Data Handling: Import, Cleaning and Visualisation

Lecture 7:

Data Sources, Data Gathering, Data Import

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Welcome back!

Updates

Part II: Data gathering and preparation

Date	Topic
12.11.20	Data sources, data gathering, data import
19.11.20	Data preparation and manipulation
19.11.20	Exercises/Workshop 4: Data import and data preparation/manipulation

Part III: Analysis, visualisation, output

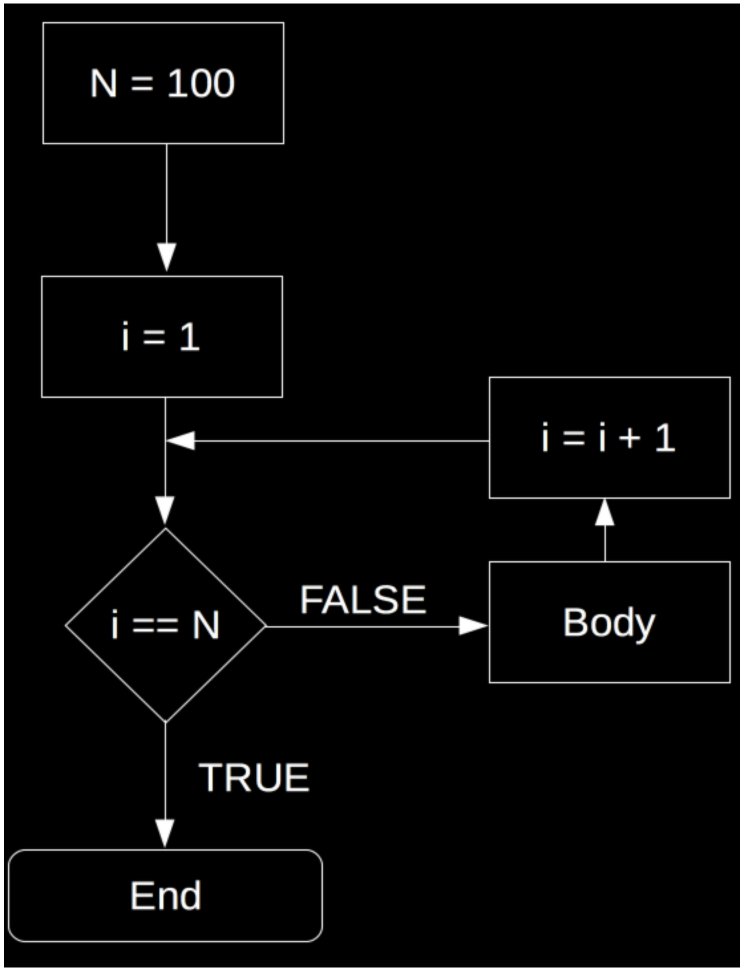
Date	Topic
26.11.20	Guest Lecture
03.12.20	Basic statistics and data analysis with R
03.12.20	Exercises/Workshop 5: Applied data analysis with R
10.12.20	Visualisation, dynamic documents
17.12.20	Summary, Wrap-Up, Q&A, Feedback
17.12.20	Exercises/Workshop 6: Visualization, dynamic documents
18.12.20	Exam for Exchange Students

