Web Scraping

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SCI 2000–Introduction to Data Science

Lecture Objectives

- Understand the basics of HTTP, URLs, and HTML
- Extract data from HTML documents using CSS selectors

Motivation

- There's lots of data on the Internet...
    - It's estimated that there are over 1 trillion websites around the world.
- Some information is easy to capture and copy-paste to CSV file.
    - E.g. a nicely formatted table on Wikipedia.
- More often, data is spread over multiple pages, and not stored in nice tables.
- **Web scraping** is the (automated) process of extracting data from the web.

Crash course on HTTP i

- HTTP: Hypertext Transfer Protocol
- It's the standard way of communicating over the web.
    - But not the only way! Email uses other protocols (e.g. POP, SMTP, IMAP).
    - Pages you read, images you see, videos you watch are sent to your web browser using HTTP.
- When you want to visit a website, your web browser sends a **request** for content to a web server, and the server sends back a **response**.
    - To see a single page, you typically perform multiple requests.

Crash course on HTTP ii

- There are six different types of requests you can make, but we will focus on only two:
  - `GET`: Client asks for a resource from the server.
  - `POST`: Client also asks for a resource, but sends data at the same time (e.g. inputs from an HTML form).
- The server will then send back a response:
  - Contains a status code (e.g. `404` means resource is unavailable).
  - Contains information about the type of content being sent over (e.g. images, videos, HTML)
  - The actual content we asked for.

Identifying resources i

- The standard way of identifying which resource we want is by using a **Uniform Resource Locator** (URL).
- The general syntax is as follows:

```
scheme://hostname:port/path?querystring#fragment
```

- The *scheme* is typically either HTTP or HTTPS (but could also be FTP).
- The *hostname* is the name of the host, e.g. `www.ecosia.org` or `www.nytimes.com`.

Identifying resources ii

- The *port* is the "door" on the server through which the communication occurs. The default is 80, and it is usually omitted.
- The *path* is the location of the resource, e.g. `2021/03/15/movies/oscars-nominees-list.html`.
- The *query string* is a series of `name=value` pairs separated by an ampersand (&)
    - `https://www.ecosia.org/search?q=web+scraping`
    - `q=web+scraping&freshness=month` would further restrict to results to past month.

Identifying resources iii

- The *fragment* points to a specific part of the returned output (usually an HTML file). It doesn't change what the server sends, only how the browser displays it.

Example i

```
library(httr)
resource <- GET("https://www.ecosia.org")
resource$status_code
```

```
## [1] 200
```

```
http_status(resource)
```

Example ii

```
## $category
## [1] "Success"
##
## $reason
## [1] "OK"
##
## $message
## [1] "Success: (200) OK"
```

```
# What did we receive?
resource$headers$`content-type`
```

Example iii

```
## [1] "text/html; charset=utf-8"

content(resource)

## {html_document}
## <html data-n-head-ssr="" lang="en"
data-n-head="%7B%22lang%22:%7B%22ssr%22:%22en%22%7D%7D">
## [1] <head>\n<meta http-equiv="Content-Type"
content="text/html; charset=UTF-8 ...
## [2] <body>\n <div data-server-rendered="true"
id="__nuxt"><div id="__layou ...
```

Example iv

```
# What about images?
url <- paste0("https://www.maxturgeon.ca/",
              "figure/posts/oscar2019_bestPic.png")
image <- GET(url)
image$status_code
```

```
## [1] 200
```

```
image$headers$`content-type`
```

```
## [1] "image/png"
```

Example v

```
str(content(image))
```

```
## num [1:350, 1:700, 1:3] 1 1 1 1 1 1 1 1 1 1
...
```

