Introduction to data cleaning in

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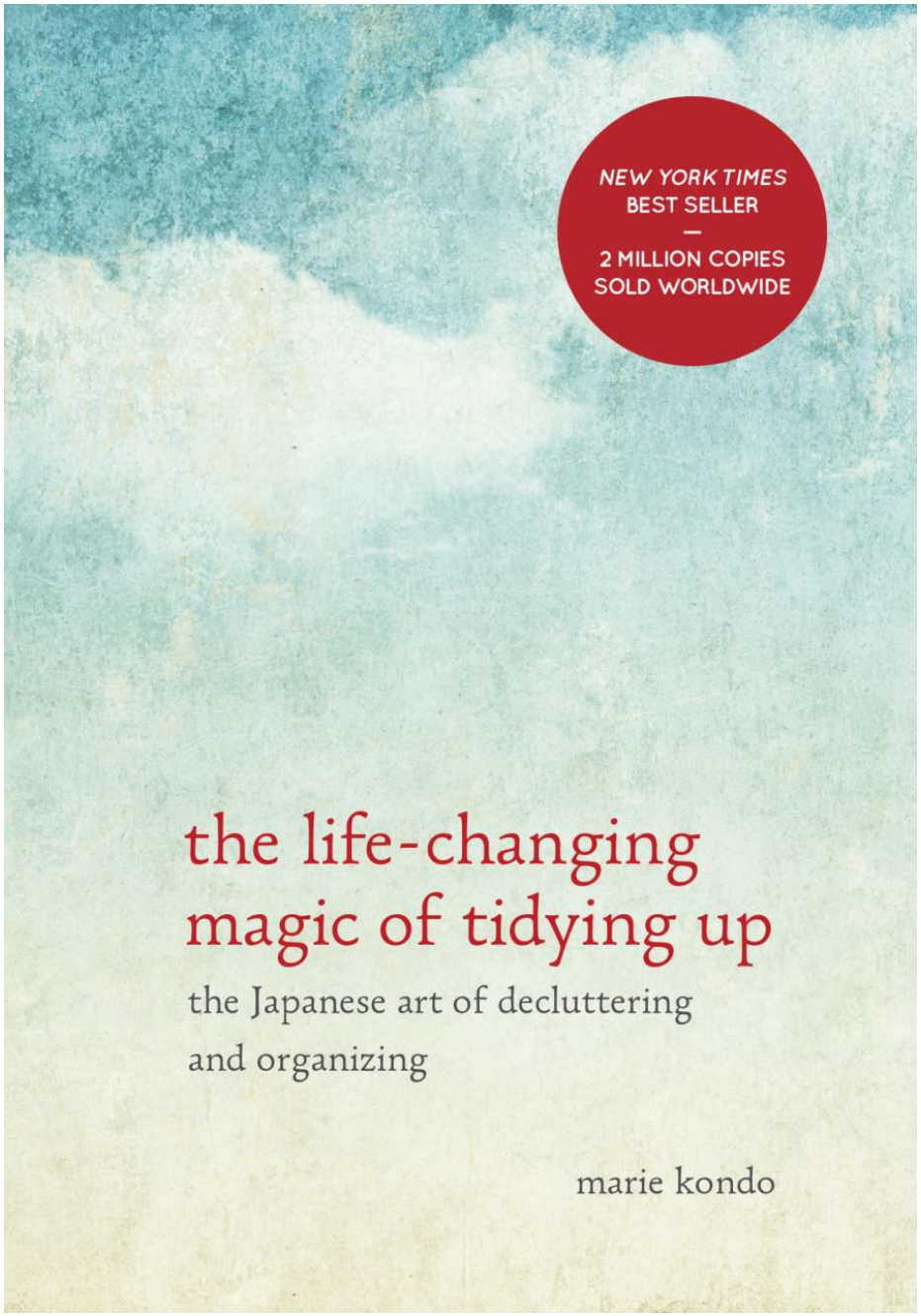
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the life-changing
magic of tidying up
the Japanese art of decluttering
and organizing
marie kondo

