STAT 2604
Lecture 1

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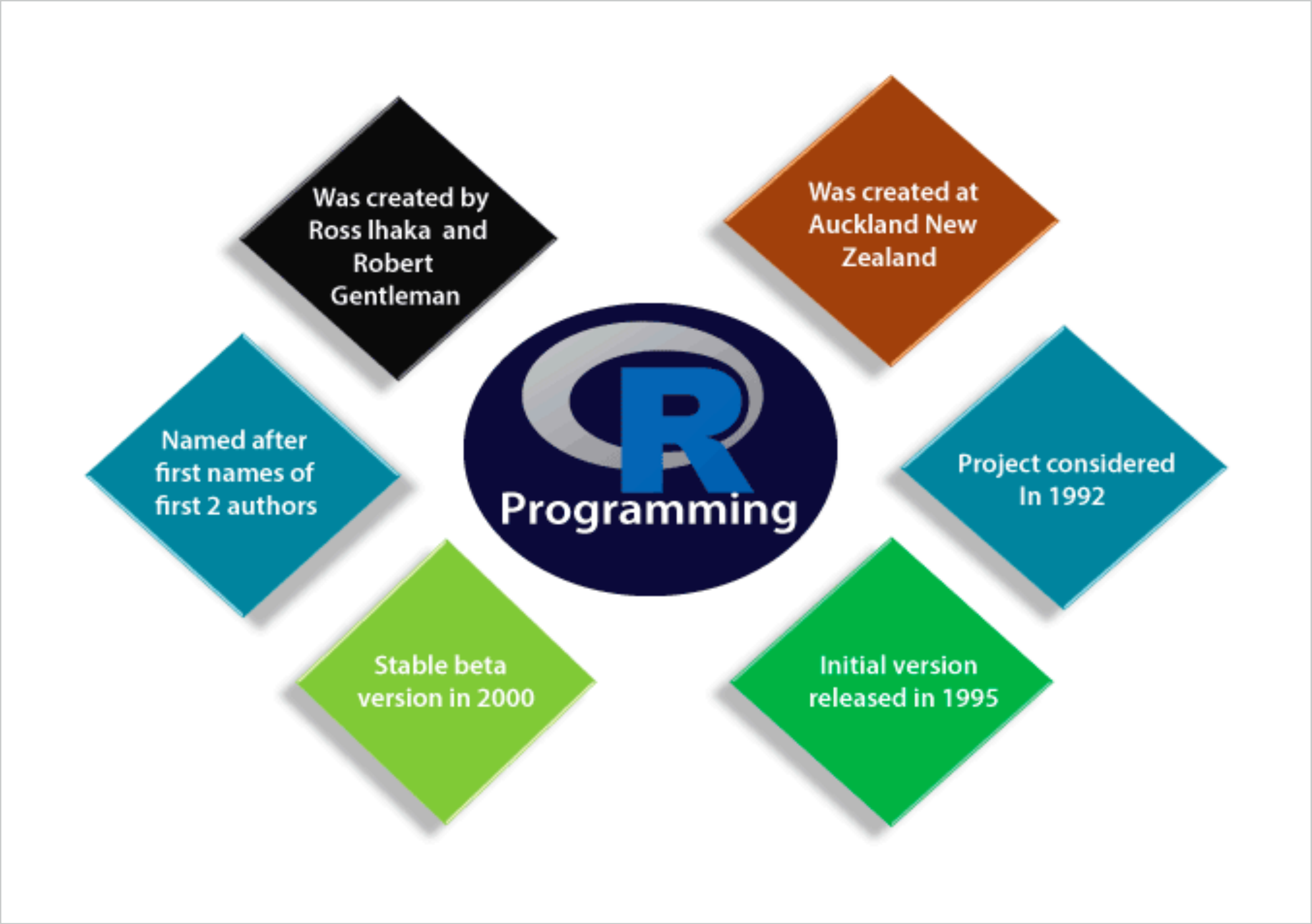
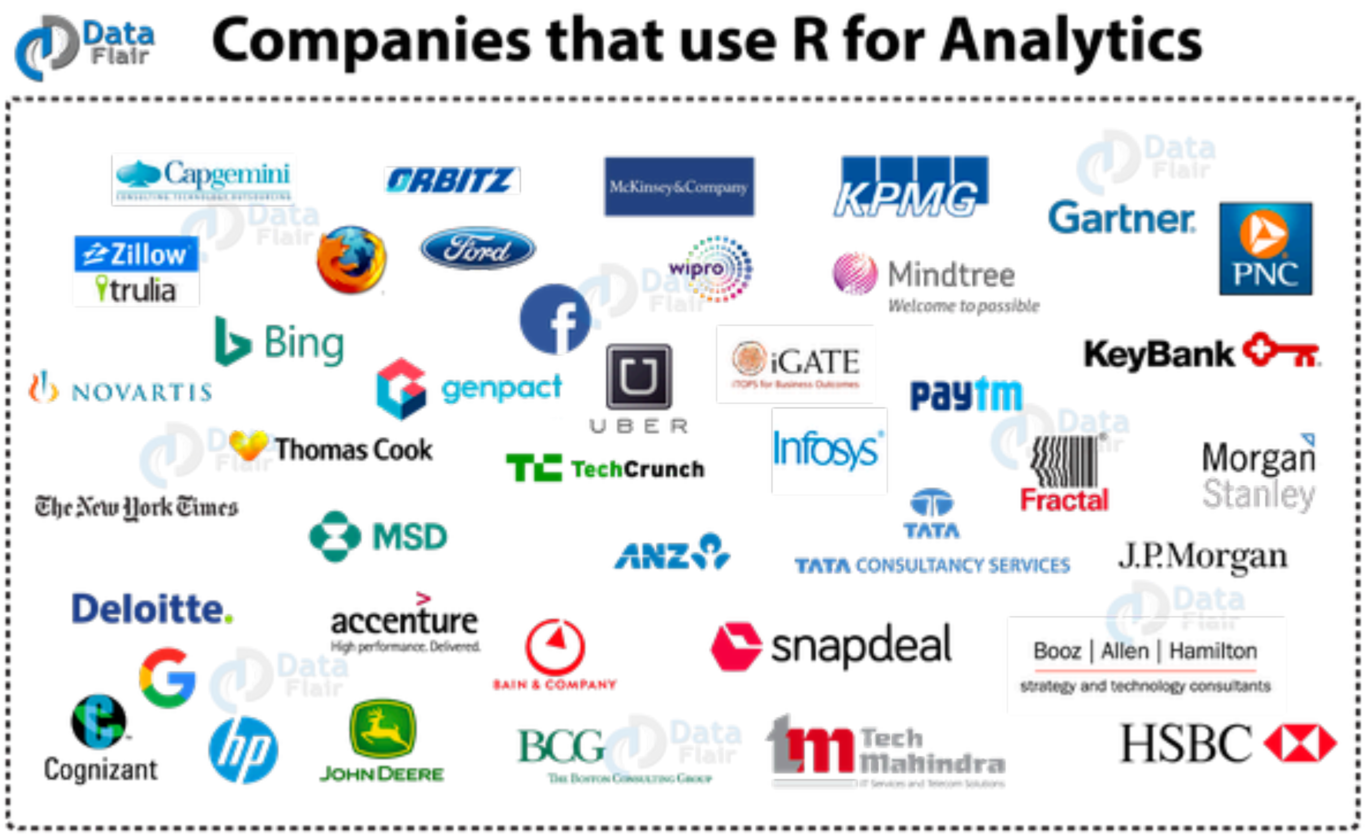
What is R?