Recap: Programming with Data

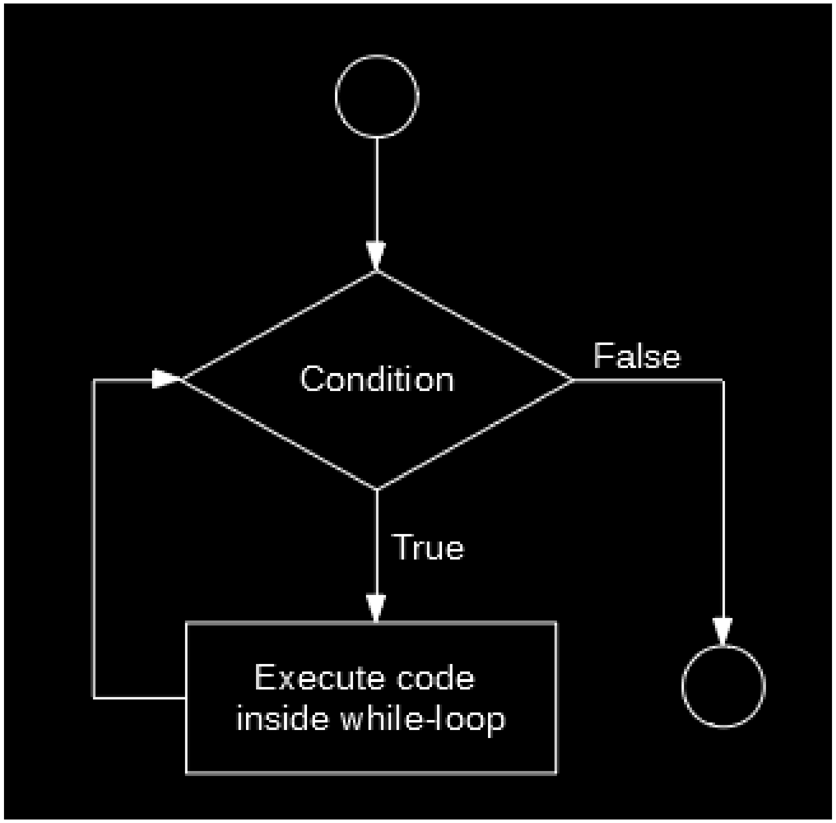
Loops

- Repeatedly execute a sequence of commands.
- Known or unknown number of iterations.
- Types: ‘for-loop’ and ‘while-loop’.
    - ‘for-loop’: number of iterations typically known.
    - ’while-loop: number of iterations typically not known.

for-loop



while-loop



Booleans and logical statements

```
2+2 == 4
```

```
## [1] TRUE
```

```
3+3 == 7
```

```
## [1] FALSE
```

```
4!=7
```

```
## [1] TRUE
```

Booleans and logical statements

```
condition <- TRUE

if (condition) {
     print("This is true!")
} else {
     print("This is false!")
}
```

```
## [1] "This is true!"
```

R functions

- $f : X \to Y$
- ‘Take a variable/parameter value X as input and provide value Y as output’
- For example, $2 \times X = Y$.
- R functions take ‘parameter values’ as input, process those values according to a predefined program, and ‘return’ the results.

R functions

```r
# define our own function to compute the mean, given a numeric vector
my_mean <- function(x) {
     x_bar <- sum(x) / length(x)
     return(x_bar)
}
```