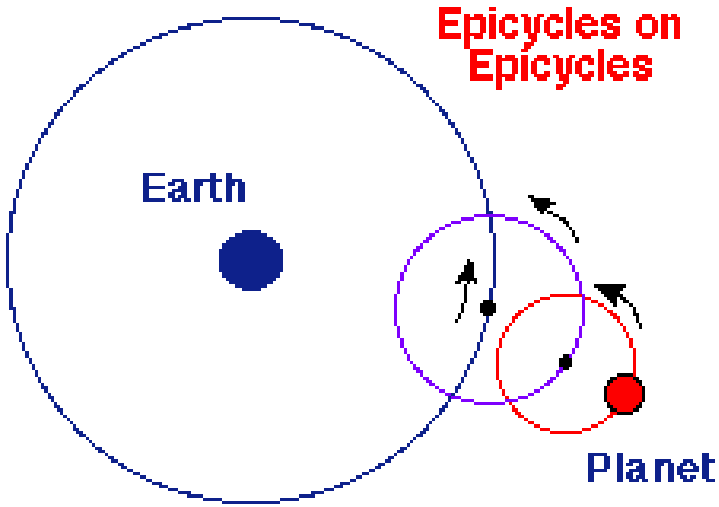
Names for the early steps of “Data Science”

- Data *munging*
- Data *wrangling*
- Web *scraping*
- Data *pulling*
- *Pre-processing*
- Data *cleansing*
- Data *harmonising*
- Data *cleaning*

- *https://www.datacamp.com/community/blog/an-introduction-to-cleaning-data-in-r*

Epicycle of Analysis (*Art of Data Science*, Peng)

- There are 5 core activities of data analysis:
  - Stating and refining the question
  - Exploring the data (EDA)
  - Building formal statistical models
  - Interpreting the results
  - Communicating the results



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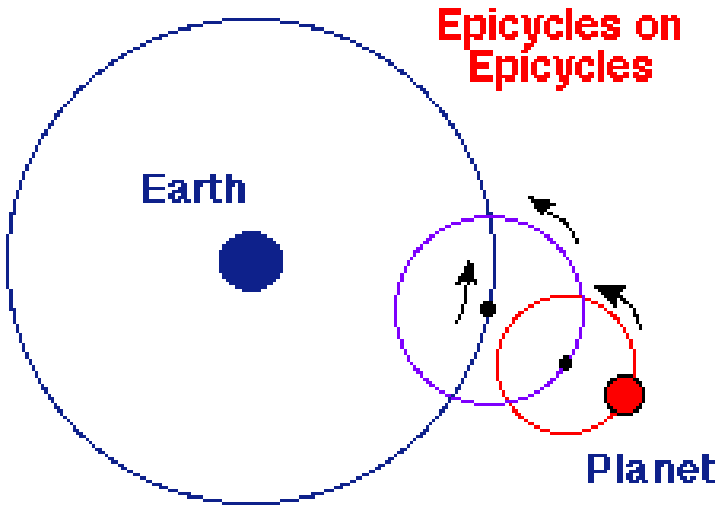


EDA

- *"There are no routine statistical questions, only questionable statistical routines."*—Sir David Cox

- *"Far better an approximate answer to the right question, which is often vague, than an exact answer to the wrong question, which can always be made precise."*—John Tukey

Exploratory Data Analysis

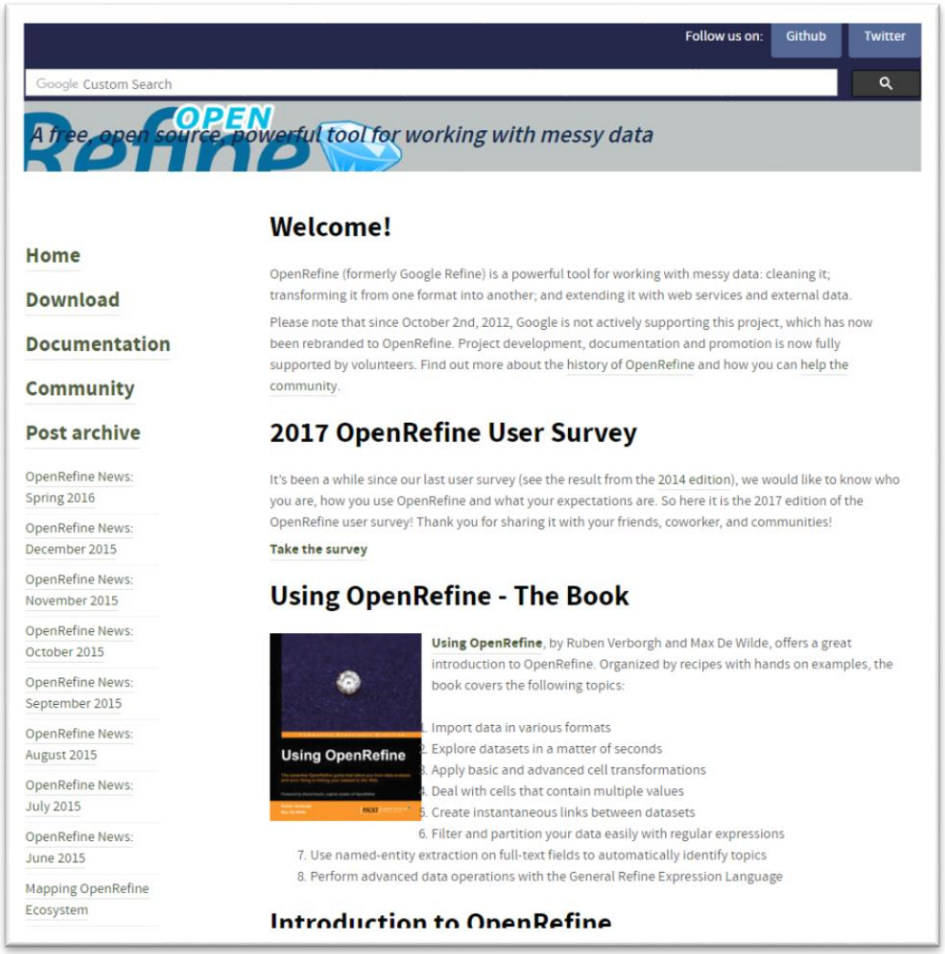
- (From *Art of Data Science*) Formulate your question:
  - Read in your data
  - Look at the top and the bottom of your data
  - Check your "n"s
  - Validate (with at least one external data source)
  - Make a plot
  - Try the *easy* solution first
  - Follow up…

