BCCP Web Scraping Course

Day 1

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Day 1

Very short intro to Python

Your experiences

- Which tools or programming languages do you use when working with data?
- Have you used Python before?

Why Python for web scraping?

- Common web data structures are similar to data structures in Python.
- Many Python packages for web scraping and APIs can be found.

Python interpreter — interactive mode

- input prompt `>>>`
- comments `#`
- operators `+`, `-`, `*` and `/`

```
>>> 2 + 2
4
>>> 8 / 5  # division always returns a floating point number
1.6
>>> 5 ** 2  # 5 squared
25
```

Python data structures

- Lists (`value`)

```
squares = [1, 4, 9, 16, 25]
```

- Dictionaries (`key: value`)

```
followers = {'kevin': 15, 'julian': 9}
```

Python data structures — Lists

```
>>> squares = [1, 4, 9, 16, 25]
>>> squares[0]  # indexing returns the item
1
>>> squares[-1]
25
>>> squares[-3:]  # slicing returns a new list
[9, 16, 25]
>>> squares.append((len(squares) + 1) ** 2)  # using append() method
>>> squares
[1, 4, 9, 16, 25, 36]
```

Python data structures — Dictionaries

- Dictionaries (`key: value`)
- Unlike lists, dictionaries are indexed by keys not by positions.

```
>>> followers = {'kevin': 15, 'julian': 9}
>>> followers['kevin']
15
>>> followers['kevin'] = 16
```

Common web data structures

For example, JSON nearly identical to combination of Python's dictionaries and lists.

```
[
  {
    "id": "1290837412912998347",
    "followers": "15",
    "name": "Kevin"
  },
  {
    "id": "1290837412973490803",
    "followers": "9",
    "name": "Julian"
  }
]
```

Functions

- `def` defines a function.
- Followed by function name with parenthesized sequence of parameters.
- Body of function must be indented.

```
>>> def list_append(a, mylist=[]):
...     """Example documentation string:
...     Append value to list. mylist defaults to empty list."""
...     mylist.append(a)
...     return mylist

>>> list_append(97, [99, 98])
[99, 98, 97]

>>> list_append(1)
[1]
```

Modules

- Definitions (functions and variables) can be saved in **modules**. Our example function `list_append()` can be saved in a file `list_operations.py`.
- Such modules can be imported into the interpreter, scripts, or other modules.

```
import list_operations
list_operations.list_append(1)

from list_operations import list_append
list_append(1)

import list_operations as lo
lo.list_append(1)
```

- Bad practice: `from sound.effects import *`

Packages

- Packages structure modules namespace by using dotted module names. `A.B` designates a submodule named `B` in a package named `A`.

```
import matplotlib.pyplot as plt
```

- Packages can be installed with pip.

```
pip install matplotlib
```

- A common convention is to have a list of packages in requirements.txt:

```
pip install -r requirements.txt
```

Files

- Reading and writing files

```
f = open('workfile', 'r') # read-only
f = open('workfile', 'w') # write-only
f = open('workfile', 'a') # appending

f = open('workfile') # read-only, as mode defaults to 'r'
```

- Closing files

```
f.close() # Manually close a file

with open('workfile') as f: # with closes file "automatically"
     read_data = f.read()
```

- Several packages offer file operations (e.g. `pandas.read_csv()`)

Further reading

- Official Python Docs Tutorial
- W3Schools Python Tutorial
- Cookiecutter Data Science Project Template

Day 1

Intro to web scraping

Introduction to web scraping

- Basic idea: Turn information on website to structured data
- Typical workflow:
  1. Look at website to decide best approach
     - Is an Application Programming Interface (API) available?
     - Do the HTML elements have fixed names?
     - Does the page load statically or dynamically?
  2. Load the page and save the source code/API result
  3. Convert source code/API result to Python object
  4. Take wanted information from Python object, convert to DataFrame, and save

Some concepts

- APIs
- HTML parsing vs text matching
- Static vs dynamic websites

APIs

- If available, a convenient way to get pre-structured data (usually JSON or XML).
- Example: OpenStreetMap (OSM) (https://www.openstreetmap.org)
  - When searching manually, results can be shown as XML. Automating the search on OpenStreetMap and clicking on the relevant links would therefore be a way to save this data.
  - However, OSM offers several APIs that simplify this task. One API is the Nominatim API (https://nominatim.openstreetmap.org).

