

INTRODUCTION TO DATA SCIENCE

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Lecture #16 – 10/22/2018

CMSC320

Mondays & Wednesdays

2:00pm – 3:15pm



COMPUTER SCIENCE
UNIVERSITY OF MARYLAND

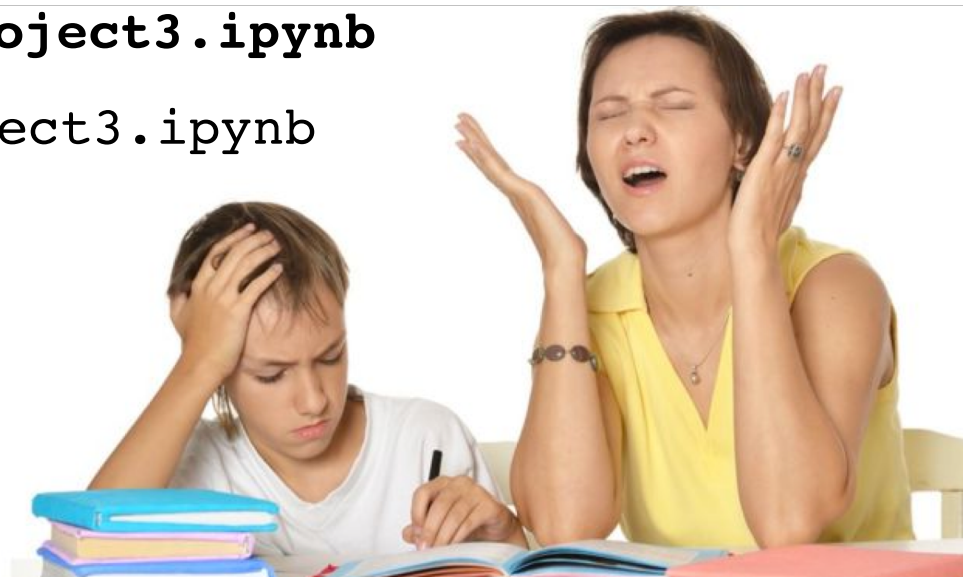
ANNOUNCEMENTS

Mini-Project #3 is **not out yet! Will be out after the midterm.**

- It will be linked to from ELMS; will also be available at:
<https://github.com/umddb/cmsc641-fall2018/tree/master/project3>
- Deliverable is a .ipynb file submitted to ELMS
- Due **before Thanksgiving (TBD)**

**Please label your ipynb file something like
<lastname>_<firstname>_project3.ipynb**

- E.g., dickerson_john_project3.ipynb



PROJECT 1 GRADES ARE UP!



General comments:

People did really well!

We used a fairly strict rubric, but if you have a real bone to pick with your grade, please triage through TAs/office hours!

Comments for our sanity, moving forward:

- `df.head(n)` -- defaults to `n = 5`, use `~10`, `20`, `50` as needed
- Please label your `ipynb` file something like `<lastname>_<firstname>_project3.ipynb`
- E.g., `dickerson_john_project3.ipynb`

COMMON ISSUE

A value is trying to be set on a copy of a slice from a DataFrame

Often not a problem! But, sometimes a problem ...

Example:

- `df[df['intensity'] > 0.1]['color'] = 'red'`
- `???????????`
- This will not set a value in df – assignment is **chained**
- Instead, use `df.loc[df['intensity'] > 0.1, 'color'] = 'red'`

MIDTERM: STRUCTURE

50 points = 25% of the total grade

10 points:

- 10 True/False questions, 1 point each

10 points:

- 5 multiple choice questions, 2 points each

30 points:

