Lecture 6: Input and Output

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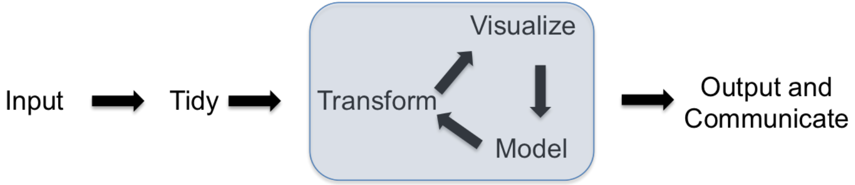
BSDS 100 - Intro to Data Science with R

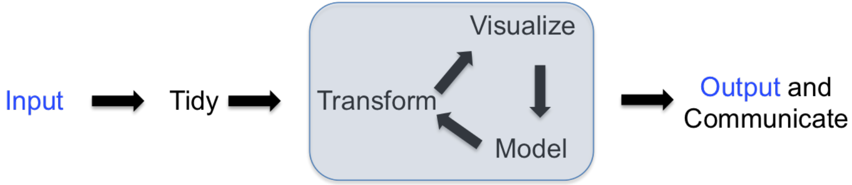
Outline

- Types of data
- Input
  - Tabular data files (.txt and .csv)
  - Irregular data files
  - Previously saved scripts and data files
- Output and Saving
  - Tabular data files
  - R data files
  - Images

The Flow of Data Science



Where are we now?



Data Basics

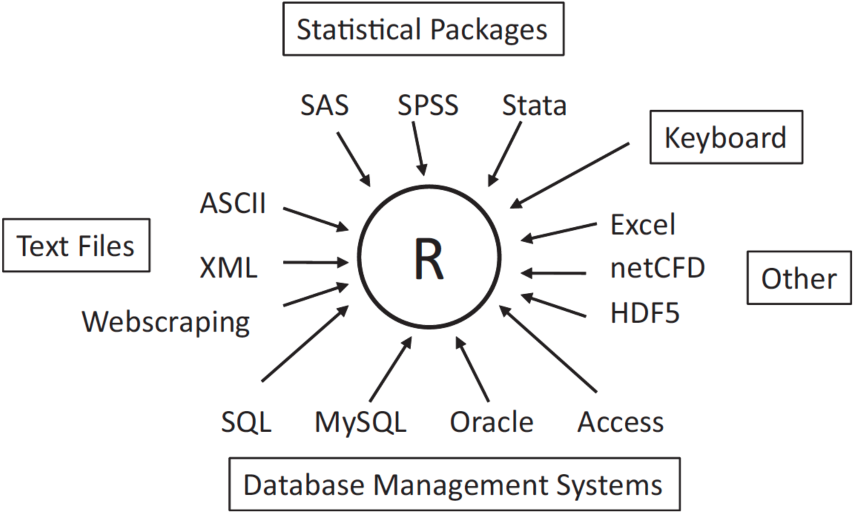
- "All statistical work begins with data, and most data is stuck inside files and databases. Dealing with input is probably the first step of implementing any significant statistical project" - R Cookbook

- "All statistical work ends with reporting numbers back to a client, even if you are the client. Formatting and producing output is probably the climax of your project" - R Cookbook

- "The data may not contain the answer. The combination of some data and an aching desire for an answer does not ensure that a reasonable answer can be extracted from a given body of data." - John Tukey

Part I: Types of Data

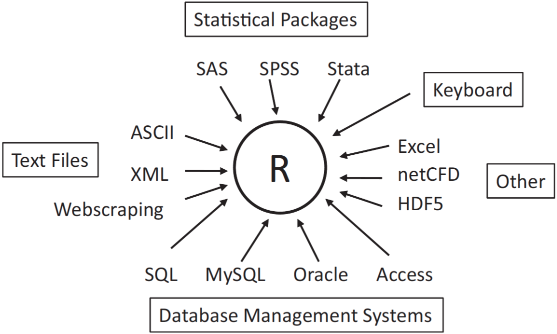
R can import from *many* sources



Data from the Keyboard

- Manual entry on the `R` console
- Only appropriate for *small* data sets
- Simplest data type - stored directy to memory
- This is what we've been doing so far this entire semester:

```
> midterm.grades <- c(85, 72, 90)
> measurement.1 <- c(1, 1.5, 0.25)
> class.stats <- data.frame(Grade = midterm.grades,
Measurement1 = measurement.1)
> class.stats
  Grade Measurement1
1    85         1.00
2    72         1.50
3    90         0.25
```



Everything else! Web files, text files, and software data files!

