Literate Programming in R Markdown

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Literate Programming

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   - doing *real* research
   - ~~in the pub~~ baking sourdough

Effective communication

"If you can't write clearly, you probably don't think nearly as well as you think you do." — Kurt Vonnegut

"If it was hard to write, it should be hard to read."
— Computer programmers' proverb

Commenting code

What does this code do?

```r
data(women)
plot(women)
fit <- lm(weight ~ height, data = women)
abline(fit)
```

Commenting code

With comments:

```r
# Analysis of the 'women' dataset in R
data(women) # Load the data
plot(weight~height, data = women) # Make a scatter plot
fit <- lm(weight ~ height, data = women) # Fit linear model
abline(fit) # Add a line of best fit to the plot
```

Literate Programming

"Let us change our traditional attitude to the construction of programs: Instead of imagining that our main task is to instruct a computer what to do, let us concentrate rather on explaining to humans what we want the computer to do."
— Donald Knuth

Who will read your code?

1. Your supervisor
2. Collaborators
3. Reviewers
4. Future *you*

The *World Almanac and Book of Facts* (1975) includes a dataset of heights (in) and weights (lbs) of 15 American women aged 30–39. It is built into R:

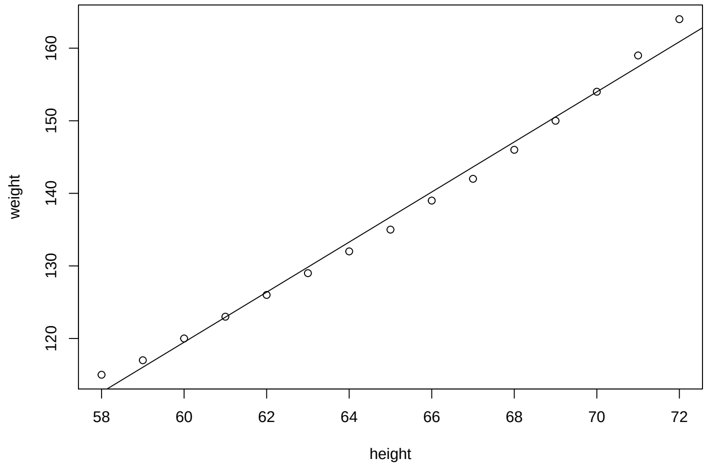
```r
data(women)
```

As height increases, weight appears to increases (almost) linearly: every inch in height adds approximately 3.45 lbs. This was determined by fitting a simple linear regression model of weight against height:

```r
fit <- lm(weight ~ height, data = women)
```

The resulting least-squares regression line can be drawn on a scatter plot of height against weight. The fit looks quite good. . .

```r
plot(weight~height, data = women)
abline(fit)
```


weight
160
150
140
130
120
58
60
62
64
66
68
70
72
height

Markdown

Markdown syntax

```
Here is some text in *italics*, in **bold** and `teletype`.

Here is a new paragraph, a [link](www.google.com) and an
image:
![Wally](wally.jpg)

* These are
* bullet points

> "To be, or not to be, that is the question."
^[*Hamlet*, Act III, Scene I]

1. And this is
1. a numbered
7. list
```

Markdown output

Here is some text in *italics*, in **bold** and `teletype`.
Here is a new paragraph, a link and an image:

- These are
- bullet points

> *“To be, or not to be, that is the question.”* [1]

1. And this is
2. a numbered
3. list

[1] *Hamlet*, Act III, Scene I

Markdown mathematics (*LaTeX*)

Generate **in-line** maths with `$ ... $` or `\( ... \)`
and **display** maths with `$$ ... $$` or `\[ ... \]`.

