KnitR + LaTeX → paper

Tools for Reproducible Research

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Course web: bit.ly/tools4rr

LaTeX

```
\documentclass[12pt]{article}

\usepackage{graphicx}

\title{An example document}
\author{Karl Broman}

\begin{document}

\maketitle
\thispagestyle{empty}

\section{A section}

This is a simple example of a \LaTeX\/ document for an article.
Here's some in-line math: $y = \beta_0 + \beta_1 x + \epsilon$.

And here's a display equation:

$$ \hat{\beta} = (X'X)^{-1} X'y $$

\end{document}
```

What I actually do

```
\documentclass[12pt]{article}

\setlength{\headheight}{10pt}
\setlength{\headsep}{15pt}
\setlength{\topmargin}{-25pt}
\setlength{\topskip}{0in}
\setlength{\textheight}{8.7in}
\setlength{\footskip}{0.3in}
\setlength{\oddsidemargin}{0.0in}
\setlength{\evensidemargin}{0.0in}
\setlength{\textwidth}{6.5in}

\begin{document}
\begin{center}
\textbf{\large An example document}

\vspace{10mm}
Karl Broman
\end{center}

\vspace{30mm}
\textbf{\sffamily A section}
```

Why LaTeX?

- Fine control of document appearance
- Transparency of how that was achieved
- Version control (diff/merge)
- Typesetting equations
- Markdown's not quite ready, or sufficiently rich

simple $\longleftrightarrow$ flexible

simple $\quad\longleftrightarrow\quad$ flexible

```
\centerline{\Large simple \quad $\longleftrightarrow$ \quad flexible}
```

Modify your desires to match the defaults.

Focus your compulsive behavior on things that matter.

Stuff I use a lot

```
% other fonts
\usepackage{palatino}
\usepackage{times}

\setlength{\rightskip}{0pt plus 1fil} % makes ragged right

\newcommand{\LOD}{\text{LOD}}

\usepackage{setspace}
\setstretch{2.0}

\addtocounter{framenumber}{-1}

% make figures S1, S2, ...
\renewcommand{\thefigure}{\textbf{S\arabic{figure}}}
\renewcommand{\figurename}{\textbf{Figure}}

% bigger space between rows in tables
\renewcommand{\arraystretch}{1.5}

% paragraphs not indented but have space between
\setlength{\parskip}{6pt}
\setlength{\parindent}{0pt}
```

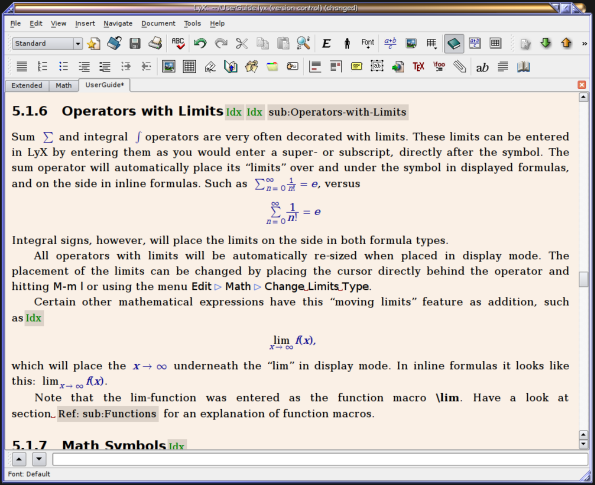
KnitR + LaTeX→ Rnw

```
\documentclass[12pt]{article}

\title{An example Rnw document}
\author{Karl Broman}

\begin{document}
\maketitle

<<load_library, echo=FALSE, results="hide">>=
library(broman) # used for myround()
@

<<example_chunk>>=
x <- rnorm(100)
y <- 5*x + rnorm(100)
lm.out <- lm(y ~ x)
plot(x,y)
abline(lm.out$coef)
@

The estimated slope is \Sexpr{myround(lm.out$coef[2], 1)}.
\end{document}
```

KnitR + LaTeX → Rnw

```
\documentclass[12pt]{article}

\title{An example Rnw document}
\author{Karl Broman}

\begin{document}
\maketitle

<<load_library, echo=FALSE, results="hide">>=
library(broman) # used for myround()
@

<<example_chunk, out.width="0.8\\textwidth">>=
x <- rnorm(100)
y <- 5*x + rnorm(100)
lm.out <- lm(y ~ x)
plot(x,y)
abline(lm.out$coef)
@

The estimated slope is \Sexpr{myround(lm.out$coef[2], 1)}.
\end{document}
```

LyX


LyX: ~/UserGuide.lyx (version control) (changed)
File Edit View Insert Navigate Document Tools Help
Standard
ABC
Font
Extended
Math
UserGuide*
Font: Default

5.1.6 Operators with Limits Idx Idx sub:Operators-with-Limits

Sum $\sum$ and integral $\int$ operators are very often decorated with limits. These limits can be entered in LyX by entering them as you would enter a super- or subscript, directly after the symbol. The sum operator will automatically place its “limits” over and under the symbol in displayed formulas, and on the side in inline formulas. Such as $\sum_{n=0}^{\infty}\frac{1}{n!}=e$, versus

$$\sum_{n=0}^{\infty}\frac{1}{n!}=e$$

Integral signs, however, will place the limits on the side in both formula types.

