

Advanced R Programming - Lecture 1

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Today

About the course

Aim of the course

Presentation(s)

Presentation(s)

Course Practicals

Why R?

Basic R

Data structures

Logic and sets

Subsetting/filtering

Functions

Learn to

- ▶ Write R programs and packages
- ▶ Write performant code
- ▶ Learn basic software engineering practices
- ▶ Solve (machine learning) problems using R

But most important...

But most important...

Your primary tool in the next 2 years

Course Plan

Part 1: R Syntax

Period: Week 1-2

Students work: Individually

Lab: Documented R file

Computer lab

Topics

- ▶ Basic R Syntax
- ▶ Basic data structures
- ▶ Program control
- ▶ R packages

Part 2: Advanced topics

Period: Week 3-7

Students work: In groups

Turn in: R package on GitHub

Seminar

Topics

- ▶ Performant code: Writing quality code
- ▶ Linear algebra, Object orientation, Graphics
- ▶ Advanced I/O
- ▶ Performant code: Writing fast code
- ▶ Machine learning in R

Today

Presentation(s)

Me - AKA, Leif Jonsson

My background

1. Computer Science,
Uppsala 1998
2. Ericsson
3. PhD Student Applied
Machine Learning, LiU,
PELAB - STIMA



Figure: Me

You

- ▶ Background?
- ▶ Why this course?
- ▶ Expectations?

Course Practicals...

Course Practicals...

- ▶ Course code: 732A94
- ▶ <https://www.ida.liu.se/~732A94/index.en.shtml>
- ▶ <https://github.com/MansMeg/AdvRCourse>
- ▶ <https://www.rstudio.com/>
- ▶ <https://cran.r-project.org/>
- ▶ <https://git-scm.com/>

Course literature...

Course literature...

- ▶ Matloff, N. The art of R programming [online]
- ▶ Wickham, H. Advanced R [online]
- ▶ Wickham, H. R packages [online]
- ▶ ...and articles.

Examination

Weekly mandatory labs/projects

– deadline: One week after corresponding lecture

Computer exam

Why R?

The One main reason

Choose the right tool for the job!

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Choose the right tool for the job!

Your main job will be statistics and data analysis...
R is the right tool for that job!

Pros

- ▶ Popular (among statisticians)
- ▶ Good graphics support
- ▶ Open source - all major platforms!
- ▶ High-level language - focus on data analysis
- ▶ Strong community - vast amount of packages
- ▶ Powerful for communicating results
- ▶ API's to high-performance languages as C/C++ and Java

Cons

- ▶ "Ad hoc", complex, language (Compare Perl, Awk, Sh...)
- ▶ Can be sloooooow
- ▶ Can be memory inefficient
- ▶ (Still) Hard'ish to troubleshoot
- ▶ (Still) Inferior IDE support compared to state of the art

Pros/Cons

- ▶ Niche language
- ▶ Specialized syntax
- ▶ Very permissive

Variable types

Variable type	Short	typeof()	R example
Boolean	logi	logical	TRUE
Integer	int	integer	1L
Real	num	double	1.2
Complex	cplx	complex	0+1i
Character	chr	character	"I <3 R"

Variable types

	Variable type	Short	typeof()	R example	
Coersion	Boolean	logi	logical	TRUE	↓
	Integer	int	integer	1L	
	Real	num	double	1.2	Coersion
	Complex	cplx	complex	0+1i	
↓	Character	chr	character	"I <3 R"	↓

Data structures

Dimension	Homogeneous data	Heterogeneous data
1	vector	list
2	matrix	data.frame
n	array	

- ▶ Constructors: `vector()` `list()` ...
- ▶ Name dimensions: `dimnames()`

Arithmetics

- ▶ Vectorized operations (element wise)
- ▶ Recycling
- ▶ Statistical functions

See reference card...

Logic operators

In symbols	A	B	$\neg A$	$A \wedge B$	$A \vee B$
In R	A	B	$!A$	$A \& B$	$A B$
	TRUE	FALSE	?	?	?
	TRUE	TRUE	?	?	?
	FALSE	FALSE	?	?	?
	FALSE	TRUE	?	?	?

