Data Analysis – Modeling and Parsing

15-110 – Monday 11/14

Announcements

- **Hw5** was due today
  - How did it go?

- **Exam2** grades released
  - Median: 77.5. A little low, probably because #3 was harder than intended.
  - We've curved the exam by **3 points** to make up for this.
    - Note that this too-difficult curve **only applies to #3**. If you struggled on some of the other problems (especially #4 or #9), you should practice those topics to build up fluency with the concepts!

New Unit: CS as a Tool

Our next unit focuses on how computer science can be used to benefit other domains.

We'll investigate three different applications of computer science: **data analysis**, **simulation**, and **machine learning**.

These three applications share a core idea in common: all three **organize data** to **help people answer questions**.

Hw6 – Introduction

Hw6 and its Checks work differently from the prior assignments. Instead of solving a bunch of small problems, you'll build a **guided project** that uses one of the three applications to solve an interesting problem in another field using programming.

The programming problems in Check6-1 will support the work in Check6-2, and the code from both will support the work in Hw6.

Because of this, **revision deadlines are earlier for these assignments**. Make sure to start each assignment promptly!

(There are also short written assignments for Check6-1 and Check6-2 that cover the lecture content – don't forget to do those too).

Hw6 – Getting Started

To get started on Hw6, review the **General Guidelines:**

https://www.cs.cmu.edu/~110/hw/hw6_general.pdf

Once you've picked a project, download the instructions & starter files from the table at the bottom of the assignments page:

https://www.cs.cmu.edu/~110/assignments.html

Then fill out this form to let us know which project you're doing (deadline **Friday 11/18 at noon**):

https://forms.gle/rV7PAxJ1r1iBrzkK7

Learning Goals

- Identify whether features in a dataset are **categorical**, **ordinal**, or **numerical**
- Interpret data according to different **protocols:** CSV and JSON
- Use string operations and methods to extract data from **plaintext**
- **Reformat** data to find, add, remove, or reinterpret pre-existing data

Data Analysis

Data Analysis Gains Insights on Data

Data Analysis is the process of using computational or statistical methods to **gain insights** about data.