API example: Nominatim API for OSM

- See https://nominatim.org/release-docs/develop/api/Search/ for documentation on search syntax
- Search for 'diw berlin' and return as JSON: https://nominatim.openstreetmap.org/search?q=diw+berlin&format=json

HTML parsing

- Use structure of HTML code to find needed information.
- Works best if the source code has a fixed structure and element names are constant or follow some pattern.
- Two basic concepts: Navigation and searching
  - Navigation: Start at one point of the HTML document and navigate along the structure of the document (e.g. go to children tags or sibling tags)
  - Searching: Search for specific HTML elements using their tag name (e.g. `<div>` or `<span>`) and values of attributes like `class` or `id`

HTML parsing example: eBay search results

- Look at results for ’star wars blu ray’ on eBay: https://www.ebay.de/sch/i.html?_nkw=star+wars+blu+ray
- Most browsers have a feature to look at source code (e.g. in Chrome, you can right click on any website element and click on ’Inspect’).
- On eBay, the HTML tags containing certain content always have the same name, this simplifies HTML parsing.
- For example, the tag `<div id="ResultSetItems">` contains all results. Inside this tag, the individual listings are saved in tags called `<li class="sresult">`. In Chrome, you can also look for elements using the XPath syntax (e.g. for the individual listings: *//li[contains(@class,’sresult’)]*). More information on XPath here: https://www.w3schools.com/xml/xpath_syntax.asp

Text pattern matching

- If the HTML code is not well-structured or names change, text pattern matching is an alternative.
- Idea: Look at HTML elements in which wanted information is stored, identify patterns, and match using a regular expression

Example of website without clear HTML tag names: Airbnb

- Search for homes in Berlin-Mitte: https://www.airbnb.de/s/Berlin-Mitte--Berlin/homes?query=Berlin-Mitte%2C%20Berlin
- Say you wanted to get the number of results for this search. The element does not have a clear name. Using HTML parsing is still possible but is prone to errors. Instead, one could match on a regular expression, e.g.

```
re.findall('[0-9]{1,2} - [0-9]{1,2} von ([0-9 +]+) Unterkünfte', srccode)
```

Static vs dynamic websites

- On static websites, the entire content is loaded immediately. E.g. eBay: https://www.ebay.de/sch/i.html?_nkw=star+wars+blu+ray
- On dynamic websites, content may not load instantaneously or only after user action, usually making them more complicated to scrape. E.g. Airbnb: https://www.airbnb.de/s/Berlin-Mitte--Berlin/homes?query=Berlin-Mitte%2C%20Berlin (Try disabling JavaScript in your browser and reloading the page).
- Getting the complete source code from a dynamic website can be done with browser automation. The idea is to open a website in an actual browser (and interacting with it if necessary) and save the source code of the content from there.

Important Python packages i

- `requests`: To load URL and recover source code (for static web pages), e.g.:

```
import requests # Import package
url = "http://www.bccp-berlin.de/events/all-events" # Define URL to load
r = requests.get(url) # Load URL
srccode = r.text # Save source code
```

Important Python packages ii

- `selenium`: For browser automation

```python
from selenium import webdriver # Import webdriver class from selenium modul
from selenium.webdriver.chrome.options import Options # Load Options class
    # from chrome.options to set options for the Chrome webdriver
chrome_options = Options() # Create instance of Chrome options
chrome_options.binary_location = browser_app # Set the location where the
    # browser is located
driver = webdriver.Chrome(browser_driver, options = chrome_options) # Start
    # the browser driver (browser_driver contains the location to the
    # webdriver
url = "https://www.berlin-econ.de/events" # Define URL to load
driver.get(url) # Load URL
html = driver.page_source # Save source code
```

Important Python packages iii

- `beautifulsoup4`: To turn HTML code to navigable Python object

```
from bs4 import BeautifulSoup # Load BeautifulSoup class from bs4 module
soup = BeautifulSoup(srccode, "lxml") # Convert source code to soup using
    # the "lxml" parser
```

- `pandas`: To create DataFrames

```
import pandas as pd # Load pandas module with short-cut pd
df = pd.DataFrame(resdict).T # Convert dictionary to DataFrame and transpos
df.to_csv(file_save) # Save df as csv (file_save contains the path to the f
```

Day 1

APIs

Application Programming Interface

Why APIs?