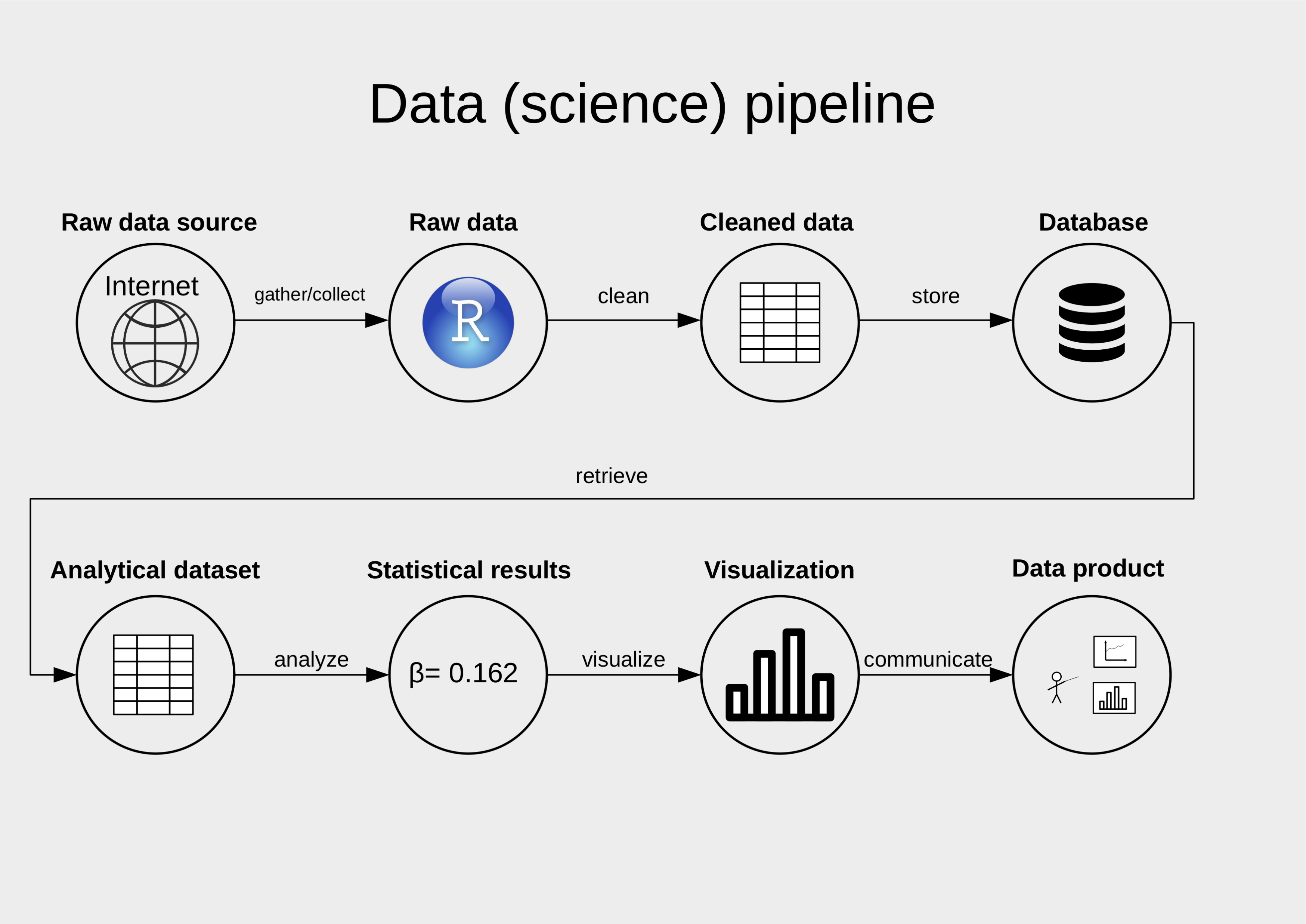
Today: Putting it All Together

Putting it all together

- You know what **'data'** is…
- You know how digital data is **stored**…
- You know how to write **computer code**…
- You know the basics of **programming in R**…

These are the basics to handel data properly!
This is the fundament of data science!

We are ready to start the data science journey



Sources/formats in economics

Sources/formats in economics

- CSV (typical for rectangular/table-like data)
- Variants of CSV (tab-delimited, fix length etc.)
- XML and JSON (useful for complex/high-dimensional data sets)
- HTML (a markup language to define the structure and layout of webpages)
- Unstructured text

Sources/formats in economics

- Excel spreadsheets (`.xls`)
- Formats specific to statistical software packages (SPSS: `.sav`, STATA: `.dat`, etc.)
- Built-in R datasets
- Binary formats

Data Gathering Procedure

Organize your data pipeline!

- One R script to gather/import data.
- The beginning of your data pipeline!

A Template/Blueprint

Tell your future self what this script is all about

```
#######################################################################
# Data Handling Course: Example Script for Data Gathering and Import
#
# Imports data from ...
# Input: links to data sources (data comes in ... format)
# Output: cleaned data as CSV
#
# U. Matter, St. Gallen, 2018
#######################################################################
```

Script sections

- Recall: programming tasks can often be split into smaller tasks.
- Use sections to implement task-by-task and keep order.
- In RStudio: Use `----------` to indicate the beginning of sections.
- Start with a ‘meta’-section.

Script sections

```r
#######################################################################
# Data Handling Course: Example Script for Data Gathering and Import
#
# Imports data from ...
# Input: links to data sources (data comes in ... format)
# Output: cleaned data as CSV
#
# U. Matter, St. Gallen, 2018
#######################################################################


# SET UP --------------
# load packages
library(tidyverse)

# set fix variables
INPUT_PATH <- "/rawdata"
OUTPUT_FILE <- "/final_data/datafile.csv"
```