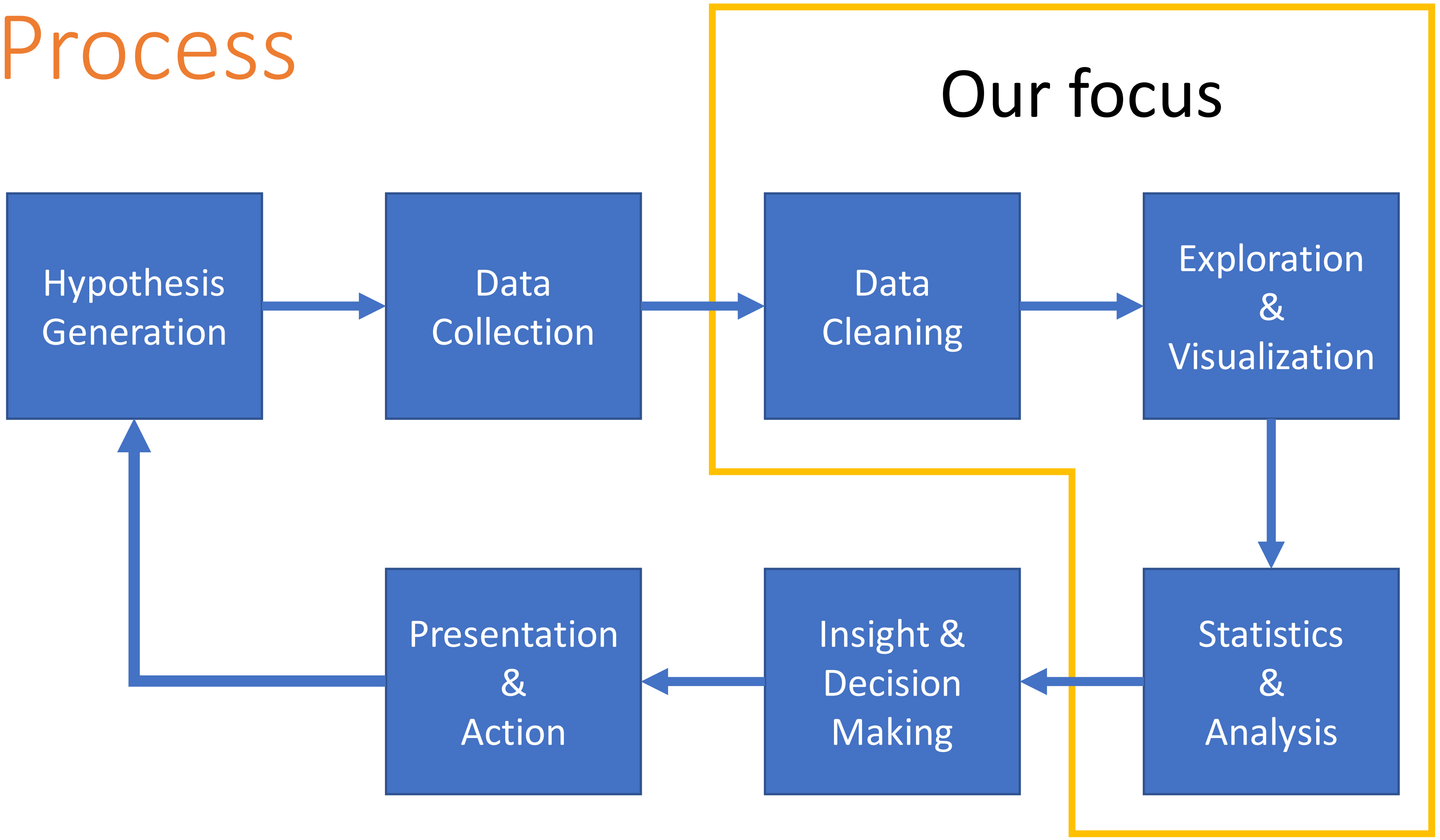
Data Analysis is used widely by many organizations to answer questions in many different domains. It plays a role in everything from advertising and fraud detection to airplane routing and political campaigns.

Data Analysis is also used widely in **logistics**, to determine how many people and how much stock is needed and where they should go.

Data Analysis Process

The full process of data analysis involves multiple steps to acquire data, prepare it, analyze it, and make decisions based on the results.

We'll focus mainly on three steps: Data Cleaning, Exploration & Visualization, and Statistics & Analysis



Data is Complicated

Before diving into data analysis, we have to ask a general question. What does data **look** like?

Data varies greatly based on the context; every problem is unique.