Text Files

- Also known as a .txt file
- Type of computer file that is structured as a sequence of lines of electronic text
- There are two types of computer files: .txt files and binary files
- Typically written using the ASCII character set (see here)
- Efficient storage, but not as efficient as binary files
- Easily interpretable

.csv Files

- Also known as a comma-separated values file
- Common form of data storage
- Special type of text file, where
  - Each line of the file is a data record
  - Each record consists of one or more fields, separated by commas
- Commas act to separate fields to ease readibility
- Commas are a type of delimeter - a sequence of one or more characters used to specify the boundary between separate regions in plain text or other data streams. There are others, including tab and " " delimeters.

.csv Files Example

Year	Make	Model	Price
1997	Ford	E350	3000.00
1999	Chevy	Camaro	5600.00
2002	Mitsubishi	Eclipse	5400.00

can be represented as

```
Year,Make,Model,Description,Price
1997,Ford,E350,3000.00
1999,Chevy,Camaro,5600.00
2002,Mitsubishi,Eclipse,5400.00
```

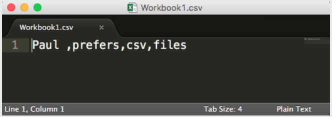
Note: You can save Excel files as .csv files (for easy input)

Why .csv Files?

Storage for four separate words "*Paul prefers csv files*"?

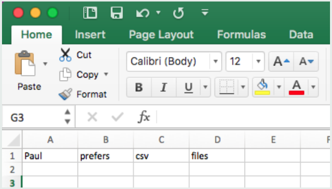
`csv` File (`.csv`)

`23 bytes`



Excel File v15 macOS (`.xlsx`)

`22,687 bytes`



.RData files

- You can save any combination of objects and functions in your current `R` workspace as an .RData file using the command:

```
save(object, file = "MyFile.RData")
```

- Later, you can then re-load that file using the command:

```
load("MyFile.RData")
```

- This is an incredibly useful way to save your work as you go, and for easy file transfer
- Issue: `R` objects require more memory than a .csv file or .txt file

.RData File Example

```
#create new data
> x <- c(2, 3, 5)
> y <- rep(seq(5, 20, by = 2), 2)
> current.dir <- getwd()
> setwd(dir = current.dir)

#save to file "my_first_data.RData"
> save(x, y, file = "my_first_data.RData")

#clear workspace
> rm(list = ls())

#load saved data
> load("my_first_data.RData")
```

Part II: Input

Importing Data

- As pointed out before, there are *many* types of data that we can import into `R`
- We will focus on a few basic types: .txt, .csv, fixed width data, irregular data, online data
- We'll delve more into input and output of images and text scraping later in the course

`read.table()`

- Perhaps the most flexible way to read a text-based file into `R`
- Can be used to read from .txt files, .csv files, and fixed width data
- `read.table()` also accepts URL addresses
- Once input, data is automatically stored as a `data.frame` object.

`read.table()`

- Default delimeter (seperator): `sep = ""` - white space, i.e., one or more spaces, tabs, newlines *or* carriage returns
- `sep` can be set to whatever separator the file uses, e.g., `sep = ","` for commas
- `header` argument: indicates whether the file has a header (`FALSE` by default)
- `colClasses` can be used to create classes for the columns
- There are *many* more options for `read.table()` that you should explore by reading the documentation

Variants of `read.table()`

- `read.csv()` is equivalent to `read.table()`, except the default separator is `sep = ","`
- `read.csv2()` is the equivalent of `read.table()`, but the default separator is `sep = ";"` and the default character assumed for decimal points is `dec = ","`

Variants of `read.table()`

- `read.delim()` is equivalent to `read.table()`, but the default separator is `sep = "\t"` (tab delimeter)
- `read.delim2()` is the equivalent of `read.table()`, but the default separator is `sep = "\t"` and the default character assumed for decimal points is `dec = ","`