All operators with limits will be automatically re-sized when placed in display mode. The placement of the limits can be changed by placing the cursor directly behind the operator and hitting M-m l or using the menu Edit ▷ Math ▷ Change Limits Type.

Certain other mathematical expressions have this “moving limits” feature as addition, such as Idx

$$\lim_{x\to\infty}f(x),$$

which will place the $x\to\infty$ underneath the “lim” in display mode. In inline formulas it looks like this: $\lim_{x\to\infty}f(x)$.

Note that the lim-function was entered as the function macro **\lim**. Have a look at section Ref: sub:Functions for an explanation of function macros.

5.1.7 Math Symbols Idx

lyx.org

Also

- WriteLaTeX
- Authorea
- ShareLaTeX
- Verbosus

Flavors of LaTeX

- LaTeX
- pdflatex
- xelatex
- lualatex

Getting help

- Google
- tex.stackexchange.com
- Ask a friend
- Look at others' documents
- Resign yourself to something less-than-ideal

Figure captions and floats

```
<<fig_with_caption, fig.cap="Scatterplot of $y$ vs $x$">>=
x <- rnorm(100)
y <- 5*x + rnorm(100)
lm.out <- lm(y ~ x)
plot(x,y)
abline(lm.out$coef)
@
```

```
\begin{figure}[]
\includegraphics{figure/fig_with_caption}

\caption{Scatterplot of $y$ vs $x$\label{fig:fig_with_caption}}
\end{figure}
```

Tables in LaTeX

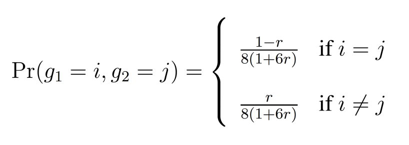
```
\begin{tabular}{rrrrr} \hline
& Estimate & Std. Error & t value & Pr($>$$|$t$|$) \\  \hline
(Intercept) & 0.04 & 0.11 &  0.4 & 0.69 \\
      x     & 0.98 & 0.10 & 10.0 & 0.00 \\ \hline
\end{tabular}
```

xtable

```
<<generate_and_fit>>=
x <- rnorm(100)
y <- x + rnorm(100)
lm.out <- lm(y ~ x)
@

<<table, results="asis">>=
library(xtable)
xtable(lm.out, digits=c(0,2,2,1,2))
@


% a non-floating version
<<table, results="asis">>=
library(xtable)
xtab <- xtable(lm.out, digits=c(0,2,2,1,2))
print(xtab, floating=FALSE)
@
```

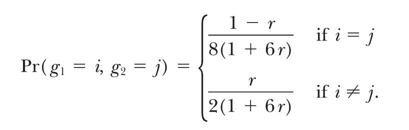
Read proofs carefully

As submitted



$$\Pr(g_1 = i, g_2 = j) = \begin{cases} \frac{1-r}{8(1+6r)} & \text{if } i = j \\ \frac{r}{8(1+6r)} & \text{if } i \neq j \end{cases}$$

As printed



$$\Pr(g_1 = i, g_2 = j) = \begin{cases} \dfrac{1 - r}{8(1 + 6r)} & \text{if } i = j \\ \dfrac{r}{2(1 + 6r)} & \text{if } i \neq j. \end{cases}$$

Broman (2005) Genetics 169:1133–1146

Re-type that!

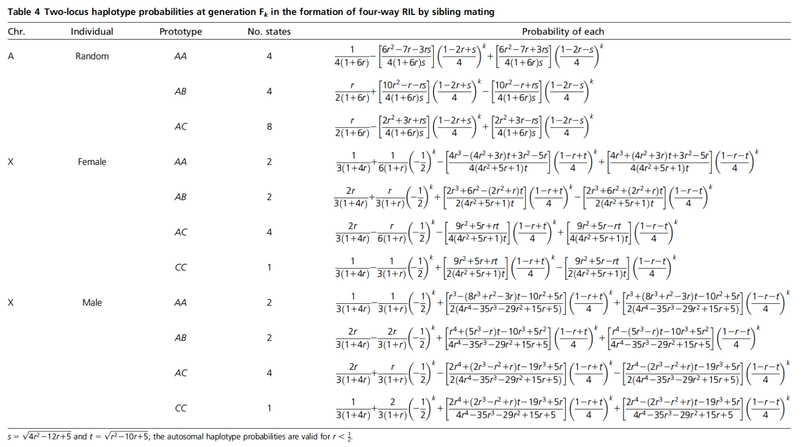


Table 4 Two-locus haplotype probabilities at generation F_k in the formation of four-way RIL by sibling mating

