Dynamic Documents For Your Research Workflow

Fernando Hoces de la Guardia
BITSS
-
Slides at https://goo.gl/VbiKb4

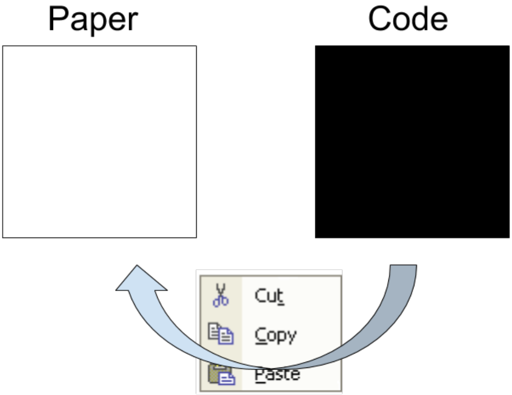
World Bank Workshop, January 2018

Dynamic Documents For Computational Reproducibility

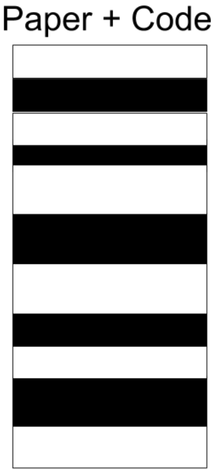
Dynamic Documents For Computational Reproducibility

- Based on principles of *literate programming* aims at combining code and paper in one single document
- Best framework to achieve the holy grail of **one-click reproducible workflow**
- Best two current implementations: `RMarkdown (R)` & `Jupyter (Python)`. `Stata` is catching up (more at the end)

Currently code and narrative components live in separate universes



Dynamic Documents: integrate the two universes!



Dynamic Documents: A Recipe

- 1 simple language that can combine text and code: `Markdown`
- 1 statistical package to do the analysis (`R`, `Python`, `3S's?`)
- 1 machinery to combine analysis and text to create a single output: `Pandoc`
- [Optional-but-not-really] 1 program to bring all the elements together: RStudio/RMarkdown, Jupyter

Markdown laguange/syntax in 60 seconds

syntax

```
Plain text
End a line with two spaces to start a new paragraph.
*italics* and _italics_
**bold** and __bold__
superscript^2^
~~strikethrough~~
[link](www.rstudio.com)

# Header 1

## Header 2

### Header 3

#### Header 4

##### Header 5

###### Header 6

endash: --
emdash: ---
ellipsis: ...
inline equation: $A = \pi*r^{2}$
image: ![](path/to/smallorb.png)

horizontal rule (or slide break):
```

becomes

Plain text
End a line with two spaces to start a new para

italics and *italics*
bold and **bold**
superscript^2
~~strikethrough~~
link

Header 1

Header 2

Header 3

Header 4

Header 5

Header 6

endash: –
emdash: —
ellipsis: …
inline equation: $A = \pi * r^2$
image:

One Type of Dynamic Document: R Markdown

For our excercise: R Markdown

- R: **open source** programming language design for statistical analysis.
- RStudio: free software that provides and Integrated Development Environment (IDE)
- RStudio combines all together: R + Markdown + Pandoc to produce multiple outputs

R Markdown


Bookdown
PDF
LaTeX
TUFTE
HTML
Slide
Headline One
Headline Two

Basic Structure

- A header
- Text
- Code: inline and chunks

Basic Structure: Header

```
---
title: "Sample Paper"
author: "Fernando Hoces de la Guardia"
output: html_document
---
```

Basic Structure: Body of Text

```
---
header
---
```

This is where you write your paper. Nothing much to add. You can check Markdown syntax here. And it can use can type equations using LaTex syntax!

Basic Structure: Code Chunks and Inline

```
---
header
---
```

Body of text.

To begin a piece of code ("code chunk"). Enclose them in the following expression (Ctrl/Cmd + shift/optn + i)

````
```{r, eval=TRUE}
here goes the code
```
````

To write inline use only one Backtick to open followed by an "r"" and one to close `` `r 1+1` `` in the output.

