Introduction to R

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Introduction

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Course Materials

- `http://www.wvbauer.com/course_oor`
- lecture slides, code, data, some useful links
- website will be updated during the course
- download the files to your computer
- also available at GitHub and GitLab

What is R?

- R is a system for the manipulation, statistical and numerical analysis, and graphical display of data
- freely available under the GNU General Public License (GPL) → open-source and free/libre
- runs under Windows, Unix/Linux, Mac OS X, ...

History of S and R

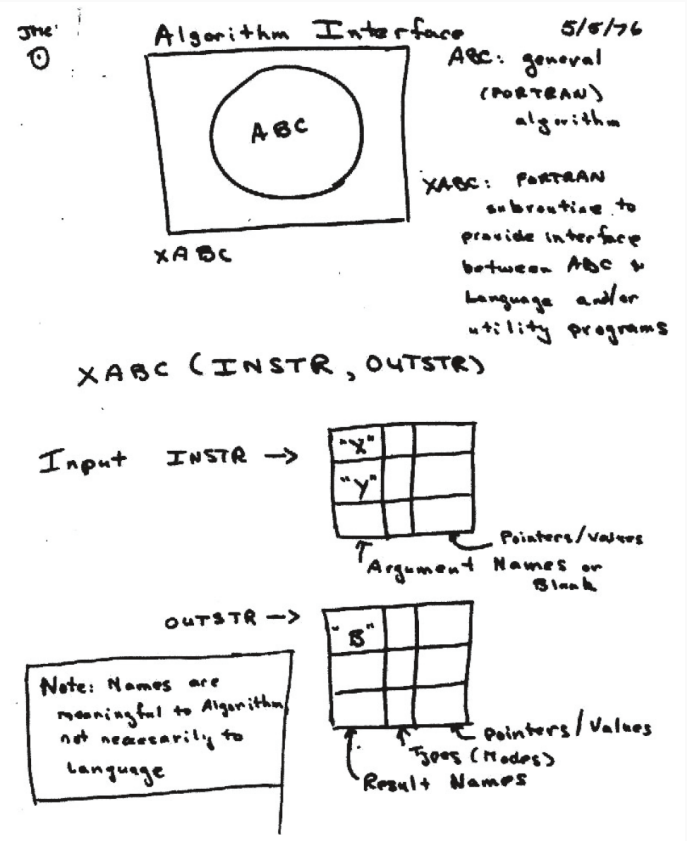
- ... it began May 5, 1976 at:

Bell Laboratories, Murray Hill, New Jersey[1]

[1] Photo by Alcatel-Lucent Bell Labs

History of S and R

- informal meeting to discuss development of a new system for statistical computing
- first implementation made by Rick Becker and John Chambers (and a few others)
- called “the system”



sketch of the system design made on the first meeting

History of S and R

- “the system” → “S” (the S language)
- first UNIX version of S in 1979 (version 2)
- distributed outside Bell Labs in 1980
- source code released in 1981, then licensed in 1984 for educational and commercial purposes
- video: Rick Becker on Forty Years of S

History of S and R

- Becker & Chambers (1984). *S: An Interactive Environment for Data Analysis and Graphics.*
- Becker & Chambers (1985). *Extending the S System.*
- Becker, Chambers, & Wilks (1988): *The New S Language: A Programming Environment for Data Analysis and Graphics.*
- Chambers & Hastie (1991). *Statistical Models in S.*
- Chambers (1998). *Programming with Data: A Guide to the S Language.*

History of S and R

- S-PLUS, a commercial implementation of S, released in 1988 by Statistical Sciences, Inc. (now TIBCO)
- Robert Gentleman and Ross Ihaka start developing a statistical programming language "not unlike S"

Robert Gentleman and Ross Ihaka[2]

[2] Photos by Stuart Isett and Kieran Scott

Some R Milestones

- first binary of R released in 1993
- Ihaka, R., & Gentleman, R. (1996). R: A language for data analysis and graphics. *Journal of Computational and Graphical Statistics, 5*(3), 299-314. [link]
- source code released in 1997 (CRAN is started)
- R Core group is formed in 1997 with 9 members
- version 1.0.0 (2000), version 2.0.0 (2004)
- first useR! conference in May 2004 in Vienna, Austria
- version 3.0.0 released April 2013
- current version: R 3.6.3 released February 2020

Other Related Developments

- Revolution Analytics founded in 2007 (now part of MS)
- RStudio founded in 2008
- New York Times article about R in January 2009
- R Consortium founded in 2015
- data science develops as a discipline
- open science, reproducible research
- the emergence of the tidyverse

Why is it called R?