“Mise en place”!

```
rm(list=ls())
getwd()
setwd("<location of your dataset>")
```

- `.Rpofile`: file for customising start-up

OpenRefine



- https://github.com/OpenRefine/OpenRefine/wiki/Documentation-For-Users

Validation

- Check basic characteristics
- Validate with another (external) data source if possible
- Make a simple plot (boxplot, (paired) scatter plot,…)

Reading data from GitHub

```
library(readr)


conception <-
read_csv("https://raw.githubuser
content.com/n8thangreen/ONS/mast
er/conception-under18.csv")
View(conception)
```

Validation type	How it works	Example
Check digit	The last couple of digits can be used as a 'check sum' that can detect if errors have occurred	Bar code readers in shops
Type check	Checks the data is in the right format	Numbers in currency cell must be a monetary value with two decimal points
Length check	Checks the data is an acceptable length	A PIN for online banking needs to be four (or six) characters long
Lookup table	Checks that the value provided matches an item in a set list	A limited set of values, such as the seven days of the week
Presence check	Checks that data has been entered into a field	In most databases a key field cannot be left blank
Range check	Checks that a value falls within the specified range	An online gift certificate purchase must be more than or equal to £5 but less than or equal to £50
Spell check	Looks up words in a dictionary	A search engine often recommends a correct spelling if a word is spelt wrong
Input mask	Checks that data has been entered with the correct amount of characters and/or numbers	National insurance numbers need to be in the format: YY XX XX XX Y, where Y = letter and X = number
Duplicate	Checks that a value has not been repeated	A primary key value can only be entered once

http://www.bbc.co.uk/education/guides/

Variables types and indexing

- `numeric` Numeric data (approximations of the real numbers, $\mathbb{R}$)
- `integer` Integer data (whole numbers, $\mathbb{Z}$)
- `factor` Categorical data (simple classifications, like gender)
- `ordered` Ordinal data (ordered classifications, like educational level)
- `character` Character data (strings)
- `raw` Binary data

```
typeof()  # what is it?
length()  # how long is it? What about two
dimensional objects?
attributes()  # does it have any metadata?

# Example

x <- "dataset"
typeof(x)
attributes(x)

y <- 1:10
typeof(y)
length(y)
attributes(y)

z <- c(1L, 2L, 3L)
typeof(z)
```

Useful functions

- `head()` – see first 6 rows
- `tail()` – see last 6 rows
- `dim()` – see dimensions
- `nrow()` – number of rows
- `ncol()` – number of columns
- `str()` – structure of each column
- `names()` – will list the names attribute for a data frame (or any object really), which gives the column names.
- `table()`
- `unique(); duplicated()`

String normalisation

```
library(stringr)
str_trim(" hello world ")
## [1] "hello world"
str_trim(" hello world ", side = "left")
## [1] "hello world "
str_trim(" hello world ", side = "right")
## [1] " hello world"

toupper("Hello world")
## [1] "HELLO WORLD"
tolower("Hello World")
## [1] "hello world"
```