Script sections

Finally we add sections with the actual code (in the case of a data import script, maybe one section per data source)

```
#######################################################################
# Project XY: Data Gathering and Import
#
# This script is the first part of the data pipeline of project XY.
# It imports data from ...
# Input: links to data sources (data comes in ... format)
# Output: cleaned data as CSV
#
# U. Matter, St. Gallen, 2018
#######################################################################


# SET UP --------------
# load packages
library(tidyverse)

# set fix variables
INPUT_PATH <- "/rawdata"
OUTPUT_FILE <- "/final_data/datafile.csv"


# IMPORT RAW DATA FROM CSVs -------------
```

Loading/Importing Rectangular Data

Loading built-in datasets

In order to load such datasets, simply use the `data()`-function:

```
data(swiss)
```

Inspect the data after loading

```
# inspect the structure
str(swiss)
```

```
## 'data.frame':    47 obs. of  6 variables:
##  $ Fertility       : num  80.2 83.1 92.5 85.8 76.9 76.1 83.8 92.4 82.4 82.9 ...
##  $ Agriculture     : num  17 45.1 39.7 36.5 43.5 35.3 70.2 67.8 53.3 45.2 ...
##  $ Examination     : int  15 6 5 12 17 9 16 14 12 16 ...
##  $ Education       : int  12 9 5 7 15 7 7 8 7 13 ...
##  $ Catholic        : num  9.96 84.84 93.4 33.77 5.16 ...
##  $ Infant.Mortality: num  22.2 22.2 20.2 20.3 20.6 26.6 23.6 24.9 21 24.4 ...
```

```
# look at the first few rows
head(swiss)
```

```
##              Fertility Agriculture Examination Education Catholic Infant.Mortality
## Courtelary        80.2        17.0          15        12     9.96             22.2
## Delemont          83.1        45.1           6         9    84.84             22.2
## Franches-Mnt      92.5        39.7           5         5    93.40             20.2
## Moutier           85.8        36.5          12         7    33.77             20.3
## Neuveville        76.9        43.5          17        15     5.16             20.6
## Porrentruy        76.1        35.3           9         7    90.57             26.6
```

Importing Rectangular Data from Text-Files

Comma Separated Values (CSV)

The `swiss`-dataset would look like this when stored in a CSV:

```
"District","Fertility","Agriculture","Examination","Education","Catholic","Infant.Mor
"Courtelary",80.2,17,15,12,9.96,22.2
```

What do we need to read this format properly?

Parsing CSVs in R

- `read.csv()` (basic R distribution)
- Returns a `data.frame`

```
swiss_imported <- read.csv("data/swiss.csv")
```

Parsing CSVs in R

- Alternative: `read_csv()` (`readr`/`tidyr`-package)
- Returns a `tibble`.
- Used in Wickham and Grolemund (2017).

```
##
## Attaching package: 'readr'


## The following object is masked from 'package:rvest':
##
##     guess_encoding


## Parsed with column specification:
## cols(
##   District = col_character(),
##   Fertility = col_double(),
##   Agriculture = col_double(),
##   Examination = col_double(),
##   Education = col_double(),
##   Catholic = col_double(),
##   Infant.Mortality = col_double()
## )
```

```
swiss_imported <- read_csv("data/swiss.csv")
```

Import and parsing with `readr`

- Why `readr`?
  - Functions for all common rectangular data formats.
  - Consistent syntax.
  - More robust and faster than similar functions in basic R.
- Alternative: The `data.table`-package (handling large datasets).

Basic usage of `readr` functions

Parse the first lines of the swiss dataset directly like this…

```
library(readr)

read_csv('"District","Fertility","Agriculture","Examination","Education","Catholic","
"Courtelary",80.2,17,15,12,9.96,22.2')
```

```
## # A tibble: 1 x 7
##   District   Fertility Agriculture Examination Education Catholic Infant.Mortality
##   <chr>          <dbl>       <dbl>       <dbl>     <dbl>    <dbl>            <dbl>
## 1 Courtelary      80.2          17          15        12     9.96             22.2
```

or read the entire `swiss` dataset by pointing to the file

```
swiss <- read_csv("data/swiss.csv")
```

```
## Parsed with column specification:
## cols(
##   District = col_character(),
##   Fertility = col_double(),
##   Agriculture = col_double(),
##   Examination = col_double(),
##   Education = col_double(),
##   Catholic = col_double(),
```

