R Programming and Data Analysis

Graphics

Introduction

1. Traditional graphics
2. Plotting with ggplot2
3. Reproducible research & documentation in R
4. Shiny

Traditional Graphics

Traditional Graphics

. . . Demonstration . . .

(See `traditional.Rmd`)

ggplot2

ggplot2

- `ggplot2` is a popular graphics package whose syntax is based on a "grammar for graphics".

- Components of a graphic are
  1. data frames
  2. aesthetics
  3. geoms
  4. facets
  5. statistical transformations
  6. scales
  7. coordinate systems

- For further reference
  1. Video tutorial by Roger Peng: `https://youtu.be/HeqHMM4ziXA`.
  2. Book (**?**).
  3. `ggplot2` Cheat Sheet

Traditional Graphics

. . . Demonstration . . .

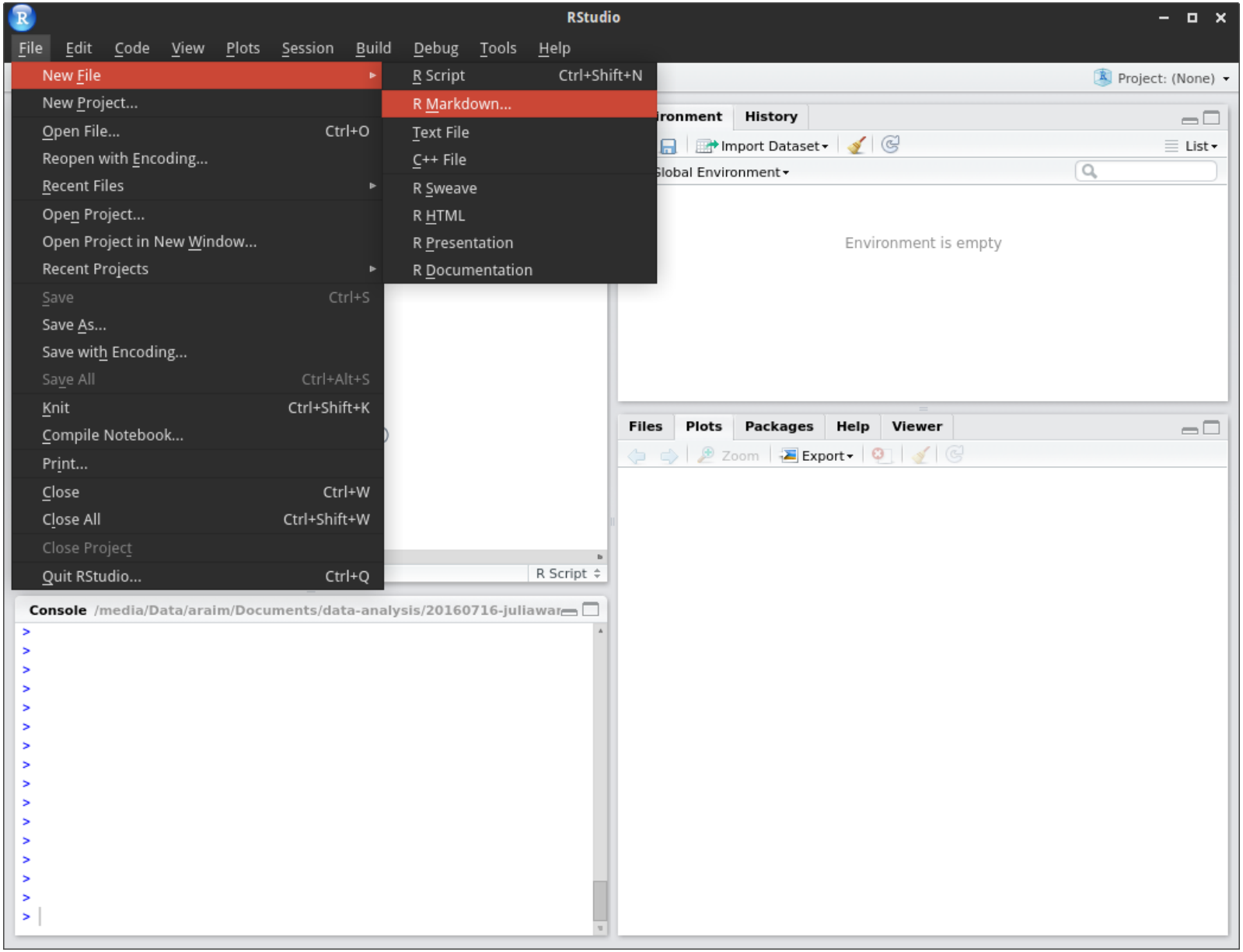
(See `ggplot2.Rmd`)

