

# Reproducible Research

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

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# Presentation Outline

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# 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  $\text{\Sexpr{round(coef(fit)[2], 2)}}$  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}
```

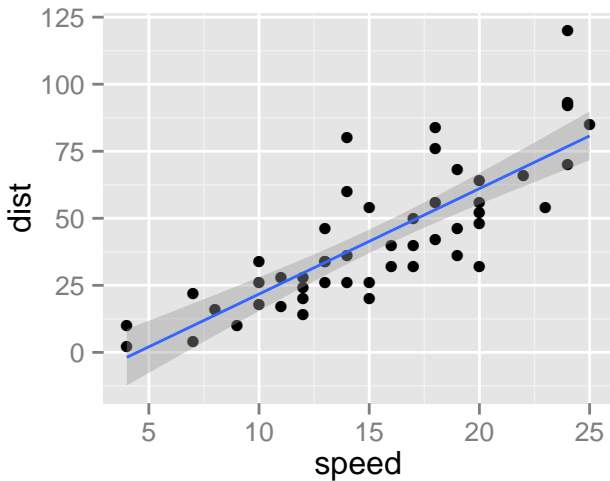
```
fit <- lm(dist ~ speed, data = cars)
latex(cbind(coef(fit), confint(fit)),
      file = "", title = "", ctable = TRUE,
      caption = "Regression Estimates",
      digits = 3, colhead = c("Est", "LCL", "UCL"))
```

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 (L<sup>A</sup>T<sub>E</sub>X, 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.

## Chunk Options

## 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<sup>1</sup>*

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

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<sup>1</sup><http://yihui.name/knitr/options>

## Language 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.

## Language Options

# 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  $\text{\LaTeX}$  html, or .docx.
- Cons:
  - no native comments.
  - ‘too minimal’

# Markup Language

 $\text{\LaTeX}$ 

- Pros:
  - Intended use: technical report writing and typesetting.
  - Comments.
  - Many tools exist for formatting R output well in  $\text{\LaTeX}$  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
- $\text{\LaTeX}$  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.

# Suggested Development Environments

- For nearly all current, and new, R programmers, RStudio is the premier R IDE.
  - Download and info: [www.rstudio.com](http://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](http://www.vim.org/index.php)
  - vim-r-plugin:  
[www.vim.org/scripts/script.php?script\\_id=2628](http://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  $\text{\LaTeX}$  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,  $\text{\LaTeX}$ , 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