Was created by Ross Ihaka and Robert Gentleman
Was created at Auckland New Zealand
Named after first names of first 2 authors
R Programming
Project considered In 1992
Stable beta version in 2000
Initial version released in 1995

Why Learn R


Data Flair
Companies that use R for Analytics
Capgemini
ORBITZ
McKinsey&Company
KPMG
Gartner
Zillow
trulia
Ford
wipro
Mindtree
Welcome to possible
PNC
Bing
iGATE
KeyBank
NOVARTIS
genpact
UBER
Paytm
Thomas Cook
TechCrunch
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R IS OPEN SOURCE
CROSS-PLATFORM COMPATIBLE
COMPLETE STATISTICAL LANGUAGE
2000+ FREE LIBRARIES
OUTSTANDING GRAPHICAL OUTPUTS
R HAS A VAST COMMUNITY
LEARNING R IS FUN AND EASY
WANT THE COOLEST JOB IN 2014?
R

Getting help

```
> help(solve)
> ?solve
> ?? solve
> example(topic)
> ? help
```

R commands, case sensitivity

- R is an expression language
- Case sensitive
- All alphanumeric symbols and ‘.’, ‘_’
- A name must start with ‘.’ or a letter; if it starts with ‘.’, the second cannot be a digit.
- Unlimited in length
- Commands are separated by ‘;’ or a newline; grouped by ‘{ }’
- Comments: #

Recall and executing commands

- Get command history
- Source (“commands.R”)
- Sink(“ ”)

Data permanency and removing objects

- Objects: variables, arrays, strings, functions..etc

```
>  objects()
>  ls()
> rm()
```

Objects are written into a file called .Rdata

Command lines are saved to a file called .Rhistory

Vectors

- Vectors and assignment

> X = c(1,2,3)

This is an assignment statement using the function “c()”

Vector arithmetic

- > z = 2*x + y + 1, where x and y are vectors of the same length
- What if x and y have different length? Try it out

- sort(x)

- order(x)

Regular sequences

- > 1:10
- > 2*1:10
- > 30:1
- seq(-5,5,by=0.2)
- rep(x,times=5)
- Rep(x,each=5)

Logical vectors

- Temp = 1 > 5
- &
- |
- FALSE =0
- TRUE=1

Missing values

- NA
- is.na(x)
- x == NA
- What is 0/0
- is.nan(x)

Character vectors

- “I love R”
- Escape letter: \n, \t, \b
- ?Quotes
- paste()

labs = paste(c(“X”,”Y”),1:10,sep=“”)

c("X1", "Y2", "X3", "Y4", "X5", "Y6", "X7", "Y8", "X9", "Y10")

Index vectors

- y <- x[!is.na(x)]
- x[1:10]
- c("x","y")[rep(c(1,2,2,1), times=4)]
- y <- x[-(1:5)]
- fruit <- c(5, 10, 1, 20)
- names(fruit) <- c("orange", "banana", "apple", "peach")
- lunch <- fruit[c("apple","orange")]
- x[is.na(x)] <- 0
- y[y < 0] <- -y[y < 0] or y <- abs(y)

Other types of objects

- Matrices, arrays
- Factors
- Lists
- Data frames
- functions

Attributes and Class

- attr(z, "dim") <- c(10,10)
- class(x)
- OOP

Arrays and matrices

- x <- array(1:20, dim=c(4,5))
- i <- array(c(1:3,3:1), dim=c(3,2))
- Z <- array(*data_vector*, *dim_vector*)
- ab <- a %o% b – outer product
- ab <- outer(a, b, "*")
- > f <- function(x, y) cos(y)/(1 + x^2)
- > z <- outer(x, y, f)
- > d <- outer(0:9, 0:9)
- > fr <- table(outer(d, d, "-"))
- > plot(fr, xlab="Determinant", ylab="Frequency")

Matrix multiplication

A and B are square matrices of the same size, then

```
> A * B
```

is the matrix of element by element products and

```
> A %*% B
```

is the matrix product. If x is a vector, then

```
> x %*% A %*% x
```

is a quadratic form

Linear equations

Solving linear equations is the inverse of matrix multiplication. When after

```
> b <- A %*% x
```

only A and b are given, the vector x is the solution of that linear equation system. In R,

```
> solve(A,b)
```

solves the system, returning x (up to some accuracy loss).