- 10 short answer questions, 3 points each

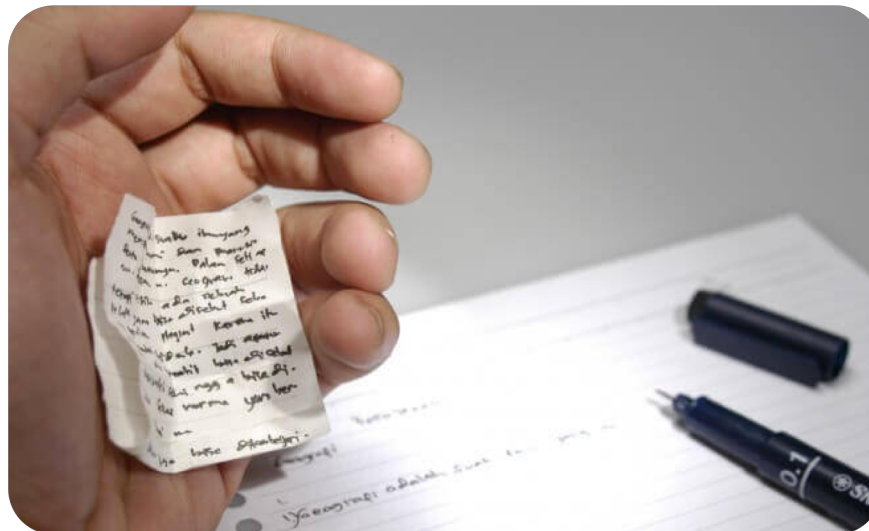
Compared to the CMSC320 midterm I posted from last semester, this midterm is **shorter.**

MIDTERM: CHEAT SHEET

You can use a **cheat sheet** on the exam:

- Create it on your own
- Handwritten notes only
- One side of one 8.5x11 inch ("normal-sized") sheet of paper

You'll turn in your cheat sheet with your midterm



QUICK MIDTERM REVIEW

As discussed in previous lectures and on Piazza, the midterm can cover:

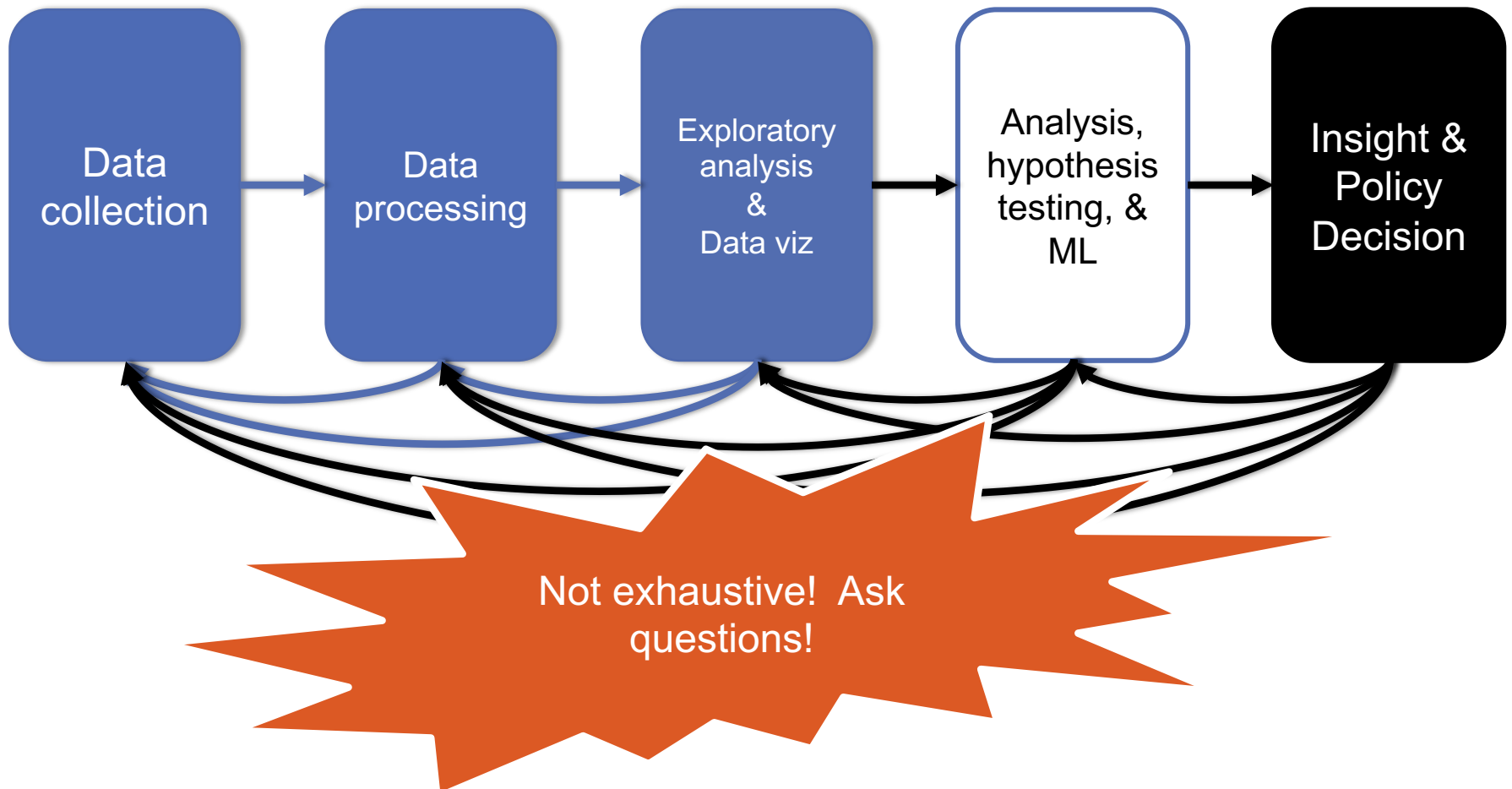
- Up to and including last Wednesday's lecture (10/17)
- Quizzes that were due on or before last Wednesday
- Stuff that you should know from doing P1 and P2

