15-388/688 - Practical Data Science: Data collection and scraping

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Outline

The data collection process

Common data formats and handling

Regular expressions and parsing

Announcements

If you’re wondering about the waitlist for 15-688 Section B, we *will* admit everyone on the waitlist (expanding the section if needed)

The section is not full right now, enrollment is just blocked by people on the waitlist that cannot be enrolled because they have too many units (if this is you, please drop your units so you can enroll)

Homework 1 will be released tonight, with a full set of tests in the assignment, but the autograder may not be ready (we have been waiting for the image with the necessary software for 2+ weeks, though it should be finally ready)

164 people are enrolled on Piazza (much fewer than enrolled in all sections), enroll today or we will start bugging you and/or kicking you out

Announcements

I will be traveling next week (Monday is a holiday anyway), so instead of lecture next Wednesday, the TAs will be running an in-class Python tutorial

Attendance is optional (though this is always true, I suppose), and it will still be recorded

Hopefully this will be useful for those who are a bit rusty with Python

Piazza post on class participation

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The first step of data science

The first step in data science …

... is to get some data

You will typically get data in one of four ways:

1. Directly download a data file (or files) manually – not much to say
2. Query data from a database – to be covered in later lecture
3. Query an API (usually web-based, these days) } covered today
4. Scrap data from a webpage }

Issuing HTTP queries

The vast majority of automated data queries you will run will use HTTP requests (it's become the dominant protocol for much more than just querying web pages)

I know we promised to teach you know things work under the hood … but we are *not* going to make you implement an HTTP client

Do this instead (requests library, http://docs.python-requests.org/):

```python
import requests
response = requests.get("http://www.datasciencecourse.org")

# some relevant fields
response.status_code
response.content # or response.text
response.headers
response.headers['Content-Type']
```

HTTP Request Basics

You’ve seen URLs like these:
`https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=9&cad=rja&uact=8…`

The weird statements after the url are *parameters,* you would provide them using the requests library like this:

```
params = {"sa":"t", "rct":"j", "q":"", "esrc":"s",
          "source":"web", "cd":"9", "cad":"rja", "uact":"8"}
response = requests.get("http://www.google.com/url", params=params)
```

HTTP GET is the most common method, but there are also PUT, POST, DELETE methods that *change* some state on the server

```
response = requests.put(...)
response = requests.post(...)
response = requests.delete(...)
```

RESTful APIs

If you move beyond just querying web pages to web APIs, you'll most likely encounter REST APIs (Representational State Transfer)

REST is more a design architecture, but a few key points:

1. Uses standard HTTP interface and methods (GET, PUT, POST, DELETE)
2. Stateless – the server doesn't remember what you were doing

Rule of thumb: if you're sending the your account key along with each API call, you're probably using a REST API

Querying a RESTful API

You query a REST API similar to standard HTTP requests, but will almost always need to include parameters

```
token = "" # not going to tell you mine
response = requests.get("https://api.github.com/user",
                        params={"access_token":token})
print response.content
#{"login":"zkolter","id":2465474,"avatar_url":"https://avatars.githubu…
```

Get your own access token at https://github.com/settings/tokens/new

GitHub API uses GET/PUT/DELETE to let you query or update elements in your GitHub account automatically

Example of REST: server doesn't remember your last queries, for instance you always need to include your access token if using it this way

Authentication

Basic authentication has traditionally been the most common approach to access control for web pages

```
# this won't work anymore
response = requests.get("https://api.github.com/user",
                        auth=('zkolter', 'passwd'))
```

Most APIs have replaced this with some form of OAuth (you'll get familiar with OAuth in the homework)

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Data formats

The three most common formats (judging by my completely subjective experience):

1. CSV (comma separate value) files

2. JSON (Javascript object notation) files and strings

3. HTML/XML (hypertext markup language / extensible markup language) files and strings

CSV Files

Refers to any delimited text file (not always separated by commas)

```
"Semester","Course","Section","Lecture","Mini","Last Name","Preferred/First
Name","MI","Andrew ID","Email","College","Department","Class","Units","Grade
Option","QPA Scale","Mid-Semester Grade","Final Grade","Default Grade","Added
By","Added On","Confirmed","Waitlist Position","Waitlist Rank","Waitlisted
By","Waitlisted On","Dropped By","Dropped On","Roster As Of Date”
"F16","15688","B","Y","N",”Kolter","Zico","","zkolter","zkolter@andrew.cmu.edu","S
CS","CS","50","12.0","L","4+"," "," ","","reg","1 Jun
2016","Y","","","","","","","30 Aug 2016 4:34"
```

If values themselves contain commas, you can enclose them in quotes (our registrar apparently always does this, just to be safe)

```python
import pandas as pd
dataframe = pd.read_csv("CourseRoster_F16_15688_B_08.30.2016.csv",
                        delimiter=',', quotechar='"')
```