Chr.	Individual	Prototype	No. states	Probability of each
A	Random	*AA*	4	$\frac{1}{4(1+6r)}-\left[\frac{6r^2-7r-3rs}{4(1+6r)s}\right]\left(\frac{1-2r+s}{4}\right)^k+\left[\frac{6r^2-7r+3rs}{4(1+6r)s}\right]\left(\frac{1-2r-s}{4}\right)^k$
		AB	4	$\frac{r}{2(1+6r)}+\left[\frac{10r^2-r-rs}{4(1+6r)s}\right]\left(\frac{1-2r+s}{4}\right)^k-\left[\frac{10r^2-r+rs}{4(1+6r)s}\right]\left(\frac{1-2r-s}{4}\right)^k$
		AC	8	$\frac{r}{2(1+6r)}-\left[\frac{2r^2+3r+rs}{4(1+6r)s}\right]\left(\frac{1-2r+s}{4}\right)^k+\left[\frac{2r^2+3r-rs}{4(1+6r)s}\right]\left(\frac{1-2r-s}{4}\right)^k$
X	Female	*AA*	2	$\frac{1}{3(1+4r)}+\frac{1}{6(1+r)}\left(-\frac{1}{2}\right)^k-\left[\frac{4r^3-(4r^2+3r)t+3r^2-5r}{4(4r^2+5r+1)t}\right]\left(\frac{1-r+t}{4}\right)^k+\left[\frac{4r^3+(4r^2+3r)t+3r^2-5r}{4(4r^2+5r+1)t}\right]\left(\frac{1-r-t}{4}\right)^k$
		AB	2	$\frac{2r}{3(1+4r)}+\frac{r}{3(1+r)}\left(-\frac{1}{2}\right)^k+\left[\frac{2r^3+6r^2-(2r^2+r)t}{2(4r^2+5r+1)t}\right]\left(\frac{1-r+t}{4}\right)^k-\left[\frac{2r^3+6r^2+(2r^2+r)t}{2(4r^2+5r+1)t}\right]\left(\frac{1-r-t}{4}\right)^k$
		AC	4	$\frac{2r}{3(1+4r)}-\frac{r}{6(1+r)}\left(-\frac{1}{2}\right)^k-\left[\frac{9r^2+5r+rt}{4(4r^2+5r+1)t}\right]\left(\frac{1-r+t}{4}\right)^k+\left[\frac{9r^2+5r-rt}{4(4r^2+5r+1)t}\right]\left(\frac{1-r-t}{4}\right)^k$
		CC	1	$\frac{1}{3(1+4r)}-\frac{1}{3(1+r)}\left(-\frac{1}{2}\right)^k+\left[\frac{9r^2+5r+rt}{2(4r^2+5r+1)t}\right]\left(\frac{1-r+t}{4}\right)^k-\left[\frac{9r^2+5r-rt}{2(4r^2+5r+1)t}\right]\left(\frac{1-r-t}{4}\right)^k$
X	Male	*AA*	2	$\frac{1}{3(1+4r)}-\frac{1}{3(1+r)}\left(-\frac{1}{2}\right)^k+\left[\frac{r^3-(8r^3+r^2-3r)t-10r^2+5r}{2(4r^4-35r^3-29r^2+15r+5)}\right]\left(\frac{1-r+t}{4}\right)^k+\left[\frac{r^3+(8r^3+r^2-3r)t-10r^2+5r}{2(4r^4-35r^3-29r^2+15r+5)}\right]\left(\frac{1-r-t}{4}\right)^k$
		AB	2	$\frac{2r}{3(1+4r)}-\frac{2r}{3(1+r)}\left(-\frac{1}{2}\right)^k+\left[\frac{r^4+(5r^3-r)t-10r^3+5r^2}{4r^4-35r^3-29r^2+15r+5}\right]\left(\frac{1-r+t}{4}\right)^k+\left[\frac{r^4-(5r^3-r)t-10r^3+5r^2}{4r^4-35r^3-29r^2+15r+5}\right]\left(\frac{1-r-t}{4}\right)^k$
		AC	4	$\frac{2r}{3(1+4r)}+\frac{r}{3(1+r)}\left(-\frac{1}{2}\right)^k-\left[\frac{2r^4+(2r^3-r^2+r)t-19r^3+5r}{2(4r^4-35r^3-29r^2+15r+5)}\right]\left(\frac{1-r+t}{4}\right)^k-\left[\frac{2r^4-(2r^3-r^2+r)t-19r^3+5r}{2(4r^4-35r^3-29r^2+15r+5)}\right]\left(\frac{1-r-t}{4}\right)^k$
		CC	1	$\frac{1}{3(1+4r)}+\frac{2}{3(1+r)}\left(-\frac{1}{2}\right)^k+\left[\frac{2r^4+(2r^3-r^2+r)t-19r^3+5r}{4r^4-35r^3-29r^2+15r+5}\right]\left(\frac{1-r+t}{4}\right)^k+\left[\frac{2r^4-(2r^3-r^2+r)t-19r^3+5r}{4r^4-35r^3-29r^2+15r+5}\right]\left(\frac{1-r-t}{4}\right)^k$