Everything is online: <http://www.cs.umd.edu/class/fall2018/cmsc320/>

I know this is a lot of material.

- Rule of thumb: open up a slide deck
- Do you feel “comfortable” with the material?
- Test will be more qualitative than prior 1xx, 2xx, 3xx tests

QUICK MIDTERM REVIEW



DATA COLLECTION (DC) & DATA PROCESSING (DP)

We talked about:

- **Scraping data**
- **RESTful APIs**
- **Structured data formats (JSON, XML, etc)**
- **Regexes**

Data manipulation via Numpy Stack (Numpy, Pandas, etc)

- **Indexing, slicing, groups, joins, aggregate queries, etc**

Tidy data + melting

Version control (just know how this works qualitatively)

RDMS, a little bit of SQL

Entity resolution & other data integration issues

Storing stuff as a graph, and manipulating it

DC: HTTP REQUESTS

`https://www.google.com/?q=cmssc320&tbs=qdr:m`



??????????

HTTP GET Request:

GET `/?q=cmssc320&tbs=qdr:m` HTTP/1.1

Host: `www.google.com`

User-Agent: `Mozilla/5.0 (X11; Linux x86_64; rv:10.0.1) Gecko/20100101 Firefox/10.0.1`

```
params = { "q": "cmssc320", "tbs": "qdr:m" }  
r = requests.get( "https://www.google.com",  
                  params = params )
```

*be careful with `https://` calls; `requests` will not verify SSL by default

DC: RESTFUL APIS

This class will just **query** web APIs, but full web APIs typically allow more.

Representational State Transfer (RESTful) APIs:

- **GET**: perform query, return data
- **POST**: create a new entry or object
- **PUT**: update an existing entry or object
- **DELETE**: delete an existing entry or object

Can be more intricate, but verbs (“put”) align with actions



DC: PANDAS: SERIES

index values

A	→	5
B	→	6
C	→	12
D	→	-5
E	→	6.7

- Subclass of `numpy.ndarray`
- Data: any type
- Index labels need not be ordered
- Duplicates possible but result in reduced functionality

DC: PANDAS: DATAFRAME

columns		foo	bar	baz	qux
index					
A	→	0	x	2.7	True
B	→	4	y	6	True
C	→	8	z	10	False
D	→	-12	w	NA	False
E	→	16	a	18	False

- Each column can have a different type
- Row and Column index
- Mutable size: insert and delete columns
- **Note the use of word “index” for what we called “key”**
 - Relational databases use “index” to mean something else
- **Non-unique index values allowed**
 - May raise an exception for some operations

DC: STORING A GRAPH

Three main ways to **represent** a graph in memory:

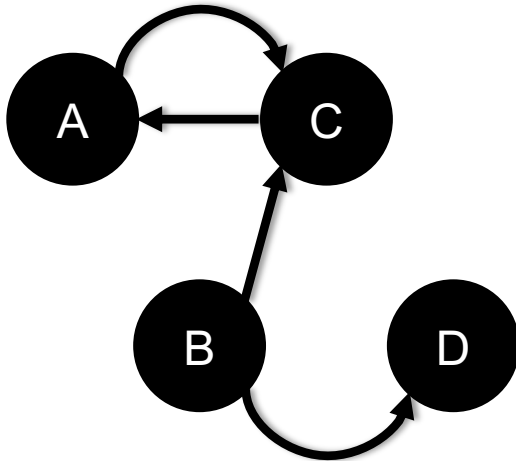
- Adjacency lists
- Adjacency dictionaries
- Adjacency matrix

The storage decision should be made based on the expected use case of your graph:

- Static analysis only?
- Frequent updates to the structure?
- Frequent updates to semantic information?

DC: ADJACENCY LISTS

For each vertex, store an array of the vertices it connects to



Vertex	Neighbors
A	[C]
B	[C, D]
C	[A]
D	[]

Pros: ?????????

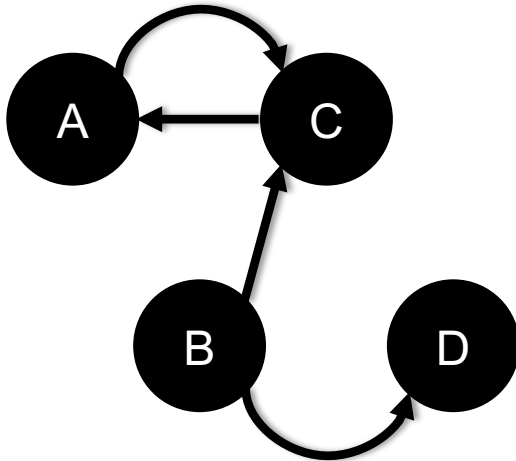
- Iterate over all outgoing edges; easy to add an edge

Cons: ?????????

- Checking for the existence of an edge is $O(|V|)$, deleting is hard

DC: ADJACENCY DICTIONARIES

For each vertex, store a dictionary of vertices it connects to



Vertex	Neighbors
A	{C: 1.0}
B	{C: 1.0, D: 1.0}
C	{A: 1.0}
D	{}

Pros: ??????????

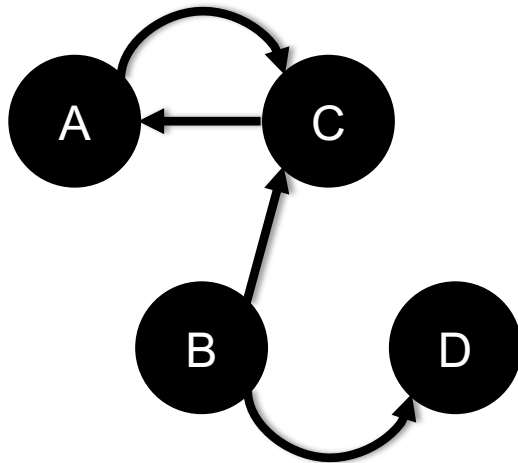
- $O(1)$ to add, remove, query edges

Cons: ??????????

- Overhead (memory, caching, etc)

DC: ADJACENCY MATRIX

Store the connectivity of the graph in a matrix



		From			
		A	B	C	D
To	A	0	0	1	0
	B	0	0	0	0
	C	1	1	0	0
	D	0	1	0	0

Cons: ??????????