- **R**oss Ihaka and **R**obert Gentleman
- pun/play on the name of the S language
  (which in turn was probably a pun based on the C programming language, also developed at Bell Labs)

Basic Concepts

- command-driven (no point-and-click interface)
- an ‘object-oriented’ and ‘functional’ language
- R console: what you see when you start R
- symbol at beginning of line (>): the ‘prompt’

Modes of Interacting with R

- **interactively:** you type commands into the R console line by line and get direct feedback
- **via script files:** you type commands into a script file and then can:
    - copy-paste commands to the console
    - read in and execute all commands at once (e.g., with `source()`, `Rscript`, ...)

Interactive Mode

- to use R as a “calculator on speed”

```
> x <- c(4,2,3,6)
> mean(x)
```

```
[1] 3.75
```

- useful for spontaneous exploration of data
- to test parts of a script file

Tab Completion and Scrolling

- when typing in commands, can use ‘tab completion’ (esp. useful for long commands)
- type `sq` and hit Tab: `sqrt` (tada!)
- if ambiguous, can get list with possible options
- type `ex` and hit Tab: get nothing, but hit Tab again, get list of options
- with ↑↓ keys, scroll through command history
- hit ESC (vigorously) if you are ‘stuck’ somewhere

Commands Over Multiple Lines

- start typing:

  ```
  > mean(
  ```

- hit return
- command is syntactically not complete
- continue on next line (prompt is now a + sign)

  ```
  > mean(
  + c(4,2,3,6))
  ```

- hit return

  ```
  [1] 3.75
  ```

Always Use Script Files

- promotes:
  - organized programming/analyses
  - code reuse
- increases replicability
- easier to fix errors/mistakes
- can write/edit script files with:
  - the built-in editor
  - an external editor
  - an integrated development environment (IDE)

The Built-In R Editor

- on Windows: rudimentary editor for script files
- on MacOS: a multidocument editor with ‘syntax highlighting’ and ‘brace-matching’
- start new script: Menu File – New Script
- put cursor in line to be executed and hit Ctrl-R (Windows) or Command-Return (MacOS)
- or highlight parts to be executed
- can save/load scripts (usually .r or .R extension)

External Text Editors

- script files are just plain-text files
- can therefore write them with your favorite text editor
- some editors have functionality for opening multiple documents, code execution, syntax highlighting, brace-matching, and other useful features
- I personally use Sublime Text with some plug-ins (i.e., Terminus, SendCode, Shell Exec, Origami, ...)

Exiting R / Saving the Workspace

- can quit R with:

  ```
  > quit()
  ```

  or by just closing the window
- you will get a prompt asking if you want to “Save workspace image? [Yes/No/Cancel]”
- if you choose yes: R will save the state of your workspace to the current working directory (into the files .RData & .Rhistory)
- my recommendation: never do this (choose ‘no’)

RStudio

- RStudio has created an IDE for R (same name)
- open source (commercial edition also available)
- runs on Windows, Mac, and Linux
- some of the useful features:
    - syntax highlighting
    - code completion
    - bracket matching
    - object list and command history
    - organized workspace (editor, console, plots, ...)
    - can run session remotely

Some RStudio Keyboard Shortcuts

Description	Windows	MacOS
Start new script	Ctrl+Shift+n	Command+Shift+n
Open script	Ctrl+o	Command+o
Save script	Ctrl+s	Command+s
Close script	Ctrl+w	Command+w
Show keyboard shortcuts	Alt+Shift+k	Option+Shift+k
In Script Files:		
Run current line / selection	Ctrl+Enter	Command+Enter
Run entire script file	Ctrl+Shift+Enter	Command+Shift+Enter
Tab completion	Tab	Tab
Show help for function	F1	F1

Working Directory

- suppose you have written a script file with the name `rcode.r` and saved it to some directory
- to set the "working directory" to where the file is stored, click:
  - **Windows:** Menu File – Change Dir
  - **MacOS:** Menu Misc – Change Working Directory
  - **RStudio:** Menu Session - Set Working Directory - To Source File Location
- alternatively:
  - `setwd()` – set the working directory
  - `getwd()` – get the current working directory

