Reproducible Research

A brief overview of Literate Programming via R and `knitr` and Version control via git

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Presentation Outline

Literate Programming

- Originally intended for software development
- Mix source code (for the computer) and documentation (for the humans) together
- Sweave built on this paradigm but with a different focus: reproducible data analysis and statistical reports.
- knitr, developed by Yihui Xie, expands on the concept of Sweave.
- 'designed to give the user access to every part of the process of dealing with a literate programming document'
- package homepage `http://yihui.name/knitr/`

Dynamic Report Writing

- Pros:
  - Reproducible reports
  - Contextual commenting
  - knitr is flexible enough to allow for multiple analysis languages, and multiple markup languages.
- Cons:
  - Not all analysis languages are ideally suited for this paradigm.
  - Collaborations with others using WYSIWYG editors requires some additional work and breaks automation. (Not a deal breaker)
- Additional Tools: Version control, e.g., git or svn.

Why knitr?

- Incorporate both the analysis code and the manuscript writing into one file.
- Contextually commented analysis code.
- Fully documented and reproducible reports.

Example: Code for the next two frames

```
\begin{frame}[fragile]

<<"cars", fig.width = 3.5, fig.height = 3.25, results = "asis">>=
fit <- lm(dist ~ speed, data = cars)
latex(cbind(coef(fit), confint(fit)),
      file = "", title = "", ctable = TRUE,
      caption = "Regression Estimates",
      digits = 3, colhead = c("Est", "LCL", "UCL"))
@

The expected stopping distance for a car during the 1920s
increased by a \Sexpr{round(coef(fit)[2], 2)} feet for every
additional mph increase in speed.
\end{frame}
\begin{frame}[fragile]

<<"cars_plot", fig.width = 3.5, fig.height = 2.75>>=
qplot(speed, dist, data = cars) + geom_smooth(method = "lm")
@

\end{frame}
```

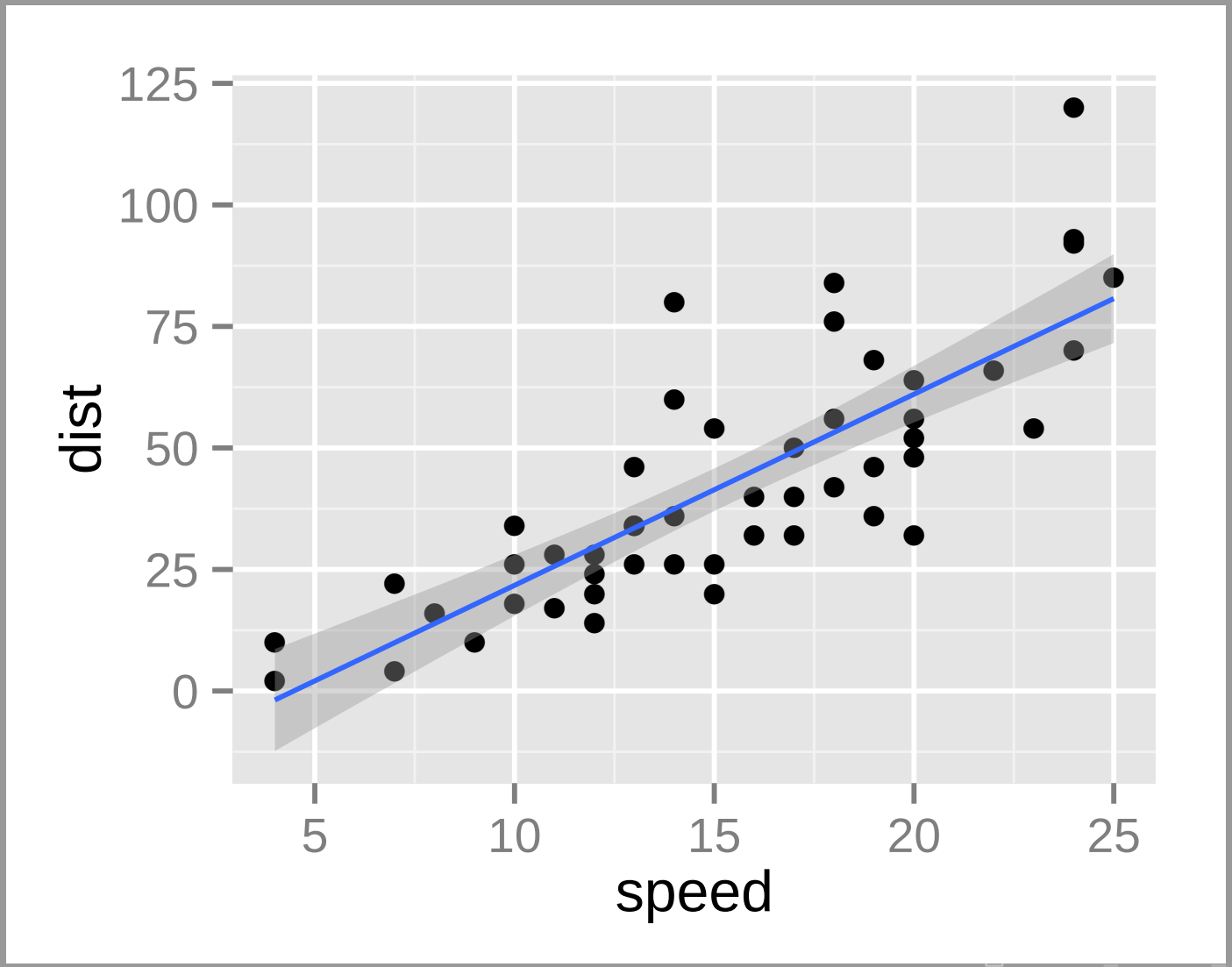
```
fit <- lm(dist ~ speed, data = cars)
latex(cbind(coef(fit), confint(fit)),
      file = "", title = "", ctable = TRUE,
      caption = "Regression Estimates",
      digits = 3, colhead = c("Est", "LCL", "UCL"))
```

Table: Regression Estimates

	Est	LCL	UCL
(Intercept)	−17.58	−31.2	−3.99
speed	3.93	3.1	4.77

The expected stopping distance for a car during the 1920s increased by a 3.93 feet for every additional mph increase in speed.

```
qplot(speed, dist, data = cars) + geom_smooth(method = "lm")
```



How does knitr work?