- $O(|V|^2)$ space regardless of the number of edges

Almost always stored as a **sparse matrix**

DP: SELECT/SLICING

Select only some of the rows, or some of the columns, or a combination

ID	age	wgt_kg	hgt_cm
1	12.2	42.3	145.1
2	11.0	40.8	143.8
3	15.6	65.3	165.3
4	35.1	84.2	185.8

Only rows
with wgt > 41

ID	age	wgt_kg	hgt_cm
1	12.2	42.3	145.1
3	15.6	65.3	165.3
4	35.1	84.2	185.8

Only columns
ID and Age

ID	age
1	12.2
2	11.0
3	15.6
4	35.1

Both

ID	age
1	12.2
3	15.6
4	35.1

DP: AGGREGATE/REDUCE

Combine values across a column into a single value

ID	age	wgt_kg	hgt_cm
1	12.2	42.3	145.1
2	11.0	40.8	143.8
3	15.6	65.3	165.3
4	35.1	84.2	185.8

SUM

73.9 232.6 640.0

MAX

35.1 84.2 185.8

$\text{SUM}(\text{wgt_kg}^2 - \text{hgt_cm})$

14167.66

What about ID/Index column?

Usually not meaningful to aggregate across it
May need to explicitly add an ID column

DP: MAP

Apply a function to every row, possibly creating more or fewer columns

ID	Address
1	College Park, MD, 20742
2	Washington, DC, 20001
3	Silver Spring, MD 20901



ID	City	State	Zipcode
1	College Park	MD	20742
2	Washington	DC	20001
3	Silver Spring	MD	20901

Variations that allow one row to generate multiple rows in the output (sometimes called “flatmap”)

DP: GROUP BY

Group tuples together by
column/dimension

ID	A	B	C
1	foo	3	6.6
2	bar	2	4.7
3	foo	4	3.1
4	foo	3	8.0
5	bar	1	1.2
6	bar	2	2.5
7	foo	4	2.3
8	foo	3	8.0

By 'A'



A = foo

ID	B	C
1	3	6.6
3	4	3.1
4	3	8.0
7	4	2.3
8	3	8.0

A = bar

ID	B	C
2	2	4.7
5	1	1.2
6	2	2.5

DP: GROUP BY

Group tuples together by column/dimension

ID	A	B	C
1	foo	3	6.6
2	bar	2	4.7
3	foo	4	3.1
4	foo	3	8.0
5	bar	1	1.2
6	bar	2	2.5
7	foo	4	2.3
8	foo	3	8.0

By 'B' →

B = 1

ID	A	C
5	bar	1.2

B = 2

ID	A	C
2	bar	4.7
6	bar	2.5

B = 3

ID	A	C
1	foo	6.6
4	foo	8.0
8	foo	8.0

B = 4

ID	A	C
3	foo	3.1
7	foo	2.3

DP: GROUP BY

Group tuples together by
column/dimension

ID	A	B	C
1	foo	3	6.6
2	bar	2	4.7
3	foo	4	3.1
4	foo	3	8.0
5	bar	1	1.2
6	bar	2	2.5
7	foo	4	2.3
8	foo	3	8.0

By 'A', 'B'



A = bar, B = 1

ID	C
5	1.2

A = bar, B = 2

ID	C
2	4.7
6	2.5

A = foo, B = 3

ID	C
1	6.6
4	8.0
8	8.0

A = foo, B = 4

ID	C
3	3.1
7	2.3

DP: GROUP BY AGGREGATE

Compute one aggregate
Per group

ID	A	B	C
1	foo	3	6.6
2	bar	2	4.7
3	foo	4	3.1
4	foo	3	8.0
5	bar	1	1.2
6	bar	2	2.5
7	foo	4	2.3
8	foo	3	8.0

Group by 'B'
Sum on C

B = 1

ID	A	C
5	bar	1.2

B = 1

Sum (C)
1.2

B = 2

ID	A	C
2	bar	4.7
6	bar	2.5

B = 2

Sum (C)
7.2

B = 3

ID	A	C
1	foo	6.6
4	foo	8.0
8	foo	8.0

B = 3

Sum (C)
22.6

B = 4

ID	A	C
3	foo	3.1
7	foo	2.3

B = 4

Sum (C)
5.4

DP: GROUP BY AGGREGATE

Final result usually seen

As a table

ID	A	B	C
1	foo	3	6.6
2	bar	2	4.7
3	foo	4	3.1
4	foo	3	8.0
5	bar	1	1.2
6	bar	2	2.5
7	foo	4	2.3
8	foo	3	8.0