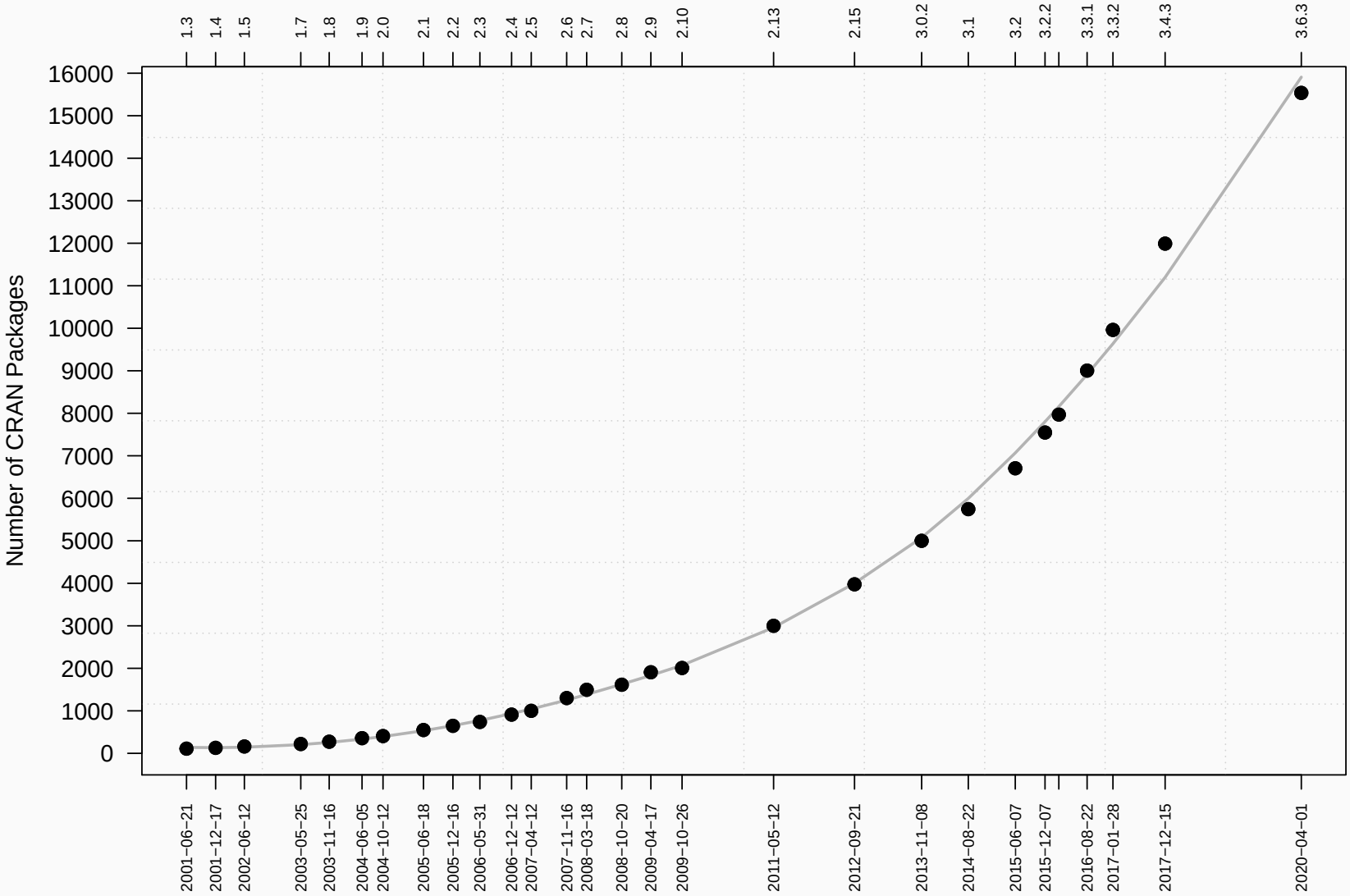
Packages

- an extensive number of add-on “packages” have been contributed by users over the years
- one of the main strengths of R
- many statisticians have adopted R as their primary programming platform → many advanced statistical methods available in R
- Comprehensive R Archive Network (CRAN): repository for R packages – packages currently available:

```
> nrow(available.packages())
```

```
[1] 15538
```

Packages


Number of CRAN Packages
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2017−01−28
2017−12−15
2020−04−01

How We Will Proceed ...

- completely hands-on
- will show step-by-step how to do things
- if I go too fast, please let me know!
- if you have questions, please ask!
- keep in mind that there is a stream delay
- anybody can also answer questions in the chat