Using Rmarkdown to generate dynamic documents

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What is Rmarkdown?

What is and why Rmarkdown?

- It allows you to effortlessly generate documents (or even websites) that can print both R codes and their outcomes (this lecture note is indeed written using **Rmarkdown**) in a single document.
- The full power of Rmarkdown is on display here.
- It is useful when you report the analysis you conducted and its source R codes to your advisor or anyone you report to (as long as that person understands R).

The power of Rmarkdown goes well beyond just creating a simple html document.

- book
- interactive map
- dashboard
- website
- presentation slides (this lecture is made using Rmarkdown)

Using WORD?

- It would be a real pain to do so because you need to copy and paste all the R codes you run and the results onto WORD **manually**.
- Often times, copied R codes and results are very much likely to be badly formatted when pasting them
- Rmarkdown obviates the need of repeating copying and pasting when you would like to communicate what you did (R codes) and what you found (results) without worrying too much about formatting.

Generating a report using Rmarkdown

Generating a report using Rmarkdown is a two-step process:

1. Create an Rmarkdown file (file with .Rmd as an extension) with regular texts and R codes mixed inside it.
    - You use a special syntax to let the computer know which parts of the file are simple texts and which parts are R codes.
2. Tell the computer to process the Rmd file (a click of a button on Rstudio, or use the `render()` function)
    - The computer runs the R codes and get their outcomes
    - Combine the text parts, R codes, and their results to produce a document

Rmarkdown: the Basics

R code chunks

Rmd file consists of two types of inputs:

- R code chunks
- Regular tects

special syntax

We can indicate R codes chunks by placing R codes inside a special syntax.

````
```{r}
codes here
```
````

Direction

Take a look at **rmd_sample.Rmd**, which can be downloaded from here.

- R codes `summary(cars)` and `plot(pressure)` are enclosed individually by the special syntax
- So, in this rmd file, R knows that it should treat them as R codes, but not regular texts.
- On the other hand, any texts that are not enclosed by the special syntax would be recognized as regular text.

Let's knit

The process of compiling an rmd file to produce a document is called **knitting**.

- The easiest way to knit is to hit the Knit button located at the top of the code pane (upper left pane by default)
- Alternatively, you can use the `render()` function to knit like below:

```
render("sample_rmd.Rmd")
```

Direction

Inspect the rmd file and its output document:

Rmd side

1. lines 1-13: a **YAML header** where you control the aesthetics of the output document (more on this later)
2. lines 34-36: texts not enclosed by the special syntax
3. lines 38-40: `summary(cars)` is an R code, which is enclosed by the special syntax

html side

1. lines 1-13: nothing
2. lines 34-36: printed as regular texts
3. lines 38-40: the R code and its results printed

Inline code

You can refer to an R object previously defined in line and display its content in line:

Direction

See lines 58-65 of the rmd file

Markdown basics

- header
- make a list
- font
- code highlighting
- inline math
- math
- web link
- citation

Direction

Compare Chapter 2 of the rmd file and its output html file

Chunk options

Direction

Inspect the rmd file and its output document

- From the R code chunk with `summary(cars)`, the code itself and its outcome are presented in the output
- From the R code chunk with `plot(pressure)`, only its outcome is presented in the output

chunk options: echo

- This is because of the chunk option `echo = FALSE` in the second R code chunk
- We can control how R code chunks are translated and appear in the output document using chunk options

Various chunk options

- `echo`
- `eval`
- `message`
- `warning`
- `results`
- `include`
- `cache`
- `fig.cap`

Chunk option: echo

- `echo` (TRUE or FALSE): specify whether the R codes appear in the output document or not
- `eval` (TRUE or FALSE): specify whether the R codes are evaluated or not

Direction

Inspect the rmd file (lines 29-53) and its output document.

[1] Values in red indicates that they are the default values

Chunk option: message

- `message` (TRUE or FALSE): specify weather messages associated with R codes evaluation appear in the output document or not
- `warning` (TRUE or FALSE): specify weather warnings associated with R codes evaluation appear in the output document or not

Direction

Inspect the rmd file (lines 55-76) and its output document

Chunk option: results

`results` (markup , hide, asis)

- `hide`: hides all the results including warnings and messages
- `asis`: the outputs of the R codes are printed as-is without any suitable formatting (which the default option `markup` does)

Direction

Inspect the rmd file (lines 55-76) and its output document

[1] Values in red indicates that they are the default values
[2] `asis` is useful when using the `stargazer()` function to present regression results.

Chunk option: include

`include = FALSE` is equivalent to having `eval = TRUE, echo = FALSE, results = "hide"`

Direction

Inspect the rmd file (lines 55-76) and its output document

Specify chunk options globally

Sometimes, it is useful to set chunk options that apply globally (for the entire documents).

For example,

- You are writing a term paper and the instructor may want to see only results, but not R codes.
- You do not want any of the R codes to appear on the output document, but `echo = TRUE` is the default.

Specify chunk options globally

You can use `opts_chunk$set()` from the **knitr** package to set chunk options globally.

```
opts_chunk$set(
  echo = FALSE,
  messages = FALSE,
  warnings = FALSE,
  fig.align = "center",
  fig.width = 5,
  fig.height = 4
)
```

Direction

Uncomment lines 13 - 23 and knit

Important: Local option overrides the global option.