Example

`\(e^{i\pi}\)` gives $e^{i\pi}$ and

```
\[ f(x) =
\frac{1}{\sigma\sqrt{2\pi}}
e^{\frac{(x-\mu)^2}{2\sigma^2}} \]
```

gives

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}}e^{\frac{(x-\mu)^2}{2\sigma^2}}$$

Markdown tables

```
| Left               | Centre          | Right  |
| ------------------ |:---------------:| ------:|
| You can            | This text is    |    42  |
| use **Markdown**   | centre-aligned  |   314  |
| *within* tables    |                 |    37  |
```

Output

Left	Centre	Right
You can	This text is	42
use **Markdown**	centre-aligned	314
within tables		37

Markdown code blocks

~~~
To investigate the relationship between `height` and `weight`
we fitted a *simple linear regression model*, as follows.

```r
model <- lm(weight ~ height, data = women)
summary(model)
plot(model) # Residual diagnostics
```
~~~

To investigate the relationship between `height` and `weight`, we fitted a *simple linear regression model*, as follows.

```r
model <- lm(weight ~ height, data = women)
summary(model)
plot(model) # Residual diagnostics
```

YAML headers

```
---
title: "The name of my Markdown document"
author: "David A. Selby"
date: "15 January 2021"
output: pdf_document
---

(content)
```

YAML (yet another markup language) headers let you specify additional options before `rendering` your document

Markdown: so what?

So far, Markdown is just a lightweight typesetting program.
How will this help you become more productive?
Introducing ***R* Markdown**. . .

R Markdown

R Markdown

An ordinary Markdown code block:

~~~
```r
your R code goes here
```
~~~

An R Markdown **R code** chunk:

~~~
```{r}
your R code goes here
```
~~~

R Markdown

You can run R **in-line** with text as well. To add in-line R code, we use the syntax `` `r your_code_here` ``. This will **evaluate and return the result** within the paragraph. For example:

```
If we multiply 13 and 56 we get `r 13 * 56`.
The date today is `r format(Sys.Date(), "%d %B %Y")`.
There are `r nrow(iris)` observations in the iris data set.
```

Output

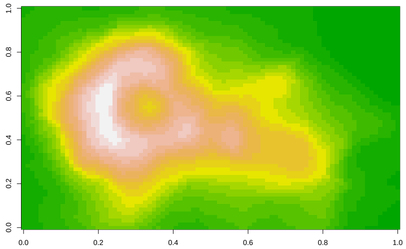
If we multiply 13 and 56 we get 728.
The date today is 15 January 2021.
There are 150 observations in the iris data set.

Re-using code chunks

~~~
Check out this *cool* plot:

```{r chunk1, echo = FALSE}
image(volcano, col = terrain.colors(20), labels = NULL)
```

Here is the code we used to make it!

```{r chunk2}
```{r chunk1, eval = FALSE}
```
~~~

Re-using code chunks (output)

Check out this *cool* plot:



Here is the code we used to make it!

```
image(volcano, col = terrain.colors(20), labels = NULL)
```

Other programming languages[2]

A Python code chunk

~~~
```{python}
x = ['To', 'be', 'or', 'not', 'to', 'be']
y = [i.upper() for i in x]
print(" ".join(y) + 5 * '?!')
```
~~~

Output

```
x = ['To', 'be', 'or', 'not', 'to', 'be']
y = [i.upper() for i in x]
print(" ".join(y) + 5 * '?!')
```

```
## TO BE OR NOT TO BE?!?!?!?!?!
```

[2] Assuming they are installed and on your PATH

Lazy, productive research

Nobody need ever know!

- `knitr::kable` or `xtable::xtable` to auto-generate tables
- `echo = FALSE` to hide code in output
- `cache = TRUE` to save results that take a long time to run
- `output: word_document` to generate `.docx` files
- Set a `bibliography` in YAML, then cite:
  e.g. "As found by `[@fisher1931]`..."

Another thing R Markdown is great for

Presentations. . .

Links & further reading

Literate Programming Donald Knuth (1992)
R Markdown `https://rmarkdown.rstudio.com`
knitr `https://yihui.name/knitr`
R Markdown reference guide and cheat sheet
`https://www.rstudio.com/resources/cheatsheets/`

R-thritis user group

- Regular informal R talks/tutorials/discussions
- Next meeting: Friday 29th January?
- See also: `https://meetup.com/Warwick-useRs`