- One input file with
  - an analysis language (R, Python, awk, SAS, ...) and
  - an output markup language (LaTeX, html, Markdown, ...)
- `knitr` determines the appropriate set of patterns (regular expression to extract analysis language and options from the input file)
- The input file is knitted..., analysis language is evaluated and the appropriate output markup results are placed into a .tex, .html, .md, ..., file.
- Final document (the .tex, .html, .md, ...) is ready for release or post processing as needed.

Customizing the behavior of `knitr`

For Rnw files:

```
<<"chunk_label", echo = FALSE, results = "asis">>=
@
```

- Chunk options must be a single line, no line breaks.
- Options must be valid R expressions.
- Chunk options can be specified for each individual chunk.
- Global options are set via `opts_chunk$set()`

Chunk Options

Full details for all the chunk options see
`http://yihui.name/knitr/options`

- Code Evaluation
- Text Results
- Code Decoration
- Cache
- Plots
- Animation
- Chunk References
- Child Documents
- Language Engines
- Extracting source code

Input/Analysis Language

- R is the 'default' language for analysis
- Other options are available, including SAS. The chunk option 'engine' allows for different languages to be used.

  > *engine: ('R'; character) the language name of the code chunk; currently other possible values are 'python' and 'awk'/'gawk'; the object knit_engines in this package can be used to set up engines for other languages*[1]

- Pick the right language for the job. R is great, but every now and then SAS would be preferable.

[1] http://yihui.name/knitr/options

Markup Language

html

- Pros:
  - easy to send to others,
  - comments in html,
  - great for tutorials or anything that will be published on line.
- Cons:
  - Clunky (in my opinion),
  - not apt for large data analysis reports.
- html code can be placed natively in markdown, ergo, markdown has supplanted html.

Markup Language

Markdown

- Pros:
  - Easy to learn
  - Simple and versatile
  - Growing user community
  - Via pandoc, easy to convert to many other file formats such as LaTeX, html, or .docx.
- Cons:
  - no native comments.
  - 'too minimal'

Markup Language
LaTeX

- Pros:
  - Intended use: technical report writing and typesetting.
  - Comments.
  - Many tools exist for formating R output well in LaTeX files.
  - Cross referencing, citations.
- Cons:
  - Not so good when working with others using Microsoft Office.
  - R is small, Tex Live, MacTeX, and proTeXt are not.
  - Steepest learning curve
- LaTeX is my preferred markup language for data analysis reports and presentations (via beamer).
- Markdown is my preferred markup language for developing a web page. Easier to work in than html and more flexible.

That's great, but ...

- LaTeX is my preferred markup language for data analysis reports and presentations (via beamer).
- Markdown is my preferred markup language for developing a web page. Easier to work in than html and more flexible.
- LaTeX pdf are not always easy to transfer to MS Word
- html pages are easy to break (more files outside of the required directory structure)
- Misconceptions about viewing local files versus remote files in a web browser.
- .doc(x) are 'accidentally' editable. So much for reproducible research.

$$\text{.Rmd} \overset{\text{knitr}}{\rightarrow} \text{.md} \overset{\text{pandoc}}{\rightarrow} \begin{cases} \text{.html} & \text{okay} \\ \text{.doc(x)} & \text{might require VB scripting} \\ \text{.pdf} & \text{Use LaTeX} \end{cases}$$

Suggested Development Environments

- For nearly all current, and new, R programmers, RStudio is the premier R IDE.
  - Download and info: `www.rstudio.com`
  - Built in tools for version control, projects, knitting...
- I prefer the vim editor and with the vim-r-plugin.
  - Vim Editor: `www.vim.org/index.php`
  - vim-r-plugin: `www.vim.org/scripts/script.php?script_id=2628`
- RStudio is the better R development environment. Vim is a better text editor.
- A pseudo WYSIWYG editor for LaTeX which will work well with `kntir` is LyX.

Reproducible examples

These slides, and the following examples, can be downloaded/cloned, from
`https://github.com/dewittpe/knitrexamples`

- A simple data analysis report using R, and three different markup languages, LaTeX, html, and Markdown.
- An example of using SAS within knitr.
- An example of a more complex and extensive data analysis report.

Version Control with git

- Distributed version control: everything is local and can be synced with a remote server.
- Simple to use.
  - Built in GUI with RStudio
  - Only need five commands to be able to use git.
    1. git status
    2. git log
    3. git add
    4. git pull
    5. git push
  - Other very helpful commands: tag, fetch, merge, mergetool, and branch

Do you need a server?

- The repositories are local, so servers are not needed.
- Servers to host a central repository are helpful for collaborations.
- Read/Write permissions can be set for different users.
- There are options to put a git enterprise on a server behind our firewall, but it's expensive.
- github.com has free public repos, pay for private repos
- bitbucket.org has free public and private repos.

More on git

- Visit `http://git-scm.com/book` for documentation on git.
- Fully introducing git would take more time than is available right now.