Chunk option for figure

- `fig.align`: 'default', 'center', 'left', 'right'
- `fig.width`: in inches
- `fig.height`: in inches
- `fig.cap`: figure caption

Direction

Play with these options. See here for more chunk options.

Caching

- In the course of creating a document using Rmarkdown, You are going to hit the "Knit" button numerous times when you are writing a report to check whether the final output looks fine.
- Every time you knit, all the R code chunks are evaluated, which is inefficient because R has evaluated those R code chunks before.
- So, if we can somehow store the results of R code chunks (caching), and then let R call up the saved results instead of re-evaluating the codes all over again, we can save lots of time.
- The benefit of doing so is greater when the processing time of the codes is longer. Caching can be done by adding `cache==TRUE` as a chunk option.
- By adding the option, once an R chunk is processed, its results are saved and can be reused again by R later when you compile the document again.

Direction

- change `eval = F` to `eval = T` in the **cache_1** chunk
- knit and confirm that **sample_rmd_cache** and **sample_rmd_files** folders are created
- knit again and observe that the knitting process is much faster now

When any part of the R codes within a cached R code chunk is changed, R is smart enough to recognize the change and evaluate the R code chunk again without using the cached results for the chunk.

Direction

Change `y = 1 + x + v` to `y = 1 + 2 * x +v` in the **cache_1** chunk and knit

- Sometimes, your R codes within an cached R code chunk have not changed, but the content of a dataset used in the R code chunk may have changed.
- In such a case, R is unable to recognize the change in the content of the dataset.

Direction

- change `eval = F` to `eval = T` in the `cache_2` chunk and knit
- change `y = 1 + 2 * x + v` back to `y = 1 + x +v` and knit (notice that the printed number from `cache_2` did not change)

- To R, everything in the `cache_2` chunk looks the same as they only look at the code texts, but not the contents of R objects.
- Therefore, R would call up the saved results instead of rerunning the R codes, which is not what you want.
- You can use the `dependson` option to make R recognize any changes in cached R objects

Direction

Add `dependson = "cache"` to the `cache_2` chunk as an option and knit again.

YAML

YAML

At the very beginning of an rmd file, you have a YAML header, where you specify how the resulting documents look like.

Example

```
---
title: "Reporting using Rmarkdown"
author: "Taro Mieno"
date: "2022-06-13"
output:
  html_document:
    number_sections: yes
    theme: flatly
    toc: yes
    toc_float: yes
  word_document:
    toc: yes
---
```

Direction

- Try other themes and highlight methods found here
- Visit here for the other options.

Directory

Reading Files

Suppose you are interested in reading a dataset file like this:

```
read.csv("corn_price.csv")
```

Important:

By default, RStudio looks for **corn_price.csv** in the same folder in which the Rmd file is located.

So,

- In my case, the sample_rmd.rmd is located in /Users/tmieno2/Taro Mieno Dropbox/Taro Mieno/TeachingUNL/Data-Science-with-R/Chapter-2-Rmarkdown.
- So, RStudio tries to find /Users/tmieno2/Taro Mieno Dropbox/Taro Mieno/TeachingUNL/Data-Science-with-R/Chapter-2-Rmarkdown/corn_price.csv.
- If the file is not in the directory, RStudio won't be able to find the file to import and returns an error. Clearly, all the subsequent actions dependent on the dataset will not run.

To avoid errors in reading files, there are three options:

Option 1. (recommended for a beginner)

Put all the datasets you intend to use in the same directory in which your rmd file is located

Option 2.

If the file is not in the directory, supply the full path to the file like this

```
read.csv("~/Dropbox/TeachingUNL/Data-Science-with-R/Chapter-2-Rmarkdown/corn_price.csv")
```

Option 3.

Tell Rstudio to look for a specific directory for datasets by setting a working directory using `opts_knit$set(root.dir = directory)` at the beginning

```
opts_knit$set(root.dir = "~/Dropbox/TeachingUNL/Data-Science-with-R/Chapter-2-Rmarkdown/")
```

Output types

Output types

- html
- Word
- pdf

How

To select the output type, first click on the black triangle button next to the "Knit" button, and then select your preferred option type.

- By far the preferred version of the three is html if you do not intend to print out the output document.
- html is void of the concept of **page**. Consequently, you do not have to worry about how you should organize texts, tables, and figures within a page (fixed amount of space).
- The formatting of figure and tables can be screwed up in Word

Interactive features

html is much more powerful than pdf or WORD in the sense that it is interactive.

htmlwidgets: tools to generate interactive contents using R

See the list of htmlwidgets here

Interactive features: table

`datatable()` from the `DT` package lets you create an interactive table

```
library(tidyverse)
library(DT)

iris %>% datatable(
  extensions = "Buttons",
  options = list(
    dom = "Blfrtip",
    buttons = c("copy", "csv", "excel", "pdf", "print"),
    lengthMenu = list(
      c(10, 25, 50, -1),
      c(10, 25, 50, "All")
    )
  )
)
```