Eigenvalue and Eigenvectors

The function eigen(Sm) calculates the eigenvalues and eigenvectors of a symmetric matrix Sm.

```
ev <- eigen(Sm)
evals <- eigen(Sm)$values
```

The function svd(M) takes an arbitrary matrix argument, M, and calculates the singular value decomposition of M

Forming partitioned matrices

- X <- cbind(*arg_1*, *arg_2*, *arg_3*, …)
- X <- cbind(1, X1, X2)

- **Frequency tables from factors**

table(x,y)

Lists

- An R *list* is an object consisting of an ordered collection of objects known as its *components*.

Lst <- list(name=“Fred”, wife=“Mary”, no.children=3, child.ages=c(4,7,9))

Concatenating lists

list.ABC <- c(list.A, list.B, list.C)

Data frames

- accountants <- data.frame(home=statef, loot=incomes, shot=incomef)

attach()

detach()

read.table()

scan()

Writing your own functions

Two-sample t-test function

```
twosam <- function(y1, y2) {
 n1 <- length(y1); n2 <- length(y2)
yb1 <- mean(y1); yb2 <- mean(y2) ;
s1 <- var(y1); s2 <- var(y2)
s <- ((n1-1)*s1 + (n2-1)*s2)/(n1+n2-2)
tst <- (yb1 - yb2)/sqrt(s*(1/n1 + 1/n2))
tst }
```

With this function defined, you could perform two sample *t*-tests using a call such as

- `> tstat <- twosam(data$male, data$female); tstat`

The arguments

- Thus if there is a function fun1 defined by

 > fun1 <- function(data, data.frame, graph, limit) { [function body omitted] }

 Then the function may be invoked in several ways, for example

> ans <- fun1(d, df, TRUE, 20) > ans <- fun1(d, df, graph=TRUE, limit=20) > ans <- fun1(data=d, limit=20, graph=TRUE, data.frame=df)

are all equivalent.

- The '…' arguments

fun1 <- function(data, data.frame, graph=TRUE, limit=20, ...) { [omitted statements] if (graph) par(pch="*", ...) [more omissions] }

Scope

```
f <- function(x) {
  y <- 2*x
 print(x)
 print(y)
 print(z) }
```

x is a formal parameter, y is a local variable and z is a free variable.

Lexical scope.

```
cube <- function(n) {
   sq <- function() n*n
   n*sq()
  }
## evaluated in R
> cube(2)
[1] 8
```

A bank account example in R

```
open.account <- function(total) {
  list(
    deposit = function(amount) {
      if(amount <= 0)
        stop("Deposits must be positive!\n")
      total <<- total + amount
      cat(amount, "deposited.  Your balance is", total,
"\n\n")
    },
    withdraw = function(amount) {
      if(amount > total)
        stop("You don't have that much money!\n")
      total <<- total - amount
      cat(amount, "withdrawn.  Your balance is", total,
"\n\n")
    },
    balance = function() {
      cat("Your balance is", total, "\n\n")
    }
  )
}
```

Run the function

```
ross <- open.account(100)
robert <- open.account(200)

ross$withdraw(30)
ross$balance()
robert$balance()

ross$deposit(50)
ross$balance()
ross$withdraw(500)
```

Flow controls

- The for() statement allows one to specify that a certain operation should be repeated a fixed number of times.