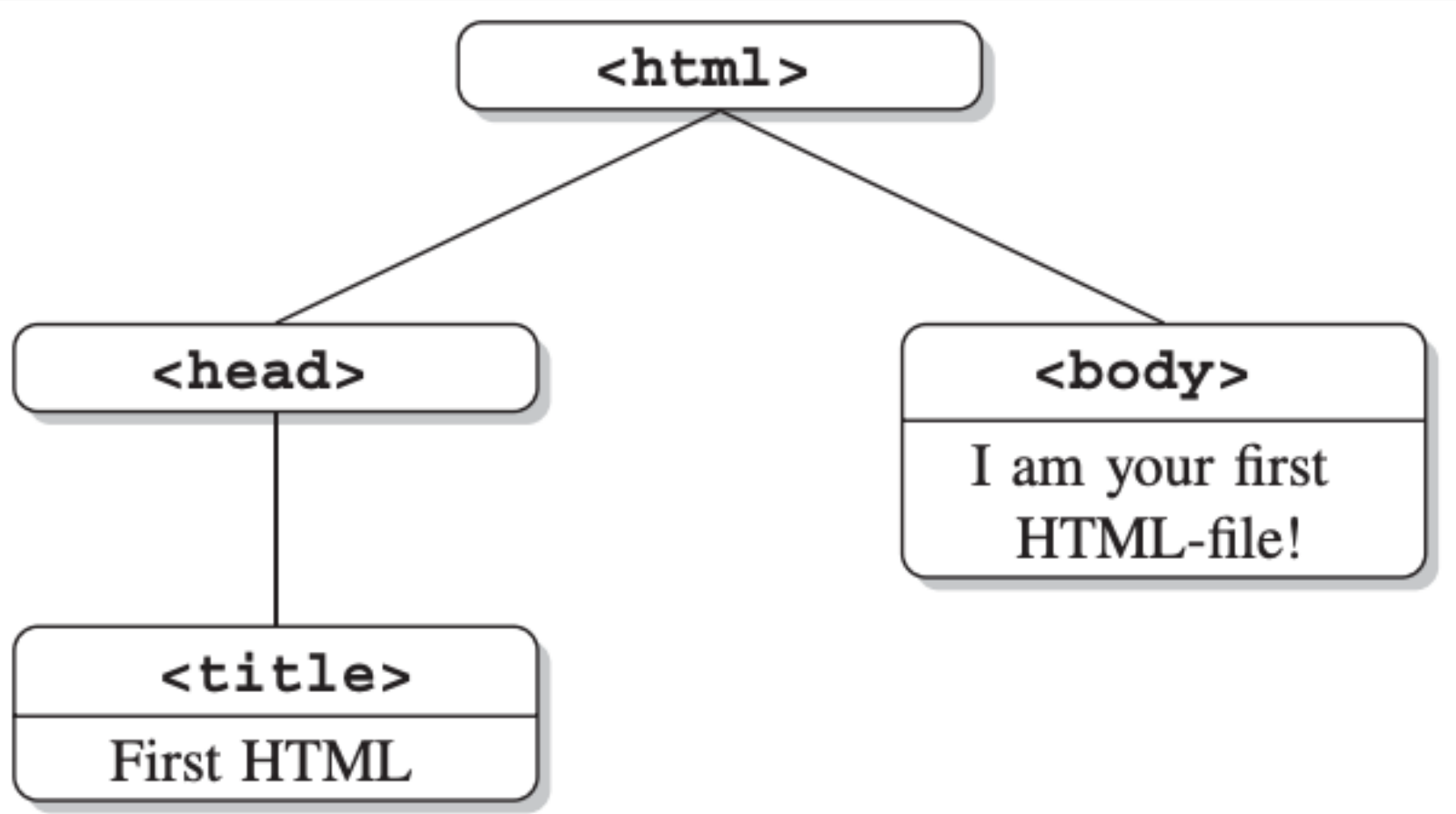
Browser developer tools

- Most modern browsers allow you to check what HTTP requests have been sent using their developer tools.
    - Safari requires you to first enable the menu (you can find instructions online).
- Live demo with `https://www.ecosia.org`

HTML documents

- By far, the most common documents we will scrape for data are **HTML** documents.
    - HTML: Hypertext Markup Language
- HTML is a language for presenting content on the Web.
    - HTML is a special case of XML (Extended Markup Language).
- HTML structures content within **tags**.
- These tags form a tree-like structure (i.e. tags are embedded into one another).
- Some elements in the tree are also given attributes to distinguish them from elements with the same tags.
    - E.g. `class="happy"` or `id="movie-1`

HTML documents—Tree structure



Munzert *et al*, *Automated Data Collection with R*

Example

```
library(tidyverse)
content(resource, as = "text") %>%
  str_extract("<title>[\\w\\s-]*</title>")
```

```
## [1] "<title>Ecosia - the search engine that
plants trees</title>"
```

Most common HTML tags i

- **Anchor elements**: They are used to link to other documents/web pages, setting reference points, or linking to reference points.

```
<a href="en.wikipedia.org/wiki/List_of_pharaohs">Link with absolute path</a>
```

- **Paragraph tag**: Create paragraphs of text

```
<p>This text is going to be a paragraph one day and separated from other text by line breaks.</p>
```

Most common HTML tags ii

- **Heading tags**: HTML provides 6 levels of headings

```
<h1>heading of level 1 -- this will be BIG</h1>
<h2>heading of level 2 -- this will be big</h2>
...
<h6>heading of level 6 -- the smallest heading</h6>
```

Most common HTML tags iii

- **Listing tags**: Both ordered (`<ol>`) and unordered (`<ul>`) lists

```
<ul>
  <li>Dogs</li>
  <li>Cats</li>
  <li>Fish</li>
</ul>
```

Most common HTML tags iv

- **Dividing tags**: Allows to organize sections (or subtrees) of the HTML document

```
<div class=”happy”>
  <p>One paragraph</p>
</div>
```

Most common HTML tags v

- **Table tags**: Used to create tables (which usually contain data!)

```
<table>
<tr> <th>Rank</th> <th>Name</th> </tr>
<tr> <td>1</td> <td>Lichtenstein</td> </tr>
<tr> <td>2</td> <td>Monaco</td> </tr>
<tr> <td>3</td> <td>Luxembourg</td> </tr>
<tr> <td>4</td> <td>Norway</td> </tr>
<tr> <td>5</td> <td>Qatar</td> </tr>
</table>
```