We’ll talk about the pandas library a lot more in later lectures

JSON files / string

JSON originated as a way of encapsulating Javascript objects

A number of different data types can be represented

- Number: `1.0` (always assumed to be floating point)
- String: `"string"` or `'string'`
- Boolean: `true` or `false`
- List (Array): `[item1, item2, item3,…]`
- Dictionary (Object in Javascript): `{"key":value}`

Lists and Dictionaries can be embedded within each other:

```
[{"key":[value1, [value2, value3]]}]
```

Example JSON data

JSON from Github API

```
{
 "login":"zkolter",
 "id":2465474,
 "avatar_url":"https://avatars.githubusercontent.com/u/2465474?v=3",
 "gravatar_id":"",
 "url":"https://api.github.com/users/zkolter",
 "html_url":"https://github.com/zkolter",
 "followers_url":"https://api.github.com/users/zkolter/followers",
 "following_url":"https://api.github.com/users/zkolter/following{/other_user}",
 "gists_url":"https://api.github.com/users/zkolter/gists{/gist_id}",
 "starred_url":"https://api.github.com/users/zkolter/starred{/owner}{/repo}",
 "subscriptions_url":"https://api.github.com/users/zkolter/subscriptions",
 "organizations_url":"https://api.github.com/users/zkolter/orgs",
 "repos_url":"https://api.github.com/users/zkolter/repos",
 "events_url":"https://api.github.com/users/zkolter/events{/privacy}",
 "received_events_url":"https://api.github.com/users/zkolter/received_events",
 "type":"User",
 "site_admin":false,
 "name":"Zico Kolter”
 ...
```

Parsing JSON in Python

Built-in library to read/write Python objects from/to JSON files

```
import json

# load json from a REST API call
response = requests.get("https://api.github.com/user",
                        params={"access_token":token})
data = json.loads(response.content)

json.load(file) # load json from file
json.dumps(obj) # return json string
json.dump(obj, file) # write json to file
```

XML / HTML files

The main format for the web (though XML seems to be loosing a bit of popularity to JSON for use in APIs / file formats)

XML files contain hiearchical content delineated by tags

```
<tag attribute="value">
    <subtag>
        Some content for the subtag
    </subtag>
    <openclosetag attribute="value2”/>
</tag>
```

HTML is syntactically like XML but horrible (e.g., open tags are not always closed), more fundamentally, HTML is mean to describe appearance

Parsing XML/HTML in Python

There are a number of XML/HTML parsers for Python, but a nice one for data science is the BeautifulSoup library (specifically focused on getting data out of XML/HTML files)

```python
# get all the links within the data science course schedule
from bs4 import BeautifulSoup
import requests
response = requests.get("http://www.datasciencecourse.org")

root = BeautifulSoup(response.content)
root.find("section",id="schedule")\
    .find("table").find("tbody").findAll("a")
```

You'll play some with BeautifulSoup in the first homework

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Regular expressions

Once you have loaded data (or if you need to build a parser to load some other data format), you will often need to search for specific elements within the data

E.g., find the first occurrence of the string “data science”

```
import re
match = re.search(r"data science", text)
print match.start()
```

Regular expressions in Python

A few common methods to call regular expressions in Python:

```
match = re.match(r"data science", text) # check if start of text matches
match = re.search(r"data science", text) # find first match or None
for match in re.finditer("data science", text):
    # iterate over all matches in the text
    ...
all_matches = re.findall(r"data science", text) # return all matches
```

You can also use “compiled” version of regular expressions

```
regex = re.compile(r"data science")
regex.match(text, [startpos, [endpos]])
regex.search(...)
regex.finditer(...)
regex.findall(...)
```

Matching multiple potential characters

The real power of regular expressions comes in the ability to match multiple possible sequence of characters

Special characters in regular expressions: `.^$*+?{}\[]|()` (if you want to match these characters exactly, you need to escape them: `\$`)

Match sets of characters:

- Match the character ‘a’: `a`
- Match the character ‘a’, ‘b’, or ‘c’: `[abc]`
- Many any character *except* ‘a’, ‘b’, or ‘c’: `[^abc]`
- Match any digit: `\d` (= `[0-9]`)
- Match any alpha-numeric: `\w` (= `[a-zA-z0-9_]`)
- Match whitespace: `\s` (= `[ \t\n\r\f\v]`)
- Match any character: `.` (including newline with `re.DOTALL`)

Matching repeated characters

Can match one or more instances of a character (or set of characters)

Some common modifiers:

Match character ‘a’ exactly once: `a`

Match character ‘a’ zero or one time: `a?`

Match character ‘a’ zero or more times: `a*`

Match character ‘a’ one or more times: `a+`

Match character ‘a’ exactly n times: a{n}

Can combine these with multiple character matching:

Match all instances of “<something> science” where <something> is an alphanumeric string with at least one character

```
\w+\s+science
```

Grouping

We often want to obtain more information that just whether we found a match or not (for instance, we may want to know what text matched)