Interactive features: table

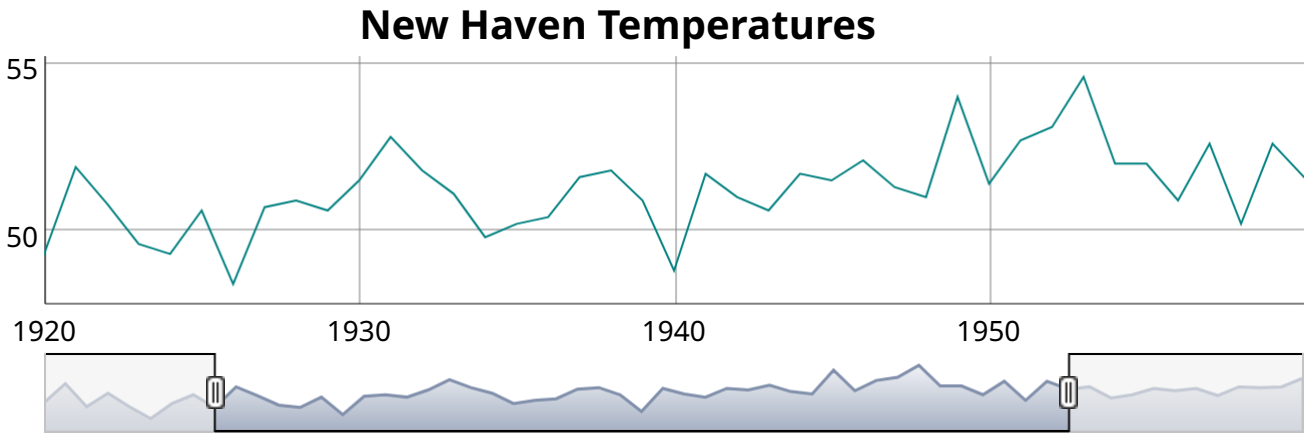
Copy CSV Excel PDF Print Show 10 entries Search:

	Sepal.Length	Sepal.Width	Petal.Length	Petal.Width	Species
1	5.1	3.5	1.4	0.2	setosa
2	4.9	3	1.4	0.2	setosa
3	4.7	3.2	1.3	0.2	setosa
4	4.6	3.1	1.5	0.2	setosa
5	5	3.6	1.4	0.2	setosa
6	5.4	3.9	1.7	0.4	setosa
7	4.6	3.4	1.4	0.3	setosa
8	5	3.4	1.5	0.2	setosa
9	4.4	2.9	1.4	0.2	setosa
10	4.9	3.1	1.5	0.1	setosa

Showing 1 to 10 of 150 entries Previous 1 2 3 4 5 ... 15 Next

Interactive features: time-series data

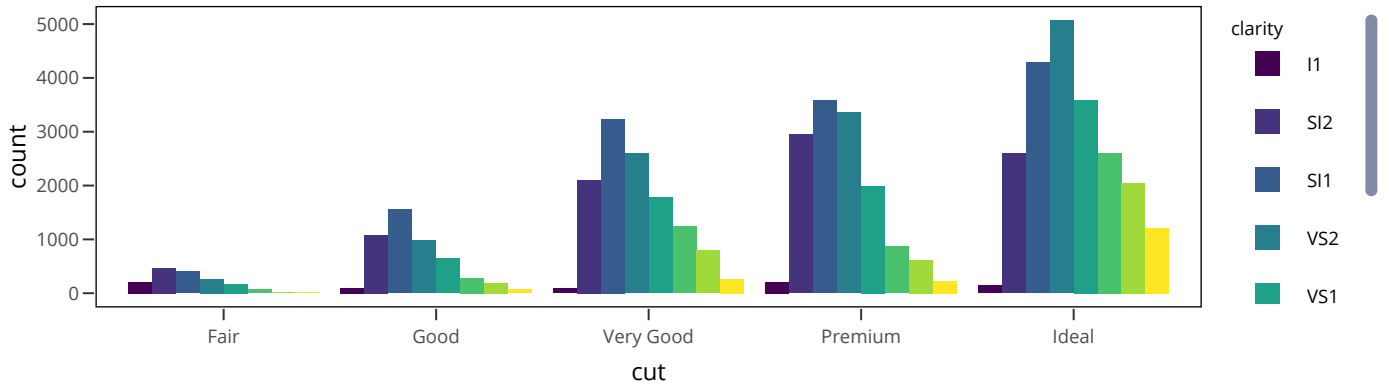
```
library(dygraphs)
dygraph(nhtemp, main = "New Haven Temperatures") %>%
  dyRangeSelector(dateWindow = c("1920-01-01", "1960-01-01"))
```



Interactive features: ggplot2 figures

```
library(ggplot2)
library(plotly)
p <- ggplot(data = diamonds) +
  geom_bar(aes(x = cut, fill = clarity), position = "dodge")

ggplotly(p)
```



Resources

Here is a list of some useful resources to learn Rmarkdown.

- R Markdown: The Definitive Guide
- Introduction to R markdown by Rstudio
- Cheat sheet by Rstudio