for (val in seq){

statement

}

- Write a program for Fibonacci sequence

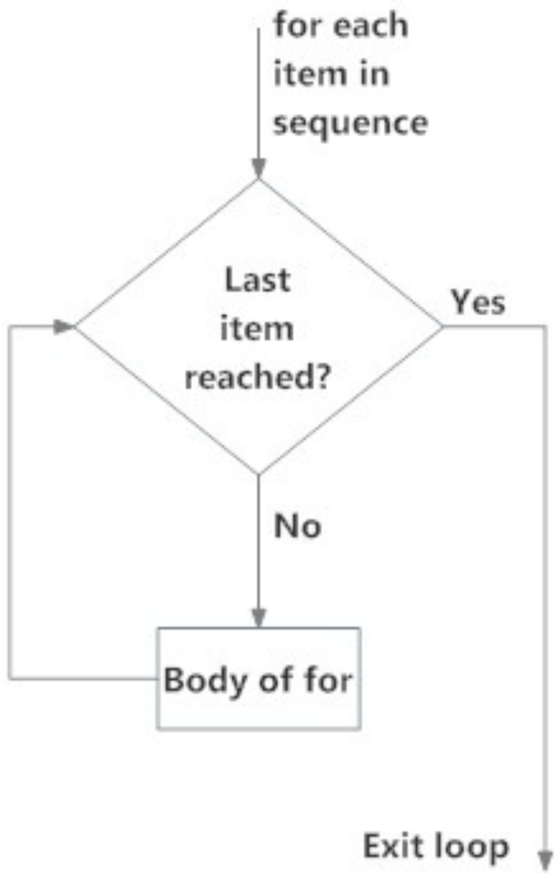


Fig: operation of for loop

if() statement

- The if() statement allows us to control which statements are executed, depending on the values of some input or variables.
- Examples

```
 if (x > 2)
 y <- 2*x
else
y <- 3*x
```

while() loop

We want to repeat statements, but the pattern of repetition is not known in advance.

– We need to do some calculations and keep going as long as a condition holds.

• Examples

```
while (x.total < 100)
x.total <- x.total + runif(1)
```

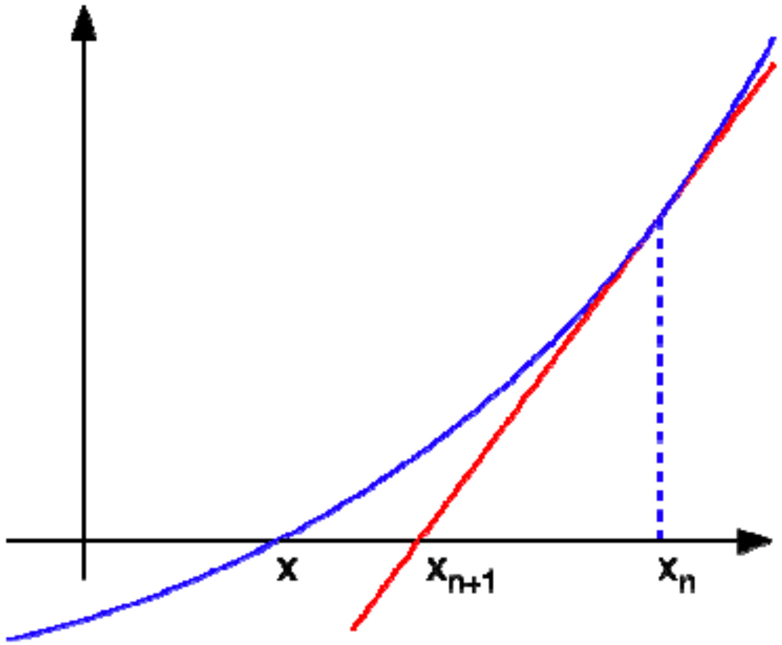
• From class: give an example of the while() loop

Exercise

- Newton‘s method for root finding using while loop

Find the root of an algebraic equation:

$f(x)=0$



Summary

- Course logistics
  - what to expect
  - everyone can contribute and learn from this
- R basics
  - Data types and structures, functions
  - Flow controls
- Personalized Homework