Grouping: enclose portions of the regular expression in quotes to “remember” these portions of the match

```
(\w+)\s([Ss]cience)
```

```python
match = re.search(r"(\w+)\s([Ss]cience)", response.content)
print match.start(), match.groups()
# 315 ('Data', 'Science')
```

Substitutions

Regular expressions provide a power mechanism for replacing some text with outer text

```
better_text = re.sub(r"data science", r"schmada science", text)
```

To include text that was remembered in the matching using groups, use the escaped sequences \1, \2, … in the substitution text

```
better_text = re.sub(r"(\w+)\s([Ss])cience", r"\1 \2hmience", text)
```

(You can also use backreferences within a single regular expression)

Ordering and greedy matching

There is an order of operations in regular expressions

`abc|def` matches the strings “abc” or “def”, not “ab(c or d)ef”

You can get around this using parenthesis e.g. `a(bc|de)f`

This also creates a group, use `a(?:bc|de)f` if you don’t want to capture it

By default, regular expressions try to capture as much text as possible (greedy matching)

`<(.*)>` applied to `<a>text</a>` will match the entire expression

If you want to capture the *least* amount of text possible use `<(.*?)>` this will just match the `<a>` term

Additional features

We left out a lot of elements here to deep this brief: start/end lines, lookaheads, named groups, etc

Don’t worry if you can’t remember all this notation (I had to look some things up while preparing this lecture too)

Use the docs: https://docs.python.org/2/howto/regex.html, https://docs.python.org/2/library/re.html

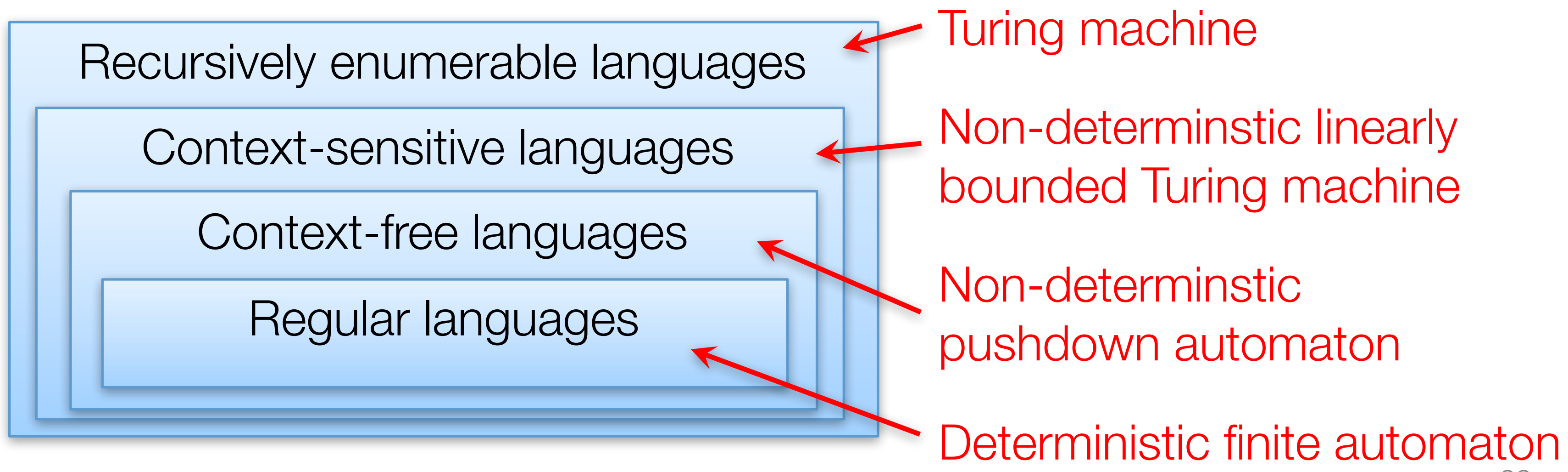
Try out test expressions to see what happens

Behind the scenes: grammars and parsing

Matching strings is actually a foundational problem in computer science

Example: we cannot write a (true) regular expression (backreferences are not allowed) that matches all strings of the form “$a^n b^n$” (any number of a’s followed by the name number of b’s)

These these problems relate to the **Chomsky hierarchy** of languages



Recursively enumerable languages
Context-sensitive languages
Context-free languages
Regular languages
Turing machine
Non-determinstic linearly bounded Turing machine
Non-determinstic pushdown automaton
Deterministic finite automaton

Examples to have in mind

Regular language: “a*b*” (any number of a’s followed by any number of b’s)
Context-free language: “a^nb^n” (any number of a’s followed by the name number of b’s)
Context-sensitive language: “$a^nb^nc^n$” (any number of a’s followed by the name number of b’s, followed by the same number of c’s)

Warning: regular expressions != regular languages (there are many extensions built into regular expressions that give them “memory”)

Can regular languages determine is a file is a valid CSV file (with fixed number of values per line)? JSON file? XML file?

What about a context-free language?