Basic usage of `readr` functions

In either case, the result is a `tibble`:

```
swiss
```

```
## # A tibble: 47 x 7
##    District     Fertility Agriculture Examination Education Catholic Infant.Mortal
##    <chr>            <dbl>       <dbl>       <dbl>     <dbl>    <dbl>            <d
##  1 Courtelary        80.2        17            15        12     9.96             2
##  2 Delemont          83.1        45.1           6         9    84.8              2
##  3 Franches-Mnt      92.5        39.7           5         5    93.4              2
##  4 Moutier           85.8        36.5          12         7    33.8              2
##  5 Neuveville        76.9        43.5          17        15     5.16             2
##  6 Porrentruy        76.1        35.3           9         7    90.6              2
##  7 Broye             83.8        70.2          16         7    92.8              2
##  8 Glane             92.4        67.8          14         8    97.2              2
##  9 Gruyere           82.4        53.3          12         7    97.7              2
## 10 Sarine            82.9        45.2          16        13    91.4              2
## # … with 37 more rows
```

Basic usage of `readr` functions

- Other `readr` functions have practically the same syntax and behavior.
  - `read_tsv()` (tab-separated)
  - `read_fwf()` (fixed-width)
  - …

Parsing CSVs

Recognizing columns and rows is one thing…

```
swiss
```

```
## # A tibble: 47 x 7
##    District     Fertility Agriculture Examination Education Catholic Infant.Mortal
##    <chr>             <dbl>       <dbl>       <dbl>     <dbl>    <dbl>           <c
##  1 Courtelary         80.2       17            15        12     9.96             2
##  2 Delemont           83.1       45.1           6         9    84.8              2
##  3 Franches-Mnt       92.5       39.7           5         5    93.4              2
##  4 Moutier            85.8       36.5          12         7    33.8              2
##  5 Neuveville         76.9       43.5          17        15     5.16             2
##  6 Porrentruy         76.1       35.3           9         7    90.6              2
##  7 Broye              83.8       70.2          16         7    92.8              2
##  8 Glane              92.4       67.8          14         8    97.2              2
##  9 Gruyere            82.4       53.3          12         7    97.7              2
## 10 Sarine             82.9       45.2          16        13    91.4              2
## # … with 37 more rows
```

What else did `read_csv()` recognize?

Parsing CSVs

- Recall the introduction to data structures and data types in R
- How does R represent data in RAM
  - **Structure**: `data.frame`/`tibble`, etc.
  - **Types**: `character`, `numeric`, etc.
- Parsers in `read_csv()` guess the data **types**.

Parsing CSV-columns

- `"12:00"`: type `character`?

Parsing CSV-columns

- `"12:00"`: type `character`?
- What about `c("12:00", "midnight", "noon")`?

Parsing CSV-columns

- `"12:00"`: type `character`?
- What about `c("12:00", "midnight", "noon")`?
- And now `c("12:00", "14:30", "20:01")`?

Parsing CSV-columns

Let’s test it!

```
read_csv('A,B
         12:00, 12:00
         14:30, midnight
         20:01, noon')
```

```
## # A tibble: 3 x 2
##   A      B
##   <time> <chr>
## 1 12:00  12:00
## 2 14:30  midnight
## 3 20:01  noon
```

Parsing CSV-columns

Let’s test it!

```
read_csv('A,B
         12:00, 12:00
         14:30, midnight
         20:01, noon')
```

```
## # A tibble: 3 x 2
##   A      B
##   <time> <chr>
## 1 12:00  12:00
## 2 14:30  midnight
## 3 20:01  noon
```

How can `read_csv()` distinguish the two cases?

Parsing CSV-columns: guess types

Under the hood `read_csv()` used the `guess_parser()`- function to determine which type the two vectors likely contain:

```
guess_parser(c("12:00", "midnight", "noon"))
```

```
## [1] "character"
```

```
guess_parser(c("12:00", "14:30", "20:01"))
```

```
## [1] "time"
```

Other Common Rectangular Formats

Spreadsheets/Excel

Needs additional R-package: `readxl`.

```r
# install the package
install.packages("readxl")
```

Spreadsheets/Excel

Then we load this additional package (‘library’) and use the package’s `read_excel()`-function to import data from an excel-sheet.

```r
# load the package
library(readxl)

# import data from a spreadsheet
swiss_imported <- read_excel("data/swiss.xlsx")
```

Data from other data analysis software

- STATA, SPSS, etc.
- Additional packages needed:
  - `foreign`
  - `haven`
- Parsers (functions) for many foreign formats.
  - For example, `read_spss()` for SPSS' `.sav`-format.