- Data owners want know who is using their services.
- Data owners want to limit requests.
- Data owners want to supply data in their preferred format.

Twitter API

- “Conduct historical research and search from Twitter’s massive archive of publicly-available Tweets posted since March 2006?”
- “Listen in real-time for Tweets of interest?”

Source: https://developer.twitter.com/en/docs/basics/getting-started.html

Twitter API — Limits

All request windows are 15 minutes in length.

Endpoint	Resource family	Requests / window (user auth)
GET followers/list	followers	15
GET lists/members	lists	900
GET lists/statuses	lists	900
GET search/tweets	search	180
GET statuses/lookup	statuses	900
GET statuses/retweeters/ids	statuses	75
GET statuses/user_timeline	statuses	900
GET users/lookup	users	900

Next to request windows other restrictions may apply (e.g. statuses/user_timeline has an additional restriction of the last 3200 tweets).

Source: https://developer.twitter.com/en/docs/basics/rate-limits

Tweepy package

We use the Tweepy package to access twitter's RESTful API.

```python
user = api.get_user('twitter')

# tweepy models contain the data plus and some methods.
print(user.screen_name)
print(user.followers_count)
for friend in user.friends():
    print(friend.screen_name)
```

Twitter API — JSON Example

Packages usually also allow to access the JSON directly, which often contains more information than provided by package classes.

```python
import tweepy
from twitter_auth import auth

def get_tweets(api, screen_name):
    tweets_json = [status._json for status in tweepy.Cursor(
        api.user_timeline,
        screen_name=screen_name,
        tweet_mode='extended'
    ).items(2)]
    return tweets_json

api = tweepy.API(auth)
tweets = get_tweets(api, '@guardian')
```

Twitter API — JSON Example

```
{'contributors': None,
 'coordinates': None,
 'created_at': 'Tue Nov 20 17:56:53 +0000 2018',
 'display_text_range': [0, 97],
 'entities': {'hashtags': [],
              'symbols': [],
              'urls': [{'display_url': 'trib.al/hDWAWvZ',
                        'expanded_url': 'https://trib.al/hDWAWvZ',
                        'indices': [74, 97],
                        'url': 'https://t.co/GpWbVaZV3F'}],
              'user_mentions': []},
 'favorite_count': 17,
 'favorited': False,
 'full_text': 'I was arrested at a climate change protest – it was worth it | '
              'Gavin Turk https://t.co/GpWbVaZV3F',
 'geo': None,
 'id': 1064940660942352385,
 'id_str': '1064940660942352385',
 'in_reply_to_screen_name': None,
 'in_reply_to_status_id': None,
 'in_reply_to_status_id_str': None,
 'in_reply_to_user_id': None,
 'in_reply_to_user_id_str': None,
 'is_quote_status': False,
 'lang': 'en',
 'place': None,
 'possibly_sensitive': False,
```

World Bank API

- World Bank APIs provide access to:
  - Indicators API
  - Data Catalog API
  - Projects API
  - Finances API
  - Climate Data API
- Access data without authentication.
- World bank API documentation
- world_bank_data package documentation

world_bank_data — Example

```python
import world_bank_data as wb

# Get estimates for the world population:
wb.get_series('SP.POP.TOTL', date='2017')

# Get timeseries of "Agricultural machinery, tractors" in Albania
wb.get_series('AG.AGR.TRAC.NO', country='ALB')
```

There might be APIs without a working package

- Check more general packages. For example, https://pandas-datareader.readthedocs.io/en/latest/readers/
- Write your own API wrappers.