Example: Airport Data

- View the database of US airports and locations here. What kind of delimeter is used here? Is there a header?
- Now, let's download this to our `R` console.

```
#Using read.table without header
> airports1 <- read.table(file = "https://raw.githubusercontent.com/
jdwilson4/Intro-Data-Science-2017/master/Data/airports.csv",
header = FALSE, sep = ",")

> airports1[1:2, 1:3]
V1                    V2                V3
1 iata               airport              city
2  00M              Thigpen       Bay Springs
```

Example: Airport Data

```
#Now add header
> airports2 <- airports <- read.table(file = "https://raw.githubuser
content.com/jdwilson4/Intro-Data-Science-2017/master/Data/airports.csv",
header = TRUE, sep = ",")
> airports2[1:2, 1:3]
  iata                airport            city
1  00M                Thigpen     Bay Springs
2  00R Livingston Municipal       Livingston

#Using read.csv
> airports3 <- read.csv(file = "https://raw.githubuser
content.com/jdwilson4/Intro-Data-Science-2017/master/Data/airports.csv",
header = TRUE)

> airports3[1:2, 1:3]
  iata                airport            city
1  00M                Thigpen     Bay Springs
2  00R Livingston Municipal       Livingston
```

Importing irregular datasets

- `read.table()` and its variants **require** perfectly rectangular data!
- In many cases, such as text documents, emails, etc., the data will **not** be rectangular.
- Try using `read.table()` on an email I received earlier this year here.

```
> email.trial <- read.table(file = "https://raw.githubuser
content.com/jdwilson4/Intro-Data-Science-2017/master/Data/USF_email.txt")

Error in scan(file, what, nmax, sep, dec, quote, skip, nlines,
na.strings,  : line 1 did not have 66 elements
```

`readLines()` function for irregular data

- The `readLines()` function is an incredibly simple function that reads lines from a file and returns them as a `list` of character strings.

- `n =` specifies the maximum number of lines to be read.

```
> email1 <- readLines("https://raw.githubusercontent.com/jdwilson4/
Intro-Data-Science-2017/master/Data/USF_email.txt")
> email1[1:3]
[1] "Dear James,"
[2] "From humble beginnings on the corner of Market and 4th Street,
we sure have come a long way and left our mark on the 19th, 20th,
and now 21st centuries. Generations of University of San Francisco
graduates have gone on to help build and inspire this unparalleled
city, this spectacular state, and the world we know. Now is your
chance to help USF go even farther."
[3] ""
```

`readLines()` function for irregular data

```
> email2 <- readLines("https://raw.githubusercontent.com/jdwilson4/
Intro-Data-Science-2017/master/Data/USF_email.txt", n = 2)
> email2
[1] "Dear James,"
[2] "From humble beginnings on the corner of Market and 4th Street,
we sure have come a long way and left our mark on the 19th, 20th,
and now 21st centuries. Generations of University of San Francisco
graduates have gone on to help build and inspire this unparalleled
city, this spectacular state, and the world we know. Now is your
chance to help USF go even farther."
```

`scan()` function for irregular data

- The `scan()` function is another useful function for irregular data, but much richer for data sets with particular structure.
- The idea here is to specify the argument `what`, which provides the type of entry expected in data set.
- Let's proceed by the two examples next.

`scan()` Example 1

Suppose you have a file named "singles.txt" that looks like this

```
2355.09 2246.73 1738.74 1841.01 2027.85
```

Then, we could run the following code to retrieve a `numeric` vector

```
> singles <- scan("singles.txt", what = numeric(0))
Read 5 items
> singles
[1] 2355.09 2246.73 1738.74 1841.01 2027.85
```

Above the option `what = numeric(0)` specifies that we expect numbers only in our sequence.

`scan()` Example 2

- A really nice feature of `scan()` is its ability to handle *repeating* sequences of **multiple data types** and efficiently sort them in a `list`.
- For example, suppose that we have a file called “triples.txt” that contains the three types of *repeating* data types:

```
15-Oct-87 2439.78 2345.63 16-Oct-87 2396.21 2,207.73
19-Oct-87 2164.16 1677.55 20-Oct-87 2067.47 1,616.21
21-Oct-87 2081.07 1951.76
```

`scan()` Example 2

- Then, we can run the following to tell the function that we expect repeating sequences of triples `character`, `numeric`, `numeric`

```
> triples <- scan("triples.txt", what = list(date = character(0),
high = numeric(0), low = numeric(0)))
Read 5 records
> triples
$date
[1] "15-Oct-87" "16-Oct-87" "19-Oct-87" "20-Oct-87" "21-Oct-87"

$high
[1] 2439.78 2396.21 2164.16 2067.47 2081.07

$low
[1] 2345.63 2207.73 1677.55 1616.21 1951.76
```