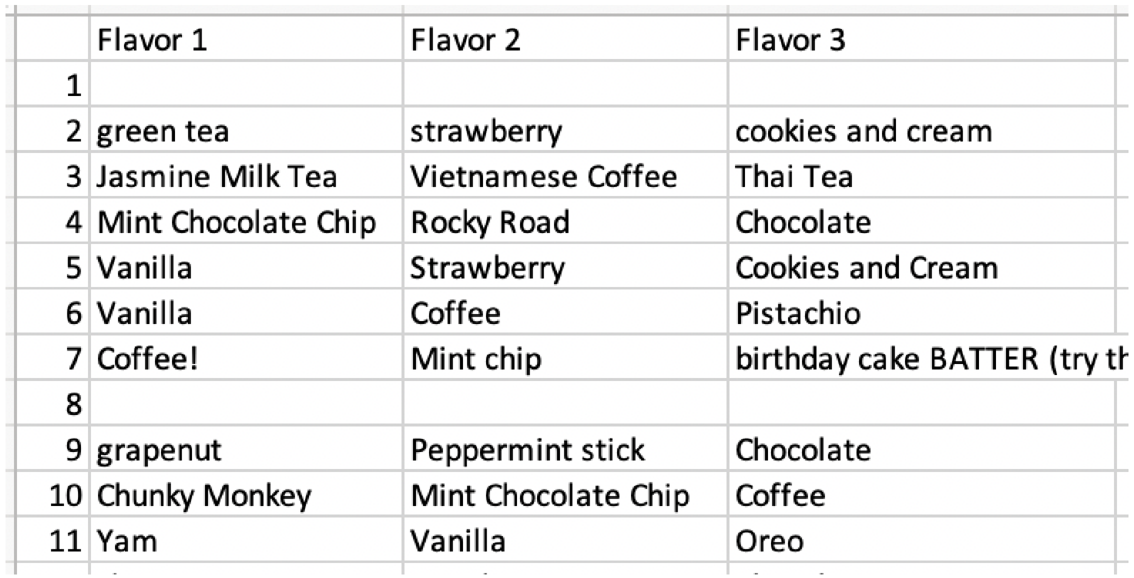
Example: let's collect our own data! Fill out the following short survey: https://bit.ly/110-ice-cream-f22

Data is Messy

Let's look at the results of our ice cream data.

Most likely, there are some **irregularities** in the data. Some flavors are capitalized; others aren't. Some flavors might have typos. Some people who don't like ice cream might have put 'n/a', or 'none', or 'I'm lactose intolerant'. And some flavors might have multiple names – 'green tea' vs. 'matcha'.

Data Cleaning is the process of taking raw data and smoothing out all these differences. It can be partially automated (all flavors are automatically made lowercase) but usually requires some level of human intervention.



	Flavor 1	Flavor 2	Flavor 3
1			
2	green tea	strawberry	cookies and cream
3	Jasmine Milk Tea	Vietnamese Coffee	Thai Tea
4	Mint Chocolate Chip	Rocky Road	Chocolate
5	Vanilla	Strawberry	Cookies and Cream
6	Vanilla	Coffee	Pistachio
7	Coffee!	Mint chip	birthday cake BATTER (try th
8			
9	grapenut	Peppermint stick	Chocolate
10	Chunky Monkey	Mint Chocolate Chip	Coffee
11	Yam	Vanilla	Oreo

Three Types of Data

When we work with simple data, that data often falls into one of three types. These types will determine what analyses we run.

Categorical: Data fall into one of several categories. Those categories are separate and cannot be compared.

Example: style of house (ranch, split-level, two-story, duplex, Victorian, etc.)

Ordinal: Data fall into separate categories, but those categories **can** be compared – they have a specific **order**.

Example: what is the condition of the house? (poor, fair, good, excellent, new)

Numerical: Data are **numbers**. We can perform mathematical operations on it and compare it to other data.

Example: how large is the house in square feet?

Activity: Data types

You do: what type of data are our ice cream flavors – categorical, ordinal, or numerical?

What if we added a column asking how many times the person ate ice cream in the past week? Would that be categorical, ordinal, or numerical?

Data Formats – CSV and JSON

Data has Many Different Formats

When reading data from a file, you need to determine what the **structure** of that data is. That will inform how you store the data in Python.