Reproducible Research & Documentation

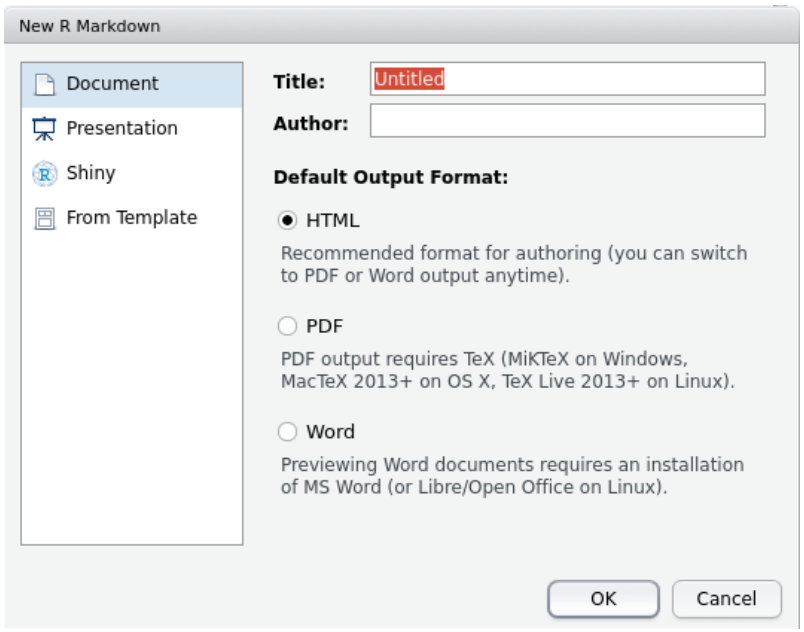
Reproducible Research & Documentation

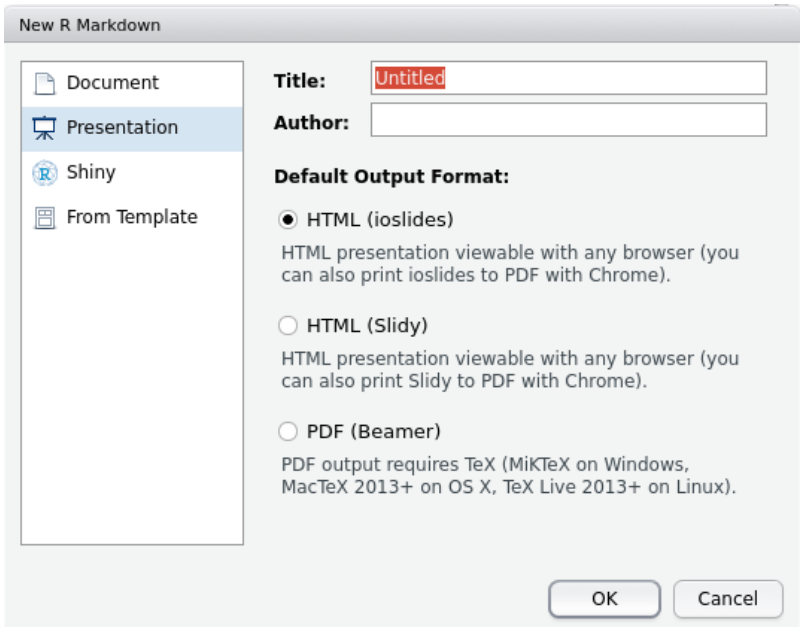
- **Reproducible research** is an idea which promotes releasing code and data from an analysis, not only the results.
- This allows others to verify details of your analysis and try alternative methods.
- There is a documentation system integrated into Rstudio.
- Embed chunks of `R` code into your document and update dynamically when document is compiled, via `knitr` package (**?**).
- R Markdown (`http://rmarkdown.rstudio.com`) is a Wiki-like language used for authoring many kinds of documents.
  1. Reports: HTML, PDF, Word
  2. Slides: HTML, Beamer
  3. Books and technical documents (**?**)
  4. Blog posts (**?**)
  5. And more: `http://rmarkdown.rstudio.com/formats.html`
- What to do about long computations embedded in document?