Part III: Output

Output to your Console

- In many cases, it is useful to output solutions to your `R` console
- To do this, you can use the `print()` or `cat()` functions

```
> name = "James D. Wilson"
> print(name)
[1] "James D. Wilson"

> cat("My name is", name, sep = " ")
My name is James D. Wilson
```

Redirecting output from the console to a file

- Often, you may want to output solutions directly to a file rather than in your console
- For this, you can use the `cat( , file = "myFile")`

```
#Create a document with "hello world" to your current directory
> cat("hello world", file = "my_doc.txt")

#Append new text to the "my_doc.txt" file
> cat("\n", "My name is James D. Wilson \n", file = "my_doc.txt",
append = TRUE)

#read what is on the document now
> readLines("my_doc.txt")
[1] "hello world"                  " My name is James D. Wilson "
```

Redirecting output from the console to a file

- Alternatively, you can call the `sink()` function to redirect **all** items pasted to the console.

```
> sink("my_doc2.txt") #begin redirecting output to document "my_doc2.txt"

> cat("hello world")

> cat("\n", "My name is James D. Wilson \n")

> sink() #end redirecting output

> readLines("my_doc2.txt")
[1] "hello world"                    " My name is James D. Wilson "
```

Saving Rectangular Output to a Data File

- Any rectangular `object` (`data.frame`, `vector`, `matrix`) that has been saved to your current workspace can be output to a .txt or .csv file using the `write.table(object, ...)` function!
- The arguments are similar to `read.table()`
- Also, there are similar variants of the function (`write.csv()`), (`write.xlsx()`), etc.

Example: Airport Data

```
#Input airport data
> airports3 <- read.csv(file = "https://raw.githubuser
content.com/jdwilson4/Intro-Data-Science-2017/master/Data/airports.csv",
header = TRUE)

#Modify to keep only the first 100 rows
> mod.airports <- airports3[1:100, ]

#Save the file to a .csv file for later use.
#And, get rid of the arbitray row numbers
> write.table(mod.airports, file = "Modified_airports.csv", sep = ",",
row.names = FALSE)

#store the file as an .RData file for later use
> save(mod.airports, file = "Modified_airports.RData")
```

Saving Images

- To save an image, one must first specify what type of file extension to save the image as, then create the plot, and finally finish with the statement `dev.off()`
- Some common file extensions include

Function	**Output to**
`pdf("mygraph.pdf")`	.pdf file
`png("mygraph.png")`	.png file
`jpeg("mygraph.jpg")`	.jpg file
`postscript("mygraph.ps")`	postscript file

Example: Airport Data

Let's plot the longitude against the latitude of each airport in the Airports data on github and save it as a .pdf file.

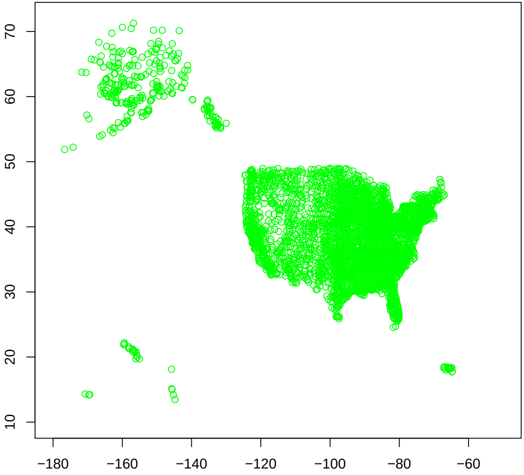
```
#Load the data
> airports <- read.csv(file = "https://raw.githubuser
content.com/jdwilson4/Intro-Data-Science-2017/master/Data/airports.csv",
header = TRUE)

#Save the plot to a .pdf file
> pdf("US_Airports.pdf")

> plot(airports$lat ~ airports$long, col = "green",
xlim = c(-180, -50), ylim = c(10, 72), xlab = "", ylab = "")

> dev.off()
RStudioGD
        2
```

The Resulting Plot



Assignment 8

- Complete the Computational Assignment here.

Due: Next Tuesday at the beginning of class.