Practical Excercise #1

Hands-on excercise: the birthday problem!

As an illustration lets write a report using the participants in this workshop to illustrate the famous birthday problem.

> *What is the probability that at least two people this room share the same birthday?*

> *Is it something like* $\frac{1}{365} \times N = 0.074$*?*

Create a new RMarkdown File

1 - In RStudio: `File-> New File -> RMarkdown...`
2 - Name it, and save it.
3 - Review/edit the header, and delete all the default body of text except for one code chunk.
4 - Define a seed (`set.seed(1234)` and number of people in the room (`n.pers = ?`)

The birthday problem: the math

Actually the math says otherwise:

$$\begin{aligned} 1 - \bar{p}(n) &= 1 \times \left(1 - \frac{1}{365}\right) \times \left(1 - \frac{2}{365}\right) \times \cdots \times \left(1 - \frac{n-1}{365}\right) \\ &= \frac{365 \times 364 \times \cdots \times (365 - n + 1)}{365^n} \\ &= \frac{365!}{365^n (365-n)!} = \frac{n! \cdot \binom{365}{n}}{365^n} \end{aligned} \tag{1}$$

$$p(n = 27) = 0.627$$

Code for the math (https://goo.gl/2z1ggK)

Don't look at this: just copy and paste into your report

```
\begin{align}
 1 - \bar p(n) &= 1 \times \left(1-\frac{1}{365}
                                  \right)
 \times \left(1-\frac{2}{365}\right) \times \cdots
 \times
 \left(1-\frac{n-1}{365}\right) \nonumber  \\
 &= \frac{ 365 \times 364 \times \cdots \times
   (365-n+1) }{ 365^n } \nonumber \\
 &= \frac{ 365! }{ 365^n (365-n)!} =
   \frac{n!\cdot\binom{365}{n}}{365^n}\\
p(n= `r n.pers`) &= `r
 round(1 - factorial(n.pers) *
        choose(365,n.pers)/ 365^n.pers, 3)`
 \nonumber
\end{align}
```

Don't like math? Let's run a simple simulation!

1 - Simulate 10,000 rooms with $n = 27$ random birthdays, and store the results in matrix where each row represents a room.
2 - For each room (row) compute the number of unique birthdays.
3 - Compute the average number of times a room has 27 unique birthdays, across 10,000 simulations, and report the complement.

Code for the simulation (https://goo.gl/2z1ggK)

```
birthday.prob = function(n.pers, n.sims) {
  # simulate birthdays
  birthdays = matrix(round(runif(n.pers * n.sims,
                                 1, 365)),
                     nrow = n.sims, ncol = n.pers)
  # for each room (row) get unique birthdays
  unique.birthdays = apply(birthdays, 1, unique)
  # Indicator with 1 if all are unique birthdays
  all.different = (lapply(unique.birthdays,
                          length) == n.pers)
  # Compute average time all have different birthdays
  result = 1 - mean(all.different)
return(result)
}
n.pers.param = 27
n.sims.param = 1e4
birthday.prob(n.pers.param,n.sims.param)
```

Results

- Many people originally think of a prob $\sim \frac{1}{365} \times N = 0.074$
- However the true probability is of $p(n = 27) = 0.627$
- And the simulated probability is of 0.6258

Practical Excercise #2

Hands-on excercise #2: Mostly Harmless Econometrics! (@WB?)

There is a fantastic Github repo that is reproducing results from MHE (Originated here?)

Lets use the of examples Figure 5.2.4 to show how dynamic docs can be used in data analysis.

Final Remarks & More Resources

Final Remarks & More Resources

- With DD we can achieve a one-click reproducible workflow.
- This is particularly helpful to understand/present results that are hard to digest.
- Stata just develop an internal version of DD for v15. Review Here
- More great examples in the workshop repo (`4-Moredynamicdocs`)
- Want to learn more: great free books (can you guess how they were written?)