Example

```
# List of pharaohs in tables
# en.wikipedia.org/wiki/List_of_pharaohs
GET("en.wikipedia.org/wiki/List_of_pharaohs") %>%
  content(as = "text") %>%
  str_extract_all("<table>")
```

```
## [[1]]
## character(0)
```

Example Redux i

```
# List of pharaohs in tables
# en.wikipedia.org/wiki/List_of_pharaohs
GET("en.wikipedia.org/wiki/List_of_pharaohs") %>%
  content(as = "text") %>%
  str_extract_all("<table class=\"wikitable\".*>") %>%
  str()
```

Example Redux ii

```
## List of 1
## $ : chr [1:44] "<table class=\"wikitable\"
width=\"100%\">" "<table class=\"wikitable\"
width=\"100%\">" "<table class=\"wikitable\"
width=\"100%\">" "<table class=\"wikitable\"
width=\"100%\">" ...
```

CSS selectors

- We need a better way to find what we are looking for within an HTML document.
    - Remember: HTML is a text file, but it also has a tree structure.
- Moreover, important HTML elements are often identified using `class` or `id` attributes.
    - So that they can be styled using CSS
- We can use this to our advantage to extract the data we want.

Example i

```
library(rvest)

read_html("https://www.ecosia.org") %>%
  html_elements("title") %>%
  html_text() # Get text from element
```

```
## [1] "Ecosia - the search engine that plants
trees"
```

Example ii

```
# Syntax: tag.class
url <- "https://en.wikipedia.org/wiki/List_of_pharaohs"
tables <- read_html(url) %>%
  html_elements("table.wikitable")
length(tables)
```

```
## [1] 44
```

```
# Let's look at first one
tables[[1]]
```

Example iii

```
## {html_node}
## <table class="wikitable" width="100%">
## [1] <tbody>\n<tr>\n<th
width="15%">Name\n</th>\n<th
width="15%">Image\n</th>\ ...

html_table(tables[[1]]) %>%
  glimpse
```

Example iv

```
## Rows: 14
## Columns: 4
## $ Name <chr> "King 01 (missing)", "Hsekiu /
Seka", "Khayu", "Tiu / Teyew",~
## $ Image <lgl> NA, NA, NA, NA, NA, NA, NA, NA,
NA, NA, NA, NA, NA, NA
## $ Comments <chr> "Only known from the Palermo
stone[7]", "Only known from the ~
## $ Reign <chr> "Unknown", "Unknown", "Unknown",
"Unknown", "Unknown", "Unkno~
```

Exercise

ON CAMPUS

Top 10 highest paid university officials in Canada

Click to see who made more than $1-million last year

By Jacob Serebrin
July 4, 2011

Here are the Top 10 highest paid university officials in Canada, ranked by their base salaries.*

1. David Johnson
University of Waterloo president (now Governor General of Canada) — $1,041,881

2. Moriarty William
president of the University of Toronto Asset Management Corp. — $697,020

Using CSS selectors, extract the salaries from

`https://www.macleans.ca/education/uniandcollege/top-10-highest-paid-university-officials-in-canada/`

Hint: Salaries (and more) are in a `div` of class `single-article-text`.

Solution i

```
library(rvest)
url <- paste0("https://www.macleans.ca/education/",
              "uniandcollege/top-10-highest-paid-",
              "university-officials-in-canada/")
data <- read_html(url) %>%
  html_elements("div.single-article-text") %>%
  html_elements("p") %>%
  html_text()
```

Solution ii

```
library(tidyverse)
data <- data.frame(text = data)
glimpse(data)
```

```
## Rows: 14
## Columns: 1
## $ text <chr> "Here are the Top 10 highest paid
university officials in Canada,~
```

Solution iii

```
data_clean <- data %>%
  filter(str_detect(text, "^\\d{1,2}\\.")) %>%
  separate(col = "text", into = c("name", "salary"),
           sep = "\\n") %>%
  mutate(name = str_replace(name,
                            "^\\d{1,2}\\.\\s*", ""),
         salary = str_extract(salary, "\\$[\\d,]+$"))
glimpse(data_clean)
```

Solution iv

```
## Rows: 10
## Columns: 2
## $ name <chr> "David Johnson", "Moriarty
William", "Amit Chakma", "Richard Le~
## $ salary <chr> "$1,041,881", "$697,020",
"$500,000", "$496,921", "$480,030", "~
```

```
library(knitr)
kable(data_clean)
```

Solution v

name	salary
David Johnson	$1,041,881
Moriarty William	$697,020
Amit Chakma	$500,000
Richard Levin	$496,921
Mamdouh Shoukri	$480,030
Indira Samarasekera	$479,000
Ramona Lumpkin	$469,837
Carl G. Amrhein	$461,000
Alastair Summerlee	$440,590
Dezsö J. Horváth	$432,374

Summary

- HTTP is the main way we ask for content from web servers.
    - And most of this content is HTML pages.
- HTML pages contain lots of information, but it can be difficult to parse.
- CSS selectors allow us to pick out exactly the pieces we want.
- It's very common to use regular expressions to clean up the data as it's collected.