Logic operators

In symbols	A	B	$\neg A$	$A \wedge B$	$A \vee B$
In R	A	B	$!A$	$A \& B$	$A B$
	TRUE	FALSE	FALSE	?	?
	TRUE	TRUE	?	?	?
	FALSE	FALSE	?	?	?
	FALSE	TRUE	?	?	?

Logic operators

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In R	A	B	$!A$	$A \& B$	$A B$
	TRUE	FALSE	FALSE	FALSE	?
	TRUE	TRUE	?	?	?
	FALSE	FALSE	?	?	?
	FALSE	TRUE	?	?	?

Logic operators

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	TRUE	TRUE	?	?	?
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	FALSE	TRUE	?	?	?

Logic operators

In symbols	A	B	$\neg A$	$A \wedge B$	$A \vee B$
In R	A	B	$!A$	$A \& B$	$A B$
	TRUE	FALSE	FALSE	FALSE	TRUE
	TRUE	TRUE	FALSE	TRUE	TRUE
	FALSE	FALSE	TRUE	FALSE	FALSE
	FALSE	TRUE	TRUE	FALSE	TRUE

Logic operators

In symbols	$\bigwedge_{i=1}^N a_i$	$\bigvee_{i=1}^N a_i$	$\{j : a_j == \text{TRUE}\}$
In R	<i>all(A)</i>	<i>any(A)</i>	<i>which(A)</i>

Relational operators

In symbols	$a < b$	$a \leq b$	$a \neq b$	$a = b$	$a \in b$
In R	$a < b$	$a \leq b$	$a != b$	$a == b$	$a \%in\% b$

Vectors

- ▶ Use []
- ▶ index by:
 - ▶ positive integers: include element(s)
 - ▶ negative integers: exclude element(s)
 - ▶ logical: include TRUEs

```
vect <- c(6,7,8,9)
> vect[vect > 7]
[1] 8 9
> vect[1:2]
[1] 6 7
> vect[c(1,2)]
[1] 6 7
> vect[c(-1,-2)]
[1] 8 9
```

Matrices

- ▶ Use [,]
- ▶ Two dimensions
- ▶ Index as vectors
- ▶ Can reduce (drop class) to vector

Matrices

```
> mat <- matrix(c(1,2,3,4,5,6), nrow=2)
> mat
```

	[,1]	[,2]	[,3]
[1 ,]	1	3	5
[2 ,]	2	4	6

```
> mat[c(1,2), c(1,2)]
```

	[,1]	[,2]
[1 ,]	1	3
[2 ,]	2	4

```
> mat[c(1,2), ]
```

	[,1]	[,2]	[,3]
[1 ,]	1	3	5
[2 ,]	2	4	6

```
> mat[mat>4]
```

[1]	5	6
-----	---	---

Lists

- ▶ Use `[]` to access list elements
- ▶ Use `[[[]]` to access list content
- ▶ Index as vectors
- ▶ Use `$` to access list element by name
- ▶ Not like typical lists in other programming languages

Lists

```
> lst <- list(a=47,b=11)
```

```
> lst[1]
```

```
$a
```

```
[1] 47
```

```
> lst[[1]]
```

```
[1] 47
```

```
> lst$b
```

```
[1] 11
```

Data frames

- ▶ Very powerful data structure
- ▶ Can roughly think about it as the R representation of a CSV file
- ▶ Can be loaded from a CSV file
- ▶ Can be accessed both as a matrix and a list

Assigning subsets

- ▶ Change values in data structures
- ▶ Works for all above mentioned data types

Assigning subsets

```
> mat
```

	[,1]	[,2]	[,3]
[1 ,]	1	3	5
[2 ,]	2	4	6

```
> mat[mat>4] = 75
```

```
> mat
```

	[,1]	[,2]	[,3]
[1 ,]	1	3	75
[2 ,]	2	4	75

Functions

```
my_function_name <- function(x, y){  
  z <- x^2 + y^2  
  return(z)  
}
```

Unlike in many languages, `return` in R is a **function**. In other languages, `return` is usually a **reserved word** (like `if`). This means you must use `return` as a function call with parenthesis. By default R returns the last computed value of the function, so `return` is not strictly necessary in simple cases.

The End... for today.
Questions?
See you next time!