Reproducible Research & Documentation



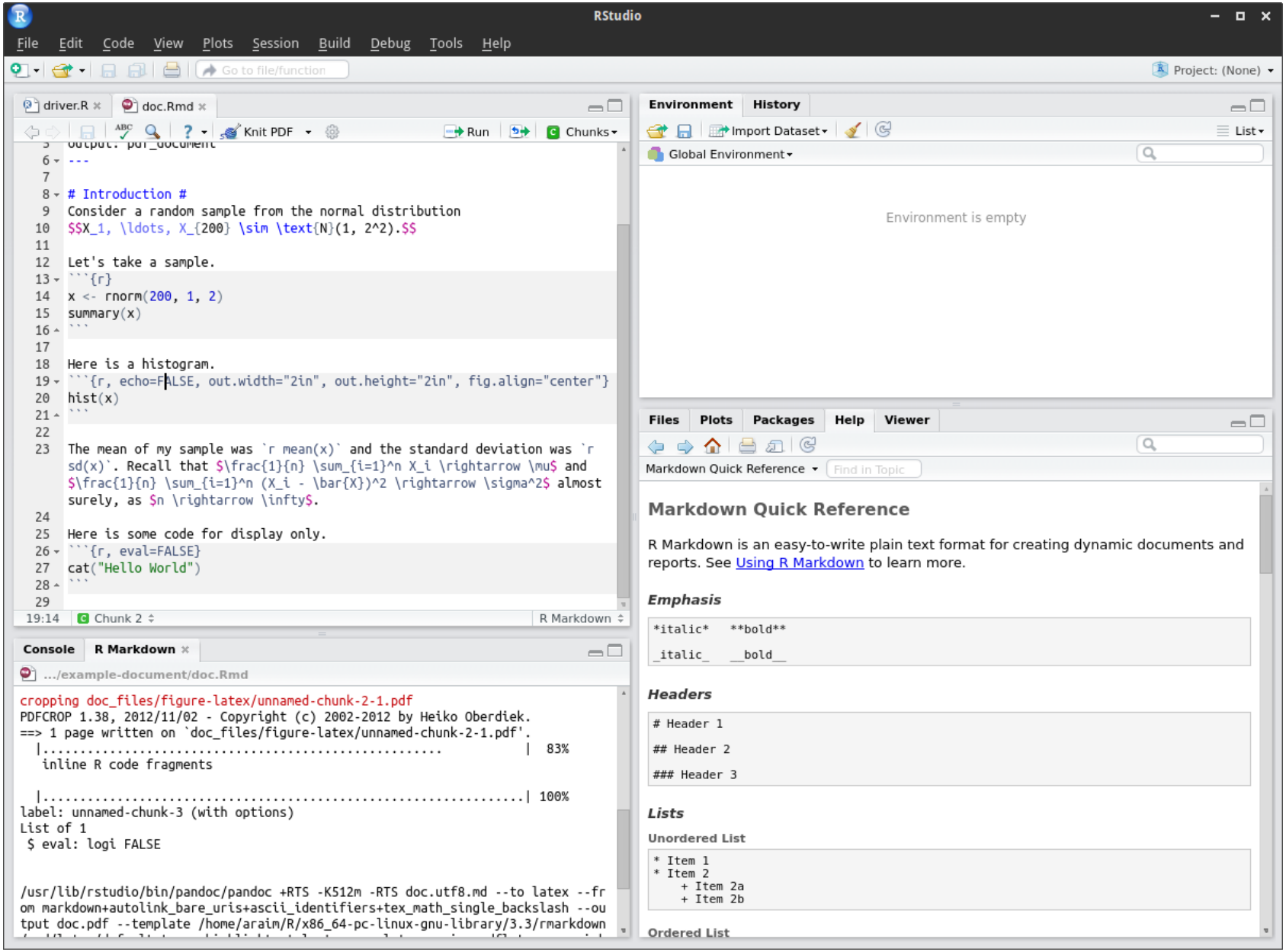
Reproducible Research & Documentation





````
---
title: "Example Markdown Document"
author: "Andrew R"
date: "July 24, 2016"
output: pdf_document
---

# Introduction #
Consider a random sample from the normal distribution
$$X_1, \ldots, X_{200} \sim \text{N}(1, 2^2).$$

Let's take a sample.
```{r}
x <- rnorm(200, 1, 2)
summary(x)
```

Here is a histogram.
```{r, echo=FALSE, out.width="2in", out.height="2in",
    fig.align="center"}
hist(x)
```

The mean of my sample was `r mean(x)` and the standard deviation was
`r sd(x)`. Recall that $\frac{1}{n} \sum_{i=1}^n X_i \rightarrow \mu$
and $\frac{1}{n} \sum_{i=1}^n (X_i - \bar{X})^2 \rightarrow \sigma^2$
almost surely, as $n \rightarrow \infty$.

Here is some code for display only.
```{r, eval=FALSE}
cat("Hello World")
```
````