$s=\sqrt{4r^2-12r+5}$ and $t=\sqrt{r^2-10r+5}$; the autosomal haplotype probabilities are valid for $r<\frac{1}{2}$.

Broman (2012) Genetics 190:403–412

BibTeX for bibliographies

```
%bibliography format
\usepackage[authoryear]{natbib}
\bibpunct{(}{)}{;}{a}{}{,}

A number of investigators have developed methods for identifying
such sample mix-ups \citep{Westra2011, Schadt2012, Lynch2012,
Ekstrom2012}, and a similar approach was applied by
\citet{Baggerly2008, Baggerly2009} in their forensic...

\bibliographystyle{genetics}
\renewcommand*{\refname}{\centerline{\normalsize\sffamily
   \textbf{Literature Cited}}}
\bibliography{samplemixups}
```

```
@article{Baggerly2008,
author = {Baggerly, Keith A. and Coombes, Kevin R.},
journal = {J. Clin. Oncol.},
pages = {1186--1187},
title = {Run batch effects potentially compromise...},
volume = {26},
year = {2008} }
```

Organizing analyses

- Directory for the main analysis project

```
~/Projects/Blah
```

- Directory for a paper

```
~/Docs/Papers/Blah
```

- Paper directory may have an analysis directory

```
~/Docs/Papers/Blah/Analysis
```

- Symbolic links to `.RData` files

```
ln -s ~/Projects/Blah/DerivedData/blah.RData .
```

- Each part well organized and fully reproducible.
- R Markdown reports documenting different aspects.
- Analysis with the paper may be re-done "properly."

Make every number reproducible.

```
<<define_numbers, echo=FALSE>>=
numbers <- c("one", "two", "three", "four", "five",
             "six", "seven", "eight", "nine", "ten")
cap <- function(vec) paste0(toupper(substr(vec, 1, 1)),
                            substr(vec, 2, nchar(vec)))
Numbers <- cap(numbers)
n <- sample(1:10, 1)
@

Then if I want to talk about a number, like \Sexpr{n}, I can
refer to it by name: \Sexpr{numbers[n]}. And I can start a
sentence with it. \Sexpr{Numbers[n]} grasshoppers walked into a
bar\dots

But be careful about singular vs. plural, and so write
\Sexpr{Numbers[n]} grasshopper\Sexpr{ifelse(n>1, "s", "")}
walked\dots
```

Keep the figures separate

```
# simple make file

mypaper.pdf: mypaper.tex Figs/fig1.pdf Figs/fig2.pdf
pdflatex mypaper

Figs/fig1.pdf: R/fig1.R
cd R;R CMD BATCH fig1.R fig1.Rout

Figs/fig2.pdf: R/fig2.R
cd R;R CMD BATCH fig2.R fig2.Rout
```

```
\clearpage
\includegraphics{Figs/fig1.pdf}

\clearpage
\includegraphics{Figs/fig2.pdf}
```

Version Control

- Your manuscript is under version control, right?

Version Control

- Your manuscript is under version control, right?
- Local or private repository for the whole thing
  - including reviewers' reports and my response
  - PDF of submitted and final manuscript
- Snapshot of the final version as a public repository
  - I don't really want to show the whole history

Word

- With papers led by a collaborator, I'm usually stuck with Word.
- But my analyses and figures are fully reproducible.
- Create an R Markdown document with the detailed results.

Summary

- LaTeX is brilliant for fine control and for equations
- Floating figures and tables can be a pain
- You use KnitR with LaTeX much the same way as you'd used it with Markdown.
- Ensure that every statistic, figure, and table in your paper are fully reproducible.
- Use xtable to make tables.
- Separate out the code for the figures.
- Use version control!