String matching (regular expressions)

```
gender <- c("M", "male ", "Female",
"fem.")
grepl("m", gender)
## [1] FALSE TRUE TRUE TRUE
grep("m", gender)
## [1] 2 3 4
grepl("m", gender, ignore.case = TRUE)
## [1] TRUE TRUE TRUE TRUE
grepl("m", tolower(gender))
## [1] TRUE TRUE TRUE TRUE
grepl("^m", gender, ignore.case = TRUE) ##
[1] TRUE TRUE FALSE FALSE
```

Running example

```
library("stringr", lib.loc="~/R/win-library/3.2")

conception$Name
conception$Name <- str_trim(conception$Name)
conception$Name <- gsub(pattern = " UA", replacement
= "", conception$Name)
```

Consistent data

- Missing values

```
age <- c(23, 16, NA)
mean(age)
## [1] NA
mean(age, na.rm = TRUE)
## [1] 19.5
```

- Checks
  - `is.na()`
  - `is.nan()`
  - `na.omit()`
  - `complete.cases(x)`

Running example

```
apply(conception, 2, function(x) any(is.na(x)))

data$Name <- toupper(conception$Name)

chartr(“AIai", "@!@!", conception$Name)
```

- Outliers
  - What's realistic? Permissible (integrity)?

    (*Outliers: An Evaluation of Methodologies*, Dhiren Ghosh, Andrew Vogt, https://www.amstat.org/sections/srms/proceedings/y2012/files/304068_72402.pdf)

- What to do?
  - Imputation: substitution mean, logistic regression prediction, matching
  - Truncation, removal, Winsorising, scaling, judgement

Subsetting

```
X[1]
x[-c(1, 5)]
x[c(TRUE, TRUE, FALSE, FALSE)]
x[which(x > 3)]
z[c("a", "d")]

df <- data.frame(x=1:3, y=3:1, z=letters[1:3])
df[df$x == 2, ]
```

The `apply()` family

- `lapply()`
  - Loop over a list and evaluate a function on each element
- `sapply()`
  - Same as `lapply` but try to simplify the result
- `apply()`
  - Apply a function over the margins of an array
- `tapply()`
  - Apply a function over subsets of a vector
- `mapply()`
  - Multivariate version of `lapply`

Examples

```
x <- matrix(rnorm(200), 20, 10)
apply(x, 2, mean)

x <- list(a = 1:5, b = rnorm(10))
lapply(x, mean)
sapply(x, mean)

x <- c(rnorm(10), runif(10), rnorm(10, 1))
f <- gl(3, 10)
tapply(x, f, mean)

rowSums = apply(x, 1, sum)
rowMeans = apply(x, 1, mean)
colSums = apply(x, 2, sum)
colMeans = apply(x, 2, mean)
```

“Tidy” data

- *Happy families are all alike; every unhappy family is unhappy in its own way* [Leo Tolstoy]

- A dataset is said to be *tidy* if it satisfies the following conditions
  - observations are in rows
  - variables are in columns
  - contained in a single dataset.

TB incidence data

```
tb <- read.csv(file =
"http://stat405.had.co.nz/data/tb.csv",
header = TRUE, stringsAsFactors = FALSE)
```

- Except for `iso2` and `year`, the rest of the columns headers are actually values of a lurking variable, in fact combination of two lurking variables, `gender` and `age`.)

Reshape(2)

- Create categorical values

```
data$zipGroups <-
cut(data$zipCode,breaks=quantile(data$zipCode))

install.packages("Hmisc")
library(Hmisc)

data$zipGroups <- cut2(data$zipCode, g=4)
table(data$zipGroups)
```

Transformations

- absolute value
  `abs(x)`
- square root
  `sqrt(x)`
- ceiling(3.4) is 4
  `ceiling(x)`
- floor(3.4) is 3
  `floor(x)`
- rounding
  `round(x, digits=n)`
- signif(3.475, digits=2) is 3.5
  `signif(x, digits=n)`
- natural logarithm
  `log(x)`
- exponentiating x
  `exp(x)`

*useful for table formatting

Sorting

```
data <- data.frame( "column1"=sample(1:5),
"column2"=sample(6:10), "column3"=sample(11:15))

data <- data[sample(1:5),]

data$column2[c(1,3)]<-NA

sort(data$column1, decreasing=FALSE)

sort(data$column2, decreasing=FALSE, na.last=TRUE)
data[order(data$column1),]
```

Running example

```
conception <- conception[order(conception$Name),]

conception <- within(conception, new <- `Number of
Conceptions`*2)

conception <- conception[order(conception
$`Conception rate per 1,000 women in age group`),]

conception <- conception[order(conception
$`Conception rate per 1,000 women in age group`,
decreasing = T),]
```