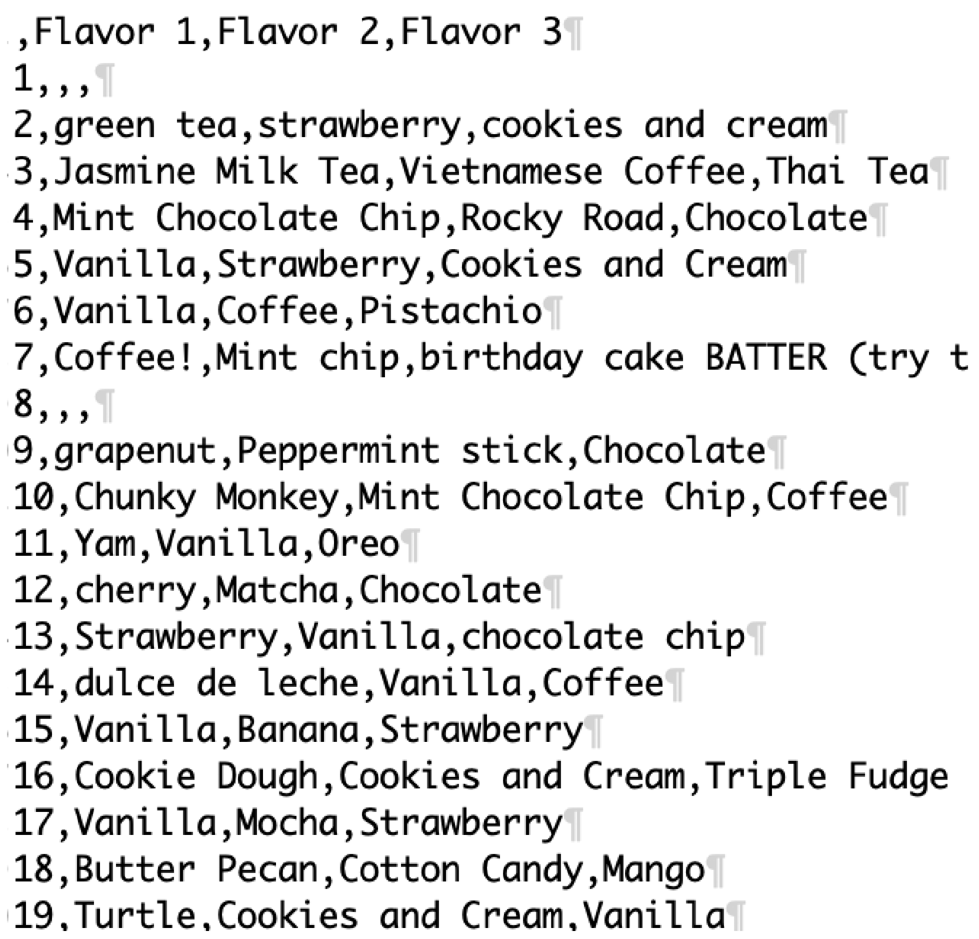
We'll discuss two formats here: CSV and JSON. Then we'll discuss how to deal with plaintext (text data not in a specific format). Many other formats exist, though!

CSV Files are Like Spreadsheets

First, **Comma-Separated Values (CSV)** files store data in two dimensions. They're effectively spreadsheets.

The data we collected on ice cream was downloaded as a CSV. If we open it in a plain text editor, you can see that values are separated by **commas**.

These files don't always have to use commas as separators, but they do need a **delimiter** to separate values (maybe spaces or tabs).



```
,Flavor 1,Flavor 2,Flavor 3¶
1,,,¶
2,green tea,strawberry,cookies and cream¶
3,Jasmine Milk Tea,Vietnamese Coffee,Thai Tea¶
4,Mint Chocolate Chip,Rocky Road,Chocolate¶
5,Vanilla,Strawberry,Cookies and Cream¶
6,Vanilla,Coffee,Pistachio¶
7,Coffee!,Mint chip,birthday cake BATTER (try t
8,,,¶
9,grapenut,Peppermint stick,Chocolate¶
10,Chunky Monkey,Mint Chocolate Chip,Coffee¶
11,Yam,Vanilla,Oreo¶
12,cherry,Matcha,Chocolate¶
13,Strawberry,Vanilla,chocolate chip¶
14,dulce de leche,Vanilla,Coffee¶
15,Vanilla,Banana,Strawberry¶
16,Cookie Dough,Cookies and Cream,Triple Fudge
17,Vanilla,Mocha,Strawberry¶
18,Butter Pecan,Cotton Candy,Mango¶
19,Turtle,Cookies and Cream,Vanilla¶
```

Reading CSV Data into Python

We could open a CSV file as plaintext and parse the file as we read it. Or we could use the **csv library** to make reading the file easier.

