# Lecture 3: Data II

How to get it, methods to
parse it, and ways to explore it.

## Harvard IACS

CS109A

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# ANNOUNCEMENTS

- **Homework 0** isn't graded for accuracy. If your questions were surface-level / clarifying questions, you're in good shape.
- **Homework 1** is graded for accuracy
  - it'll be released today (due in a week)
- **Study Break** this Thurs @ 8:30pm and Fri @ 10:15am
- After lecture, please update your Zoom to the latest version

# Background

- So far, we've learned:

| | |
|---|---|
| Lecture 1 | What is Data Science? |
| Lectures 1 & 2 | The Data Science Process |
| Lecture 2 | Data: types, formats, issues, etc. |
| Lecture 2 | Regular Expressions (briefly) |
| This lecture | How to get data and parse web data + PANDAS |
| Future lectures | How to model data |

# Background

- The Data Science Process:

Ask an interesting question

Get the Data

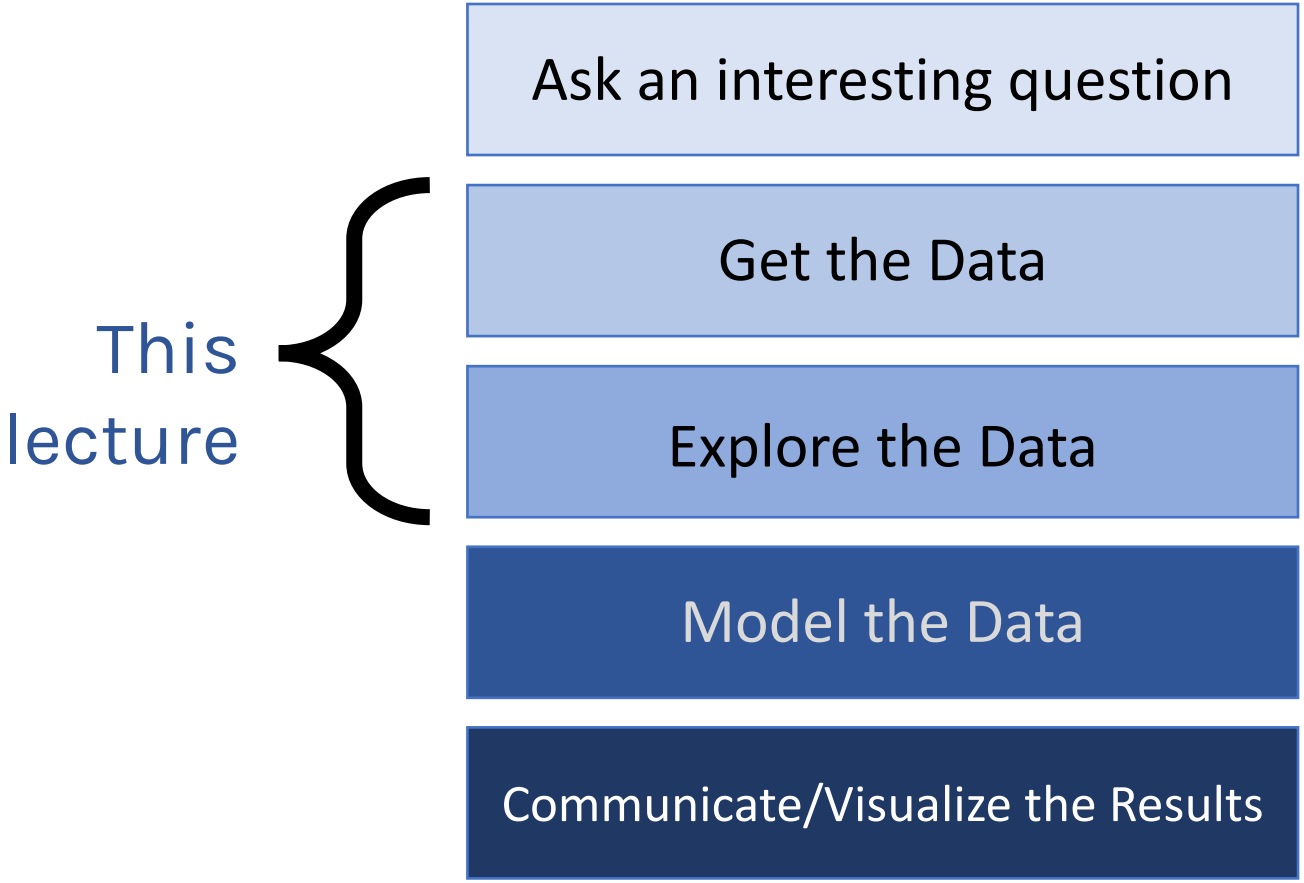
Explore the Data

Model the Data

Communicate/Visualize the Results

# Background

- The Data Science Process:



# Learning Objectives

- Understand different ways to obtain it
- Be able to extract any web content of interest
- Be able to do basic PANDAS commands to store and explore data
- Feel comfortable using online resources to help with these libraries (Requests, BeautifulSoup, and PANDAS)

# Agenda

- How to get web data?
- How to parse basic elements using BeautifulSoup
- Getting started with PANDAS

# What are common sources for data?

(For Data Science and computation purposes.)

# Obtaining Data

## Data can come from:

- You curate it
- Someone else provides it, all pre-packaged for you (e.g., files)
- Someone else provides an API
- Someone else has available content, and you try to take it (web scraping)

## Web scraping

- Using programs to get data from online
- Often much faster than manually copying data!
- Transfer the data into a form that is compatible with your code
- Legal and moral issues (per Lecture 2)

## Why scrape the web?

- Vast source of information; can combine with multiple datasets
- Companies have not provided APIs
- Automate tasks
- Keep up with sites / real-time data
- Fun!

## Web scraping tips:

- Be careful and polite
- Give proper credit
- Care about media law / obey licenses / privacy
- Don’t be evil (no spam, overloading sites, etc)

## Robots.txt

- Specified by web site owner
- Gives instructions to web robots (e.g., your code)
- Located at the top-level directory of the web server
  - E.g., http://google.com/robots.txt

## Web Servers

- A server maintains a long-running process (also called a daemon), which listens on a pre-specified port
- It responds to requests, which is sent using a protocol called HTTP (HTTPS is secure)
- Our browser sends these requests and downloads the content, then displays it
- 2– request was successful, 4– client error, often `page not found`; 5– server error (often that your request was incorrectly formed)

## HTML

- Tags are denoted by angled brackets
- Almost all tags are in pairs e.g., Hello
- Some tags do not have a closing tag e.g., <br/>

Example

```
<!DOCTYPE html>
<html>
  <head>
    <title>Ttle</title>
  </head>
  <body>
    <h1>Body Title</h1>
    <p>Body Content</p>
  </body>
</html>
```

## HTML

- **<html>**, indicates the start of an html page
- **<body>**, contains the items on the actual webpage

  (text, links, images, etc)

  - **<p>**, the paragraph tag. Can contain text and links
  - **<a>**, the link tag. Contains a link url, and possibly a description of the link
  - **<input>**, a form input tag. Used for text boxes, and other user input
  - **<form>**, a form start tag, to indicate the start of a form
  - **<img>**, an image tag containing the link to an image

## How to Web scrape:

1. **Get** the webpage content
    - Requests (Python library) **gets** a webpage for you
2. **Parse** the webpage content
    - (e.g., find all the text or all the links on a page)
    - BeautifulSoup (Python library) helps you **parse** the webpage.
    - Documentation: http://crummy.com/software/BeautifulSoup

# The Big Picture Recap

| | |
|---|---|
| Data Sources | Files, APIs, Webpages (via `Requests`) |
| Data Parsing | Regular Expressions, Beautiful Soup |
| Data Structures/Storage | Traditional lists/dictionaries, PANDAS |
| Models | Linear Regression, Logistic Regression, kNN, etc |

**BeautifulSoup** only concerns webpage data

# Obtaining Data: Web scraping

1. **Get** the webpage content

Requests (Python library) **gets** a webpage for you

```
page = requests.get(url)
page.status_code
page.text
```

1. **Get** the webpage content

Requests (Python library) **gets** a webpage for you

```
page = requests.get(url)
page.status_code
page.content
```

Gets the status from the webpage request.

200 means success.

404 means page not found.

1. **Get** the webpage content

Requests (Python library) **gets** a webpage for you

```
page = requests.get(url)
page.status_code
page.content
```

Returns the content of the response, in bytes.