RESTful API

- Most APIs are RESTful APIs (Representational State Transfer)
- RESTful APIs use HTTP methods:
  - GET — fetch item
  - POST — create item
  - DELETE — delete item
  - PUT — modify an existing item

RESTful API — Example

For web scraping we only need GET.

```
import requests

url = ('http://ec.europa.eu/eurostat/wdds/rest/data/v2.1/json/en/'
       'nama_10_gdp?geo=EU28&precision=1&na_item=B1GQ&unit=CP_MEUR&'
       'time=2010&time=2011')

resp = requests.get(url)
resp_json = resp.json()

resp_json['value']
resp_json['dimension']['time']['category']['index']
```

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Day 2

HTML parsing

HTML parsing

- After obtaining the HTML source code, how to obtain the information required?
- If the HTML code is well-structured and its tags have (more or less) unique names, we can navigate the HTML elements to get the information we want.
- The `beautifulsoup4` package converts the HTML code into a Python object that can be navigated using properties and functions.

Some HTML terms

- Consider `<a href="http://www.bccp-berlin.de" target="_blank">BCCP</a>`
- HTML Elements
  - The entire thing is an HTML element. Specifically, it is a link leading to the BCCP website and displayed as ”BCCP”.
  - HTML elements usually consist of a start tag and an end tag.
- HTML Tags
  - The start tag of the element above is `<a>` and the end tag is the corresponding `</a>`
  - Start tag can and sometimes must contain attributes.
- HTML Attributes
  - The `<a>` tag contains the attribute `href` and `target`. `href` specifies the destination to which the link should lead and `target="\_blank"` specifies that the link should be opened in a new window.
  - For web scraping purposes, the attributes `class` and `id` are usually useful as these are often used to identify certain (groups of) elements.

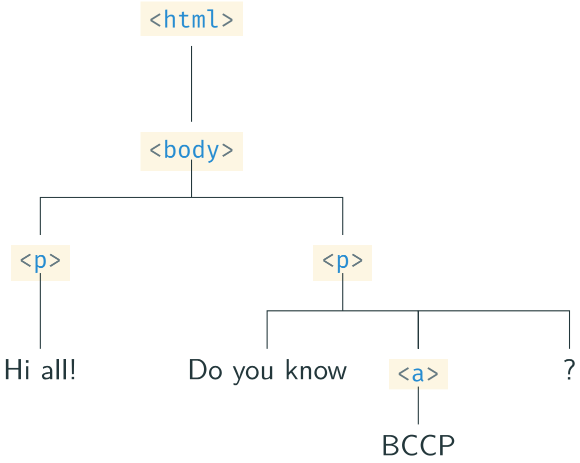
Basic HTML documents structure

- HTML documents have a tree-like/nested structure
- Elements can contain various levels of sub-elements that in the end contain some content

HTML document example

```
<html>
 <body>
  <p>
   Hi all!
  </p>
  <p>
   Do you know <a href="http://www.bccp-berlin.de" target="_blank">BCCP</a>?
  </p>
 </body>
</html>
```

Tree structure



A note on XPath i

- XPath is a syntax to address specific elements in an HTML document
- Most important expressions:
  - `//div` : Select all `<div>` tags in the HTML document
  - `//div//span` : Select all `<span>` tags in the HTML document that are descendants of a `<div>` tag, e.g. `<div><ul><li><span></span></li></ul></div>`
  - `//div/span` : Select all `<span>` tags in the HTML document that are children of a `<div>` tag, e.g. `<div><span></span></div>` but not `<div><ul><li><span></span></li></ul></div>`

A note on XPath ii

- `//div/span[@class='bccp']`: Select all `<span>` tags in the HTML document that are children of a `<div>` tag and whose `class` attribute takes the value 'bccp', e.g. `<div><span class='bccp'></span></div>` but not `<div><span class='bccp course'></span></div>`
- `//div/span[contains(@class,'bccp')]`: Select all `<span>` tags in the HTML document that are children of a `<div>` tag and whose `class` attribute value contains 'bccp', e.g. `<div><span class='bccp course'></span></div>`
- When inspecting source codes in Chrome, you can use XPath to find elements
- Find more here: https://www.w3schools.com/xml/xpath_intro.asp

