



Exercise 2: Programming & Algorithms

Exercise 2 for the lecture 'Foundations of Data Science'

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This session covers

- Regular expressions
- Manipulation of text data
- Data processing & cleaning



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Data processing & cleaning



Data processing & cleaning

- To make data machine readable, we often need to convert it to another format or extract only features we are interested in.
- Many ways to save and store data
- Overview:
 - HTML and XML
 - JSON



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HTML (Hyper Text Markup Language)

```
<!DOCTYPE html>
<html>
  <head>
    <title>Page Title</title>
  </head>
  <body>
    <h1>This is a Heading</h1>
    <p>This is a paragraph.</p>
  </body>
</html>
```



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HTML (Hyper Text Markup Language)

- Start tags `<title>` and end tags `</title>` indicate elements
- Elements have attributes: e.g. `<title id= "a"> ... </title>` has the attribute `id="a"`
- Every website is built in HTML. HTML files can be displayed by your browser. Can be inspected by right clicking in your browser.

Workflow in R:

- Download page and parse to an XML-file format in R with the **rvest** and **xml2** package (they are very similar). Both have a function named **read_html()**. Then use functions of both packages to inspect data.



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XML (Extensible Markup Language)

```
<menu id="file" value="File">
  <popup>
    <menuitem value="New" onclick="CreateNewDoc()" />
    <menuitem value="Open" onclick="OpenDoc()" />
    <menuitem value="Close" onclick="CloseDoc()" />
  </popup>
</menu>
```



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XML (Extensible Markup Language)

- Used to store data (not for visualization as compared to HTML)
- Used to exchange information between web services (e.g. apps)
- Very flexible and highly customizable

Workflow in R:

- Download data and parse it into R with the **xml2** package (**read_xml()**)
- Useful functions to inspect and extract information:
 - **xml_nodes**: to get the nodes of a file.
 - **xml_names**: to retrieve the names of the nodes
 - **xml_children**: to get the content of a node.
 - **xml_text**: to transform the content into text.



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JSON (JavaScript Object Notation)

```
{ "menu": {  
  "id": "file",  
  "value": "File",  
  "popup": {  
    "menuitem": [  
      { "value": "New", "onclick": "CreateNewDoc()" },  
      { "value": "Open", "onclick": "OpenDoc()" },  
      { "value": "Close", "onclick": "CloseDoc()" }  
    ]  
  }  
}}
```



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JSON (JavaScript Object Notation)

- Also used to store data
- More popular (especially for APIs)
- Less flexible than XML, more standardized
- Workflow in R:
 - Download data and parse it into R with the **jsonlite** package (**fromJSON()**)
 - If there aren't any encoding problems the package should already convert the data to a `data.frame`.



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Text manipulation in R



String manipulation

- Concatenate text with **paste**:

```
> (text <- paste("Demonstration of", "text manipulation."))
"Demonstration of text manipulation."
> (text <- paste("Demonstration of", "text manipulation.", sep = "-"))
"Demonstration of-text manipulation."
```

- Concatenate text and vectors with **paste**:

```
> abc <- c("a", "b", "c")
> paste("Option", abc, collapse=", ")
"Option a, Option b, Option c"
```



String manipulation

- Split strings with **strsplit**:

```
> strsplit("2020-02-11", split="-")  
"2020" "02" "11"
```

- Extract parts of a string with **substr**:

```
> substr("Rabarberrabarberrabarber", start=1, stop=8)  
"Rabarber"
```

String manipulation

- Detect a pattern in text with **grep** or the **stringr** - package

```
> grepl(pattern = "prize", "Somewhere I've hidden a prize in this sentence.")
```

TRUE

(returns whether a hit or not)

```
> grep(pattern = "prize", c("Somewhere I've hidden a prize and another prize",  
                           "But not in this one",  
                           "But there is a prize in this one."))
```

1 3

(returns positions of hits)

```
> stringr::str_extract(string="Somewhere I've hidden a prize and another prize.",  
                       pattern = "prize")
```

"prize"

(returns first match)

```
> stringr::str_extract_all(string="Somewhere I've hidden a prize and another prize",  
                          pattern = "prize")
```

"prize" "prize"

(returns all matches)



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Regular expressions



Regular expressions

- What if we want to extract or detect features more generally?

E.g. what would you do if you want to extract all the first names from such a text?

```
> text <- "Abou-Chadi Tarik AFL-H-359 +41 44 634 52 03Caramani Daniele AFL-H-344  
+41 44 634 40 10Donnay Karsten AFL-H-350 +41 44 634 58 57"
```

```
> unlist(stringr::str_extract_all(string = text,  
                                pattern = "[A-Z]{1}[a-z]+ [A-Z]{1}[a-z]+"))
```

```
"Chadi Tarik" "Caramani Daniele" "Donnay Karsten"
```

Regular expressions were the solution here!

- Formal language used in programming
- General pattern that matches text
- Cross-platform
- Can be used to clean text data or extract text features of interest



Regular expressions

- `[:punct:]`: punctuation.
- `[:alpha:]`: letters.
- `[:lower:]`: lowercase letters.
- `[:upper:]`: upperclass letters.
- `[:digit:]`: digits.
- `[:xdigit:]`: hex digits.
- `[:alnum:]`: letters and numbers.
- `[:cntrl:]`: control characters.
- `[:graph:]`: letters, numbers, and punctuation.
- `[:print:]`: letters, numbers, punctuation, and whitespace.
- `[:space:]`: space characters (basically equivalent to `\s`).
- `[:blank:]`: space and tab.
- `[abc]`: matches a, b, or c.
- `[a-z]`: matches every character between a and z (in Unicode code point order).
- `[^abc]`: matches anything except a, b, or c.
- `[\^ \-]`: matches ^ or -



Regular expressions

- Grouping
- Anchors
- Repetition

Parentheses define a group

```
> str_extract(c("grey", "gray"), "gre|ay")  
"gre" "ay"  
> str_extract(c("grey", "gray"), "gr(e|a)y")  
"grey" "gray"
```



Regular expressions

- Grouping
- Anchors
- Repetition

Anchors indicate the start or end of a text.

- ^ matches the start of string.
- \$ matches the end of the string.



Regular expressions

- Grouping
- Anchors
- Repetition

Signs after an expression indicate how often it should or may appear.

- $?$: 0 or 1.
- $+$: 1 or more.
- $*$: 0 or more.
- $\{n\}$: exactly n
- $\{n, \}$: n or more
- $\{n, m\}$: between n and m



Regular expressions

- There are many useful website to test or look up regular expressions.
- E.g. <https://regexr.com/>



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Text data



Text data

- There are many packages suitable to load specific types of data into R:
 - **jsonlite**: for JSON data
 - **xml2**: for XML data
 - **readr**: for Text data
 - **haven**: for SPSS, SAS, Stata files
 - **readxl**: for Microsoft excel files (.xls or .xlsx)
 - **DBI**: for connections to data bases
 - **httr**: to retrieve data from APIs
 - **rvest**: to retrieve data from websites/html



Text data

- Next we switch to R to demonstrate loading and analyzing text data and for the second assignment.