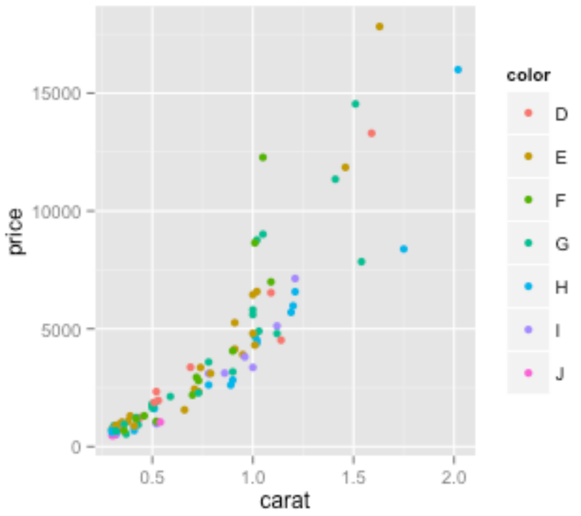
diamonds

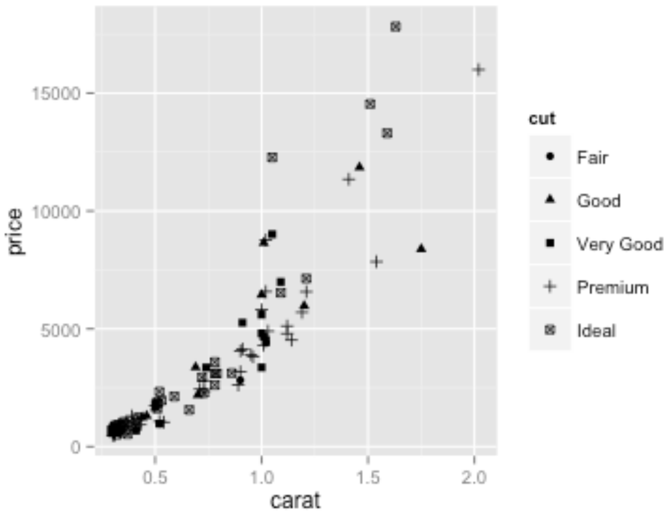
carat	cut	color	clarity	depth	table	price
0.23	Ideal	E	SI2	61.5	55	326
0.21	Premium	E	SI1	59.8	61	326

scatterplots showing the relationship between the price and carats (weight) of a diamond*.

```
qplot(carat, price, data = diamonds)
qplot(carat, price, data = diamonds, colour = color)
qplot(carat, price, data = diamonds, shape = cut)
```







* from http://ggplot2.org/book/qplot.pdf

ggplot2 - geom to control plot type

qplot is not limited to scatterplots, but can produce almost any kind of plot by varying the **geom**. geom has many options:

- "point" draws a scatterplot. This is the default.
- "smooth" fits a smoother to the data
- "boxplot" produces a box-and-whisker plot
- "line" draw lines between the data points.
- "histogram" draws a histogram
- "bar" makes a bar chart

ggplot2 – a flexible tool to plot various plots

diamonds

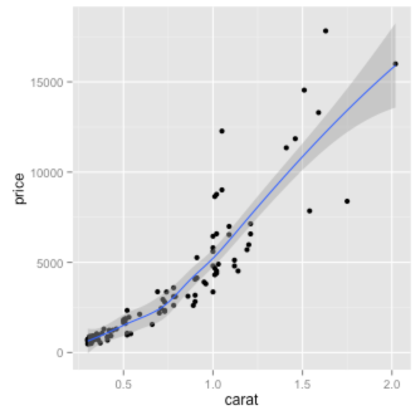
carat	cut	color	clarity	depth	table	price
0.23	Ideal	E	SI2	61.5	55	326
0.21	Premium	E	SI1	59.8	61	326

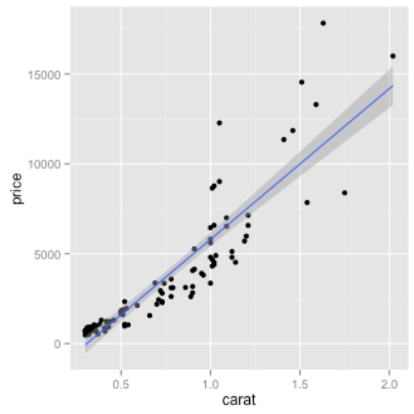
Adding a smooth line or a fitted line

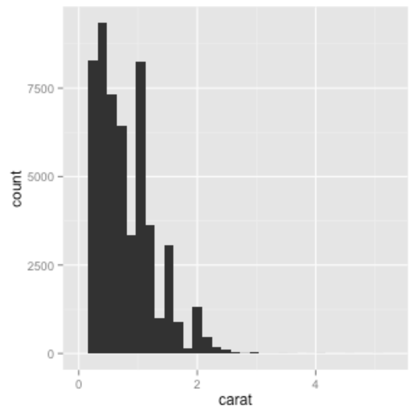
```
qplot(carat, price, data = diamonds, geom = c("point", "smooth"))
qplot(carat, price, data = diamonds, geom = c("point", "smooth"),
      method = "lm")
```

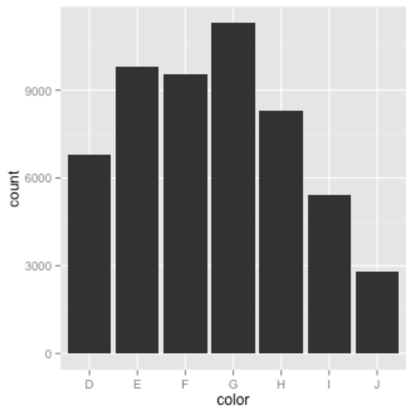
Histogram and barplot

```
qplot(carat, data = diamonds, geom = "histogram")
qplot(color, data = diamonds, geom = "bar")
```