General steps

1. Load a web page and get the source code: Use `requests` for static and `selenium` for dynamic websites
2. Convert ("parse") the source code into a soup object: Use `beautifulsoup4`
3. Navigate/search the soup object to get the information you want

Example for today

- Let's scrape the details of all upcoming BCCP events: http://www.bccp-berlin.de/events/all-events/
- Steps:
  1. Analyze HTML structure
  2. Load source code
  3. Loop through events available on the front page and save details
  4. Create DataFrame from this
  5. Loop through and load individual event pages to save further details

Analyzing the HTML structure i

- Open http://www.bccp-berlin.de/events/all-events/ in a browser and inspect the source code
- Information on events saved in div elements

```
<div class="eventList">
...
<div class="event-list-item event-type1">...</div>
...
<div class="event-list-item event-type2">...</div>
...
</div>
```

Analyzing the HTML structure ii

- Details are saved in sub-elements in each `//div[contains(@class,'event-list-item')]` element

Analyzing the HTML structure iii

```
<div class="event-list-item event-type1">
 <div class="top-bar">
  <span class="date single">June 27, 2019</span>
  <span class="b-events__item__type">Seminar</span>
 </div>
 <div class="b-events__item__inner">
  <div class="content">
   <div class="genres">Berlin Behavioral Economics Seminar</div>
   <h2 class="eventHeader">
    <a href="/events/all-events/events-detail/
    felix-holzmeister-university-of-innsbruck/">
     Felix Holzmeister (University of Innsbruck)
    </a>
   </h2>
   <div class="teaser">Delegated Decision Making in Finance</div>
   <div class="location">
    <strong class="label">Location</strong>
```

From website to Python soup

See `htmlparsing.ipynb`.

1. `requests`: Load website and save source code as string

```
url = "http://www.bccp-berlin.de/events/all-events" # URL to BCCP events pa
r = requests.get(url) # Load URL
srccode = r.text # Save source code
```

2. `beautifulsoup4`: Take source string and parse to get soup object
   - There are three different parsers: `html.parser`, `lxml`, `html5lib`
   - Differences are discussed here: https://www.crummy.com/software/BeautifulSoup/bs4/doc/#installing-a-parser
   - I usually use `lxml`

```
soup = BeautifulSoup(srccode, "lxml")
```

Some BeautifulSoup functions

- Look at the very good documentation: https://www.crummy.com/software/BeautifulSoup/bs4/doc/
- You can either *search* the document:
  - `.find_all()`: Find all elements that match a certain condition. Returns a list.
  - `.find()`: Same as `.find_all()` but only returns first match.
- If unique tag names are not available, *navigation* of the HTML tree rather than searching it is possible, e.g.:
  - Vertically: `.parent`, `.parents`, `.children`
  - Horizontally: `.next_sibling`, `.previous_sibling`

Day 2

Text pattern matching

Text pattern matching

- Regular expressions (regex) are rules for the set of possible strings to match.
- Use regex to search and extract substrings.
- Set might contain words, whole sentences, or e-mail addresses, or anything you like.
- Are there matches for the pattern anywhere in the string?

Regular Expression Syntax

- `.` matches any character except a newline.
- `^` matches the start of the string.
- `$` matches the end of the string.
- `*` match 0 or more repetitions of the preceding RE.
- `+` match 1 or more repetitions of the preceding RE.
- `?` match 0 or 1 repetitions of the preceding RE.

See: Python regex cheat sheet

Text pattern matching — Example

```python
import re

# Find all href tags with http(s) link
re.findall('href="http[s]?://.*?"', html)

# Find all href tags with http(s) link and return links only
re.findall('href="(http[s]?://.*?")', html)

# Find all href tags with http(s) link and split
links_parts = re.findall('href="(http[s]?)://(.*?)"', html)
[x[1] for x in links_parts]

# Find all prices
prices = re.findall('\\d+\\.?\\d+\\s?€', html)
prices_clean = [re.sub('[^\\d]', '', x) for x in prices]
```

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Browser automation

Why browser automation?