**2. Parse** the webpage content

BeautifulSoup (Python library) helps you **parse** a webpage

```
soup = BeautifulSoup(page, “html.parser”)
soup.title
page.title.text
```

## 2. **Parse** the webpage content

BeautifulSoup (Python library) helps you **parse** a webpage

```
soup = BeautifulSoup(page, “html.parser”)
soup.title
page.title.text
```

Returns the full context, including the title tag. e.g.,

```
<title data-rh="true">The New York Times – Breaking News</title>
```

## 2. **Parse** the webpage content

BeautifulSoup (Python library) helps you **parse** a webpage

```
soup = BeautifulSoup(page, "html.parser")
soup.title
page.title.text
```

Returns the text part of the title tag. e.g.,

`The New York Times – Breaking News`

## BeautifulSoup

- Helps make messy HTML digestible
- Provides functions for quickly accessing certain sections of HTML content

Example

```
import bs4
## get bs4 object
soup = bs4.BeautifulSoup(source)
## all a tags
soup.findAll('a')
## first a
soup.find('a')
## get all links in the page
link_list = [l.get('href') for l in soup.findAll('a')]
```

## HTML is a tree

- You don't have to access the HTML as a tree, though;
- Can immediately search for tags/content of interest (a la previous slide)

## Example

```
tree = bs4.BeautifulSoup(source)

## get html root node
root_node = tree.html

## get head from root using contents
head = root_node.contents[0]

## get body from root
body = root_node.contents[1]

## could directly access body
tree.body
```

# Exercise 1 time!

# PANDAS

Kung Fu Panda is property of DreamWorks and Paramount Pictures

## What / Why?

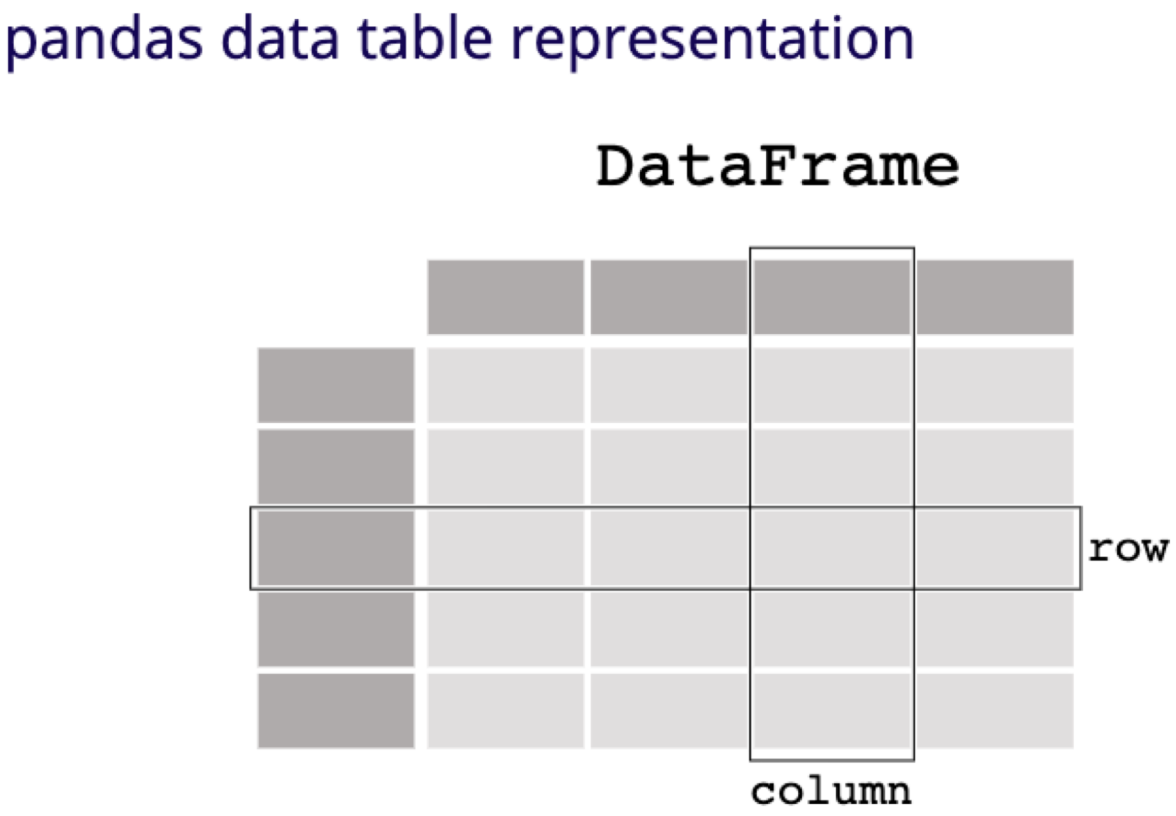
- Pandas is an *open-source* Python library (anyone can contribute)
- Allows for high-performance, easy-to-use data structures and data analysis
- Unlike NumPy library which provides multi-dimensional arrays, Pandas provides 2D table object called **DataFrame**
  (akin to a spreadsheet with column names and row labels).
- Used by *a lot* of people