Reproducible Research & Documentation



Reproducible Research & Documentation

doc.pdf — Example Markdown Document

File Edit View Go Bookmarks Help

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Example Markdown Document

Andrew R

July 24, 2016

Introduction

Consider a random sample from the normal distribution

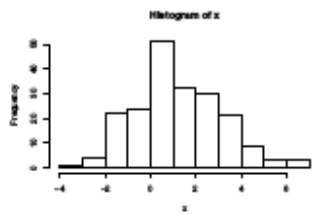
$$X_1, \ldots, X_{200} \sim \mathrm{N}(1, 2^2).$$

Let's take a sample.

```
x <- rnorm(200, 1, 2)
summary(x)
```

```
##     Min.  1st Qu.   Median     Mean  3rd Qu.     Max.
## -3.37500 -0.02034  0.97130  1.20000  2.49800  6.22000
```

Here is a histogram.

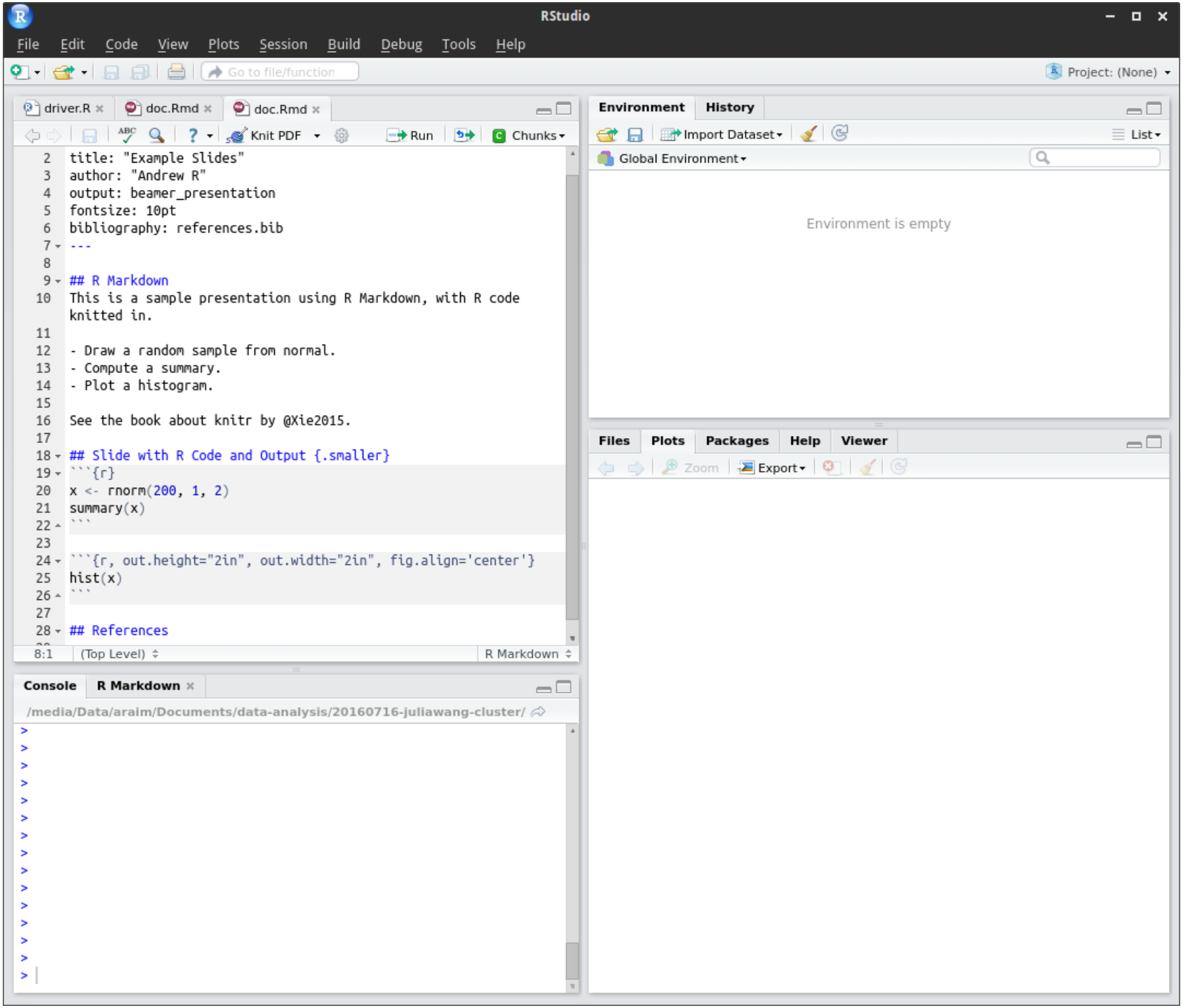


The mean of my sample was 1.1999757 and the standard deviation was 1.8745499. Recall that $\frac{1}{n}\sum_{i=1}^{n} X_i \to \mu$ and $\frac{1}{n}\sum_{i=1}^{n}(X_i - \bar{X})^2 \to \sigma^2$ almost surely, as $n \to \infty$.

Here is some code for display only.

```
cat("Hello World")
```

````
---
title: "Example Slides"
author: "Andrew R"
output: beamer_presentation
fontsize: 10pt
bibliography: references.bib
---

## R Markdown
This is a sample presentation using R Markdown, with R code knitted in.

- Draw a random sample from normal.
- Compute a summary.
- Plot a histogram.