This library creates a **Reader** object out of a File object. That object can be cast to a 2D list, where each inner list corresponds to a line in the file, and the elements on the line (as separated by the delimiter) are the elements of the inner lists.

We can pass keyword arguments into the `csv.reader` call to set the delimiter.

```
import csv

f = open("icecream.csv", "r")
reader = csv.reader(f)

data = list(reader)
print(data)

f.close()
```

Writing CSV Data to a File

What if we've processed data in a 2D list and want to save it as a CSV file?

Create a CSV **Writer** object based on a file. You can use it to write the 2D list using `writer.writerows(row)`.

Again, the delimiter can be set to values other than a comma by updating the optional parameters.

```
import csv

data = [[ "chocolate", "mint chocolate",
           "peppermint" ],
         [ "vanilla", "matcha", "coffee" ],
         [ "strawberry", "mango", "cherry" ]]

f = open("results.csv", "w", newline="")
writer = csv.writer(f)

writer.writerows(data)

f.close()
```

JSON Files are Like Trees

Second, **JavaScript Object Notation (JSON)** files store data that is **nested**, like trees. They are commonly used to store information that is organized in some structured way.

```
{
  "vanilla" : 10,
  "chocolate" : {
                  "chocolate" : 15,
                  "chocolate chip" : 7,
                  "mint chocolate chip" : 5
                },
  "other" : [ "strawberry", "matcha", "coffee" ]
}
```

JSON files can store data types including Booleans, numbers, strings, lists, dictionaries, and any combination of the above.

Reading JSON Files into Python

The easiest way to read a JSON file into Python is to use the **JSON library**.

This time, we'll use `json.load(file)`. This function reads text from a file and produces a piece of data that matches the type of the outermost data in the text (usually a list or dictionary).

In our example from the last slide, the function would produce a dictionary mapping strings to integers, dictionaries, and lists.

```
import json

f = open("icecream.json", "r")
j = json.load(f)

print(j)

f.close()
```

Writing JSON Data to a File

What if we want to store JSON data in a file for later use?

Again, use the JSON library. The `json.dump(value, file)` method will take a JSON-compatible value and write it to a file in JSON format.

```
import json

d = { "vanilla" : 10,
      "chocolate" : 27,
      "other" : [ "strawberry", "matcha", "coffee" ]
    }

f = open("results.json", "w")
json.dump(d, f)
f.close()
```

Activity: Match Data Structure to Format

You do: which data format would you use to store the following types of data?

A) A hierarchical representation of employees in a company, organized based on who reports to whom.

B) A table of tax data where each person in the table has several columns of financial information.

Extracting Data from Plaintext

Reading Plaintext Data

A lot of the data we work with might not fit nicely into either a CSV or JSON format. If we can read this data in a simple text editor but can't fit it into a standard format, we call it **plaintext data**.

To work with plaintext, you need to identify what kinds of **patterns** exist in the data and use that information to structure it. The patterns you identify may depend on which question you're trying to answer.

Questions to Ask

When parsing data in a plaintext file, start by identifying the pattern; then ask yourself a few questions about that pattern.

- Does the pattern occur across lines, or some other delimiter?
- Where is the information in a single line/section?
- What comes before or after the information you want?

Tools to Use

Once you've identified where the information is located, use **string slicing** and **string methods** to separate out the information you need.

Slicing (`s[start:end:step]`) can be used to remove parts of the data that are unnecessary.

The **split** method (`s.split(".")`) can be used to break up data that is separated by a known delimiter.

The **index** method (`s.index(":")`) can be used to find the location of the beginning or end of a section. That can be combined with slicing or splitting to isolate the needed data.

The **strip** method (`s.strip()`) can be used to remove whitespace (spaces, tabs, and newlines) from the front and back of a string. This is useful for isolating the core text of a string.