String operations - nchar

- **nchar()**

nchar the sizes of the corresponding elements of a vector.

nchar(cvec)

```
> cvec
[1] "google" "hello"  "the"    "world"

> nchar(cvec)
[1] 6 5 3 5
```

String operations - grep

- **grep()**

grep searches for matches to argument pattern within each element of a character vector

grep("o", cvec)

```
> cvec
[1] "google" "hello"  "the"    "world"

> grep("o", cvec)
[1] 1 2 4
```

String operations – sub and gsub

- **sub()** and **gsub()**

sub and gsub perform replacement of the *first* and *all* matches respectively.

sub("o", "O", cvec)

gsub("o", "O", cvec)

```
> cvec
[1] "google" "hello"  "the"    "world"


> sub("o", "O", cvec)
[1] "gOogle" "hellO"  "the"    "wOrld"
> gsub("o", "O", cvec)
[1] "gOOgle" "hellO"  "the"    "wOrld"
```

Get help

- help(ls)
- ?ls
- ??colsum: ambiguous search
- R reference card
- stackoverflow
- Google is the best helper!

R learning: http://swirlstats.com/

Rstudio

Rstudio is an open source integrated development environment (IDE) for R

- On your own machine (Rstudio Desktop)

Download and install R

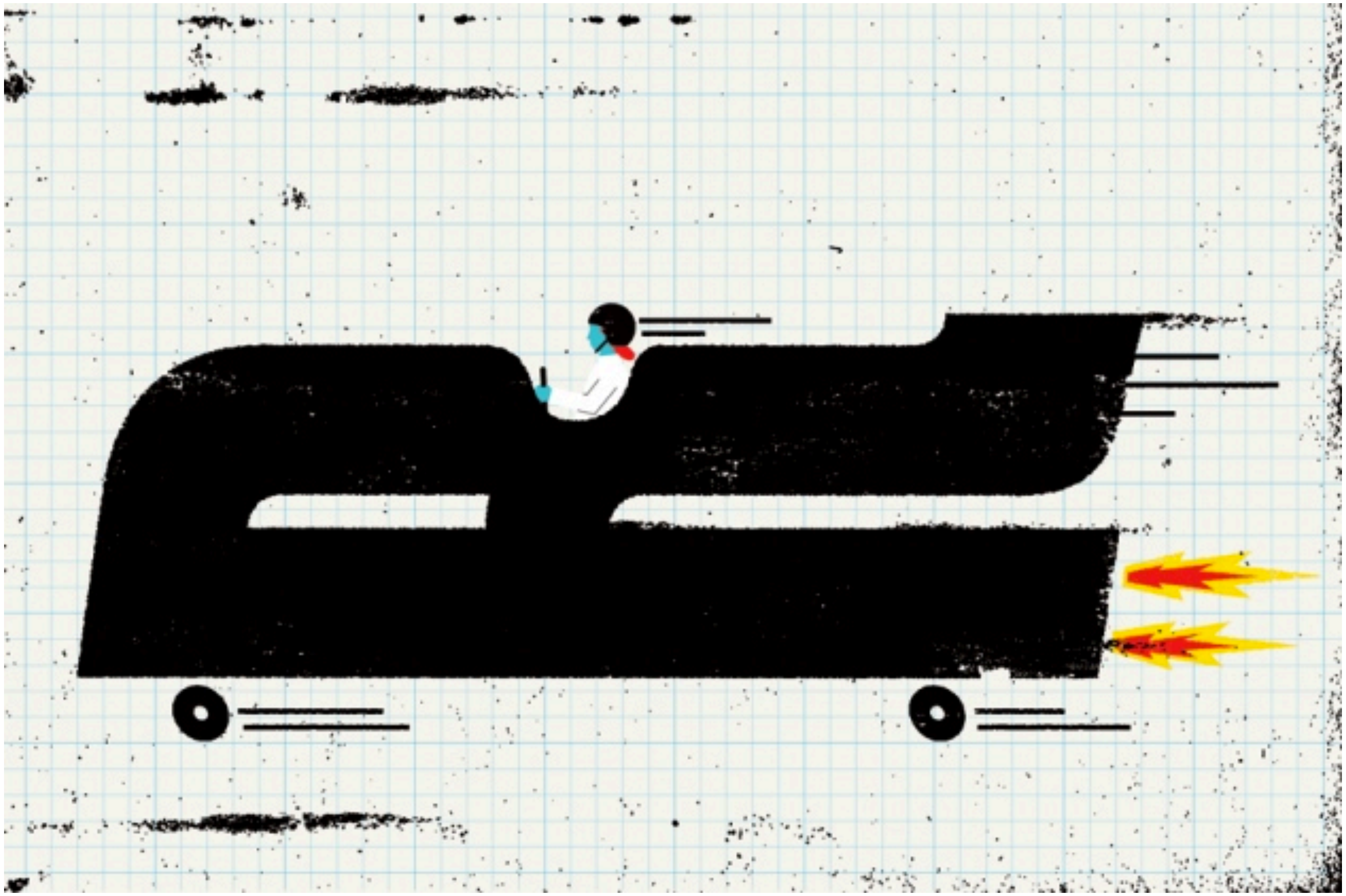
Download and install Rstudio

- Use Rstudio at Beocat (Rstudio server)

rstudio.beocat.cis.ksu.edu

Your KSU ID and password to login

Adventures with R



http://www.nature.com/news/programming-tools-adventures-with-r-1.16609