- If the content of a page is loaded dynamically (e.g. with JavaScript), using `requests` could yield an “empty” source code.
- Browser automation is then a way to load the page in an actual browser and let the JavaScript load as if you actually visited the page.
- Because this uses an actual browser and a browser driver, this approach is less stable and crashes can occur. Further, loading a page in a browser usually takes more time than loading it in `requests` .

Example for today

- Let us scrape all future events from the BERA website: https://www.berlin-econ.de/events.
- In order to load all events, we need to click on the bottom buttons to navigate through the results pages.
- However, these buttons do not link to a new URL but load content using JavaScript:

```
<a href="javascript:;" class="item" data-request-success="scroll(0,0)"
data-request="onEventSearch"
data-request-update="'@events-list': '#event-results'"
data-request-data="page:2">Next →</a>
```

Some technical notes

- We will use the `selenium` package
  - It allows you to control a browser from a Python script
  - The documentation can be found here: https://selenium-python.readthedocs.io/
- Besides `selenium`, you need to have an actual browser installed that you are going to use and a compatible browser driver that `selenium` can use to control the browser
  - We will use Google's Chrome browser (https://www.google.com/chrome/) and the corresponding ChromeDriver (http://chromedriver.chromium.org/). Some parts of the code might have a different syntax for different browsers.
  - `selenium`'s documentation includes links to drivers for four popular browsers: https://selenium-python.readthedocs.io/installation.html#drivers
  - The documentation for the various browser driver types in `selenium` can be found here: https://seleniumhq.github.io/selenium/docs/api/py/api.html
  - Make sure that the driver version fits your installed browser version

First, analyze the HTML code of https://www.berlin-econ.de/events

- Events are saved in a `<div class='event-results'>` element
- Inside this, events for different days are separated by a `<div class='event-date-separator'>` element
- The actual events are then saved in a `<div class='ui segments'>` elements, more specifically, in `<div class='ui segment'>` elements
- The buttons to navigate to the next results pages are saved in the last element in `<div class='event-results'>` (`<div class='ui pagination menu'>`)
- Need a mix of navigating and searching the HTML document

Approach

1. Load events page in browser
2. Loop through elements in `<div class='event-results'>`
   2.1 If it is a date, save the date
   2.2 If it is an event, save the event details
   2.3 If it is the buttons, click the button for the next page, if available.
   2.4 Repeat until no other next page available
3. Turn to DataFrame and save

- See `automation.ipynb`

Interacting with the webpage

- In order to be able to click the button, we need to scroll it into view first
- For this, we need to tell `selenium` where the wanted element is and have it scroll there
- This can be done e.g. using XPATH syntax
- Typical steps are therefore:
  1. Find the element in the source code (e.g. `element = driver.find_element_by_xpath(xpath)`, other alternatives here: https://selenium-python.readthedocs.io/locating-elements.html)
  2. Scroll it into view and click, e.g. `ActionChains(driver).move_to_element(element).click(element).perform()`
- See https://seleniumhq.github.io/selenium/docs/api/py/webdriver/selenium.webdriver.common.action_chains.html for documentation on `ActionChains` and things you can do with it

Waits

- It can occur that the page is not finished loading when the script continues and converts the source code
- To prevent this, Waits can be used
- There are two main types of Waits:
  - Explicit Waits: Explicitly waits until a condition is fulfilled or a maximum time is reached
  - Implicit Waits: Usually set once and is a maximum waiting time whenever some element is looked for
- More details here: https://selenium-python.readthedocs.io/waits.html

Explicit Waits with Expected Conditions

- What often comes in handy in browser automation are Explicit Waits with Expected Conditions
- Here, you can let the script pause until e.g. some element is visible on the web page
- Selenium features some methods that should be enough for most use cases: See Section 7.39 at https://selenium-python.readthedocs.io/api.html

Finding the right button

- The page buttons are saved as children of the `<div class='ui pagination menu'>` tag.
- Their tags are of the form `<a class="item">`.
- Unfortunately, the “Next” button does not have a unique id/name.
- However, using `.find_all()`, we can find the list of `<a class="item">` items, look at the last one, and determine if it is a “Next” button or not

Day 3

Own script

Own script

Today you can discuss your own script with us, ask questions, and give feedback.