Example: Parsing a Chat Log

`chat.txt` is a dataset based on a chat log from a previous class. (All student names have been modified to preserve student privacy).

How could we get the names of everyone who participated in the chat? What's the **pattern**?

```
14:54:28       From  Malika : Could I use recursion
for AuthorMap?
14:56:03       From  Ed : yep
15:00:22       From  Arman : what is str.digits?
15:01:21       From  Margaret Reid-Miller   to
Kelly Rivers(Privately) : We only hear the music
when you speak
15:08:31       From  Ed : how would you know if it
were O(n**.5)?
```

Example: Parsing a Chat Log

Each message occurs on an individual line; split the text based on newlines (`"\n"`).

`"From"` occurs before each name and `" : "` occurs afterwards. `index` to find those locations and slice based on them.

Use `strip` to clear extra whitespace.

```
f = open("chat.txt", "r")
text = f.read()
f.close()

people = [ ]
for line in text.split("\n"):
    start = line.index("From") + \
            len("From")
    line = line[start:]
    end = line.index(" : ")
    line = line[:end]
    line = line.strip()
    people.append(line)
print(people)
```

Example: Parsing a Chat Log

A few lines don't match the pattern; account for those too.

If statements are useful when something breaks a pattern.

```
...
    line = line[:end]
    if "(Privately)" in line:
        end = line.index("to")
        line = line[:end]
    line = line.strip()
...
```

Modifying Data

Reformatting Data

Once we've parsed our data into an appropriate format, we may need to change the structure to achieve the analysis we want. This is very common in data analysis.

Let's assume that we're working with a 2D list produced from the ice cream data. How can we:

- change all the flavors to be lowercase?
- remove the timestamps from the dataset?
- add a new column that counts the number of chocolatey favorites?

Update Values with Index Assignment

To **update** a value, access the appropriate column in each row and change it.

For example, you might want to convert a string to a different type via type-casting.

```
# Assume data is a 2D list parsed from the file
for row in range(len(data)):
    for col in range(len(data[row])):
        # Make all flavors lowercase
        data[row][col] = data[row][col].lower()
print(data)
```

Remove Values with pop()

To **remove** a value, pop an element of each row based on the column that needs to be removed.

For example, you might want to remove user IDS when anonymizing data.

```
# Assume data is a 2D list parsed from the file
for row in range(len(data)):
    data[row].pop(0) # remove the ID
    for col in range(len(data[row])):
        # Make all flavors lowercase
        data[row][col] = data[row][col].lower()
print(data)
```

Add Values with append()/insert()

To **add** a value, append or insert a new value into each row, potentially based on the pre-existing values.

You can add data from a separate-but-connected dataset, or by performing small analyses on the existing data.

```
# Assume data is a 2D list parsed from the file
for row in range(len(data)):
    data[row].pop(0) # remove the ID
    chocCount = 0 # count number of chocolate
    for col in range(len(data[row])):
        # Make all flavors lowercase
        data[row][col] = data[row][col].lower()
        if "chocolate" in data[row][col]:
            chocCount += 1
    # track chocolate count
    data[row].append(chocCount)
print(data)
```

Headers are Special Cases

When using **headers**, make sure to treat them appropriately!

It's often easiest to skip the 0th row in the loop and deal with it separately instead.

```python
# Assume data is a 2D list parsed from the file
for row in range(len(data)):
    data[row].pop(0) # remove the ID
    chocCount = 0 # count number of chocolate
    for col in range(len(data[row])):
        # Make all flavors lowercase
        data[row][col] = data[row][col].lower()
        if "chocolate" in data[row][col]:
            chocCount += 1
    # track chocolate count
    if row == 0:
        data[row].append("# chocolate")
    else:
        data[row].append(chocCount)
print(data)
```

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- **Reformat** data to find, add, remove, or reinterpret pre-existing data