See the book about knitr by @Xie2015.

## Slide with R Code and Output {.smaller}
```{r}
x <- rnorm(200, 1, 2)
summary(x)
```

```{r, out.height="2in", out.width="2in", fig.align='center'}
hist(x)
```

## References
````


RStudio
File Edit Code View Plots Session Build Debug Tools Help
Go to file/function
Project: (None)
driver.R
doc.Rmd
doc.Rmd
Knit PDF
Run
Chunks
2 title: "Example Slides"
3 author: "Andrew R"
4 output: beamer_presentation
5 fontsize: 10pt
6 bibliography: references.bib
7 ---
8
9 ## R Markdown
10 This is a sample presentation using R Markdown, with R code knitted in.
11
12 - Draw a random sample from normal.
13 - Compute a summary.
14 - Plot a histogram.
15
16 See the book about knitr by @Xie2015.
17
18 ## Slide with R Code and Output {.smaller}
19 ```{r}
20 x <- rnorm(200, 1, 2)
21 summary(x)
22 ```
23
24 ```{r, out.height="2in", out.width="2in", fig.align='center'}
25 hist(x)
26 ```
27
28 ## References
8:1 (Top Level) R Markdown
Environment History
Import Dataset
List
Global Environment
Environment is empty
Files Plots Packages Help Viewer
Zoom
Export
Console R Markdown
/media/Data/araim/Documents/data-analysis/20160716-juliawang-cluster/

Example Slides

Andrew R

R Markdown

This is a sample presentation using R Markdown, with R code knitted in.