## How

- import **pandas** library (convenient to rename it)
- Use **read_csv()** function

```
import pandas as pd
dataframe = pd.read_csv("yourfile.csv")
```

## What it looks like




Visit https://pandas.pydata.org/pandas-docs/stable/getting_started/intro_tutorials/01_table_oriented.html for a more in-depth walkthrough

# Example

- Say we have the following, tiny DataFrame of just 3 rows and 3 columns

```
>>> df2
   a  b  c
0  1  2  3
1  4  5  6
2  7  8  9
```

`df2['a']` selects column a

```
>>> df2['a']
0    1
1    4
2    7
```

`df2['a'] == 4` returns a Boolean list representing which rows of column a equal 4: [False, True, False]

`df2['a'].min()` returns 1 because that's the minimum value in the a column

`df2[['a', 'b']]` selects columns a and c

```
>>> df2[['a','c']]
   a  c
0  1  3
1  4  6
2  7  9
```

# Example continued

```
>>> df2
   a  b  c
0  1  2  3
1  4  5  6
2  7  8  9
```

`df2['a'].unique()` returns all distinct values of the a column once

`df2.loc[2]` returns a Series representing the row w/ the label 2

```
>>> df2.loc[2]
a    7
b    8
c    9
```

`df2.loc[df2['a'] == 4]` .loc returns all rows that were passed-in

[False, True, False]

```
>>> df2.loc[df2['a'] == 4]
   a  b  c
1  4  5  6
```

# Example continued

```
>>> df2
   a  b  c
0  1  2  3
1  4  5  6
2  7  8  9
```

`df2.iloc[2]` returns a Series representing the row at index 2 (NOT the row labelled 2. Though, they are often the same, as seen here)

`df2.sort_values(by=['c'])` returns the DataFrame with rows shuffled such that now they are in ascending order according to column c. In this example, df2 would remain the same, as the values were already sorted

## Common PANDAS functions

- **High-level viewing:**
- head() – first N observations
- tail() – last N observations
- describe() – statistics of the quantitative data
- dtypes – the data types of the columns
- columns – names of the columns
- shape – the # of (rows, columns)

## Common PANDAS functions

- **Accessing/processing:**
- df["column_name"]
- df.column_name
  - .max(), .min(), .idxmax(), .idxmin()
- <dataframe> <conditional statement>
- .loc[] – label-based accessing
- .iloc[] – index-based accessing
- .sort_values()
- .isnull(), .notnull()

# Common Panda functions

- **Grouping/Splitting/Aggregating:**
- groupby(), .get_groups()
- .merge()
- .concat()
- .aggegate()
- .append()

## Why?

- EDA encompasses the "*explore* data" part of the data science process
- EDA is crucial but often overlooked:
  - If your data is bad, your results will be bad
  - Conversely, understanding your data well can help you create smart, appropriate models

# What?

1. Store data in data structure(s) that will be convenient for exploring/processing
   (Memory is fast. Storage is slow)
2. Clean/format the data so that:
   - Each row represents a single object/observation/entry
   - Each column represents an attribute/property/feature of that entry
   - Values are numeric whenever possible
   - Columns contain atomic properties that cannot be further decomposed*

* Unlike food waste, which can be composted.
Please consider composting food scraps.

# What? (continued)

3. Explore **global** properties: use histograms, scatter plots, and aggregation functions to summarize the data
4. Explore **group** properties: group like-items together to compare subsets of the data (are the comparison results reasonable/expected?)

This process transforms your data into a format which is easier to work with, gives you a basic overview of the data's properties, and likely generates several questions for you to follow-up in subsequent analysis.

# Up Next

We will address EDA more and dive into Advanced PANDAS operations

# Exercise 2 time!