Data from other data analysis software

```r
# install the package (if not yet installed):
# install.packages("haven")

# load the package
library(haven)

# read the data
swiss_imported <- read_spss("data/swiss.sav")
```

Importing Web Data Formats

XML in R

```
## {xml_document}
## <customers>
## [1] <person>\n  <name>John Doe</name>\n  <orders>\n    <product> x </product>\n
## [2] <person>\n  <name>Peter Pan</name>\n  <orders>\n    <product> a </product>\n
```

```r
# load packages
library(xml2)

# parse XML, represent XML document as R object
xml_doc <- read_xml("../../data/customers.xml")
xml_doc
```

XML in R: tree-structure

‘customers’ is the root-node, ‘persons’ are it’s children:

```
# navigate downwards
persons <- xml_children(xml_doc)
persons
```

```
## {xml_nodeset (2)}
## [1] <person>\n  <name>John Doe</name>\n  <orders>\n    <product> x </product>\n
## [2] <person>\n  <name>Peter Pan</name>\n  <orders>\n    <product> a </product>\n
```

```
# navigate sidewards
xml_siblings(persons)
```

```
## {xml_nodeset (2)}
## [1] <person>\n  <name>Peter Pan</name>\n  <orders>\n    <product> a </product>\n
## [2] <person>\n  <name>John Doe</name>\n  <orders>\n    <product> x </product>\n
```

```
# navigate upwards
xml_parents(persons)
```

```
## {xml_nodeset (1)}
## [1] <customers>\n  <person>\n    <name>John Doe</name>\n    <orders>\n      <produ
```

XML in R: tree-structure

Navigate sidewards and upwards

```
# navigate sidewards
xml_siblings(persons)
```

```
## {xml_nodeset (2)}
## [1] <person>\n  <name>Peter Pan</name>\n  <orders>\n    <product> a </product>\n
## [2] <person>\n  <name>John Doe</name>\n  <orders>\n    <product> x </product>\n
```

```
# navigate upwards
xml_parents(persons)
```

```
## {xml_nodeset (1)}
## [1] <customers>\n  <person>\n    <name>John Doe</name>\n    <orders>\n      <produ
```

XML in R: tree-structure

Extract specific parts of the data:

```
# find data via XPath
customer_names <- xml_find_all(xml_doc, xpath = ".//name")
# extract the data as text
xml_text(customer_names)
```

```
## [1] "John Doe"  "Peter Pan"
```

JSON in R

```
## List of 6
##  $ firstName  : chr "John"
##  $ lastName   : chr "Smith"
##  $ age        : int 25
##  $ address    :List of 4
##   ..$ streetAddress: chr "21 2nd Street"
##   ..$ city         : chr "New York"
##   ..$ state        : chr "NY"
##   ..$ postalCode   : chr "10021"
##  $ phoneNumber:'data.frame': 2 obs. of  2 variables:
##   ..$ type  : chr [1:2] "home" "fax"
##   ..$ number: chr [1:2] "212 555-1234" "646 555-4567"
##  $ gender     :List of 1
##   ..$ type: chr "male"
```

```
# load packages
library(jsonlite)

# parse the JSON-document shown in the example above
json_doc <- fromJSON("../../data/person.json")

# look at the structure of the document
str(json_doc)
```

JSON in R

The nesting structure is represented as a **nested list**:

```
# navigate the nested lists, extract data
# extract the address part
json_doc$address
```

```
## $streetAddress
## [1] "21 2nd Street"
##
## $city
## [1] "New York"
##
## $state
## [1] "NY"
##
## $postalCode
## [1] "10021"
```

```
# extract the gender (type)
json_doc$gender$type
```

```
## [1] "male"
```

Q&A

References

Wickham, Hadley, and Garrett Grolemund. 2017. Sebastopol, CA: O’Reilly. http://r4ds.had.co.nz/.