- Draw a random sample from normal.
- Compute a summary.
- Plot a histogram.

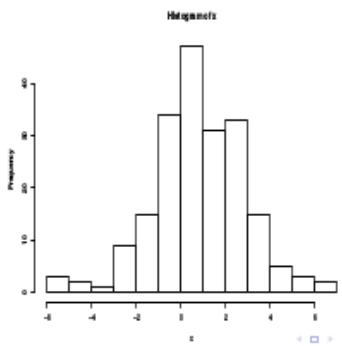
See the book about knitr by Xie (2015).

Slide with R Code and Output

```
x <- rnorm(200, 1, 2)
summary(x)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
## -5.6240 -0.2962  0.7280  0.8635  2.3890  6.3140
```

```
hist(x)
```



References

Xie, Yihui. 2015. *Dynamic Documents with R and Knitr*. 2nd ed. Chapman; Hall/CRC.

Shiny

Shiny

- Shiny (`http://shiny.rstudio.com`) is a web application framework for `R`.
- Develop and run applications in RStudio for yourself.
- Deploy applications to the web for public use.
  1. Via `http://www.shinyapps.io` hosting service.
  2. Or by deploying a Shiny Server.
- In-depth tutorials are available at `http://shiny.rstudio.com/tutorial`.

Beta-Binomial Distribution

- The Beta-Binomial (BB) distribution is an extension of Binomial which allows for extra variation.

- $Z \sim \text{Binomial}(m, p)$ measures the number of successes out of m independent success/failure trials, each having success probability p.

- Suppose

$$Y \sim \text{Binomial}(m, p)$$
$$p \sim \text{Beta}(\pi\rho^2(1-\rho^2), (1-\pi)\rho^2(1-\rho^2)),$$

  where $a = \pi(1-\rho^2)/\rho^2$ and $b = (1-\pi)(1-\rho^2)/\rho^2$.

- Marginally, $Y \overset{\text{iid}}{\sim} \text{BB}(\pi, \rho)$, with density

$$f(y \mid m, \pi, \rho) = \frac{\Gamma(m+1)}{\Gamma(y+1)\Gamma(m-y+1)} \frac{\Gamma(a+y)\Gamma(b+m-y)\Gamma(a+b)}{\Gamma(a+b+m)\Gamma(a)\Gamma(b)},$$

$$\text{E}(Y) = m\pi$$
$$\text{Var}(Y) = m\pi(1-\pi)\{1+\rho(m-1)\}$$

Beta-Binomial Shiny App

. . . Demonstration . . .

(See `betabin-shiny` subdirectory)

Dirichlet Distribution

- The Dirichlet distribution models probabilities $\boldsymbol{X} = (X_1, \ldots, X_k)$ that sum to 1 ("compositional data").
- It is an extension of the Beta distribution (where $k = 2$).
- We can write $\boldsymbol{X} \sim \text{Dirichlet}(\alpha_1, \ldots, \alpha_k)$, if data is drawn from Dirichlet with density

$$f(\boldsymbol{x}) = \frac{x_1^{\alpha_1 - 1} \cdots x_k^{\alpha_k - 1}}{B(\alpha_1, \ldots, \alpha_k)}, \boldsymbol{x} \in \mathcal{S}^k,$$

where

$$B(\alpha_1, \ldots, \alpha_k) = \frac{\Gamma(\alpha_1) \cdots \Gamma(\alpha_k)}{\Gamma(\alpha_1 + \cdots + \alpha_k)}$$

$$\mathcal{S}^k = \left\{ (x_1, \ldots, x_k) : x_j \in (0, 1), \sum_{j=1}^{k} x_j = 1 \right\}.$$

Shiny

Dirichlet Shiny App

. . . Demonstration . . .

(See `dirichlet-shiny` subdirectory)

References I