Group by 'B'
Sum on C

B = 1

Sum (C)
1.2

B = 2

Sum (C)
7.2

B = 3

Sum (C)
22.6

B = 4

Sum (C)
5.4



B	SUM(C)
1	1.2
2	7.2
3	22.6
4	5.4

DP:

UNION/INTERSECTION/DIFFERENCE

Set operations – only if the two tables have identical attributes/columns

ID	A	B	C
1	foo	3	6.6
2	bar	2	4.7
3	foo	4	3.1
4	foo	3	8.0

U

ID	A	B	C
5	bar	1	1.2
6	bar	2	2.5
7	foo	4	2.3
8	foo	3	8.0



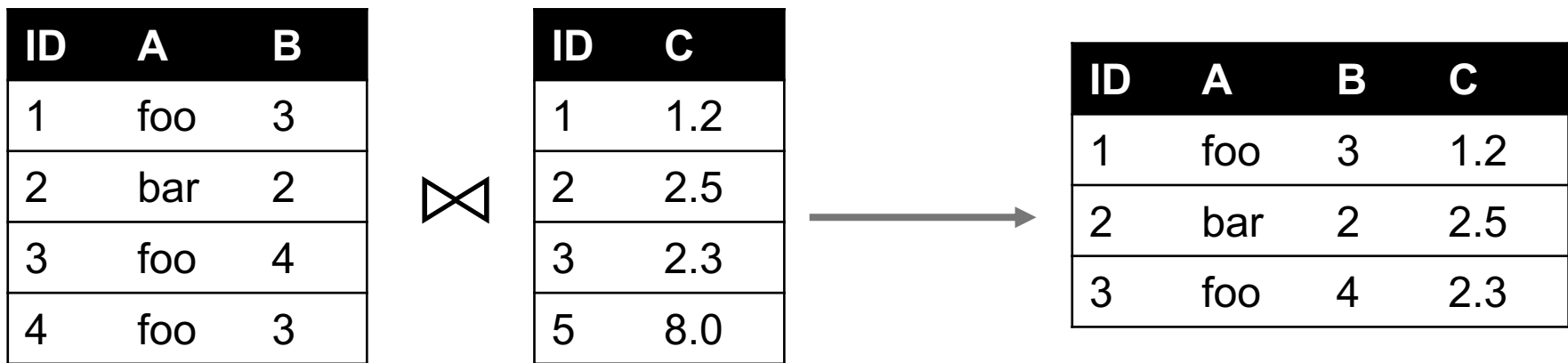
ID	A	B	C
1	foo	3	6.6
2	bar	2	4.7
3	foo	4	3.1
4	foo	3	8.0
5	bar	1	1.2
6	bar	2	2.5
7	foo	4	2.3
8	foo	3	8.0

Similarly Intersection and Set Difference manipulate tables as Sets

IDs may be treated in different ways, resulting in somewhat different behaviors

7. MERGE OR JOIN

Combine rows/tuples across two tables if they have the same key



What about IDs not present in both tables?

Often need to keep them around

Can “pad” with NaN

DP: MERGE OR JOIN

Combine rows/tuples across two tables if they have the same key

Outer joins can be used to "pad" IDs that don't appear in both tables

Three variants: LEFT, RIGHT, FULL

SQL Terminology -- Pandas has these operations as well

ID	A	B
1	foo	3
2	bar	2
3	foo	4
4	foo	3



ID	C
1	1.2
2	2.5
3	2.3
5	8.0

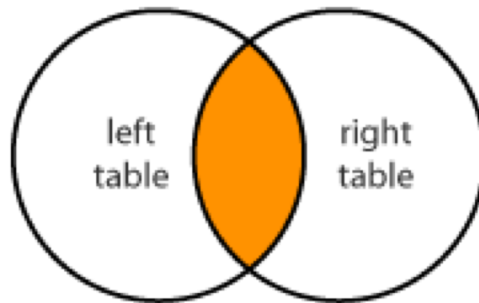


ID	A	B	C
1	foo	3	1.2
2	bar	2	2.5
3	foo	4	2.3
4	foo	3	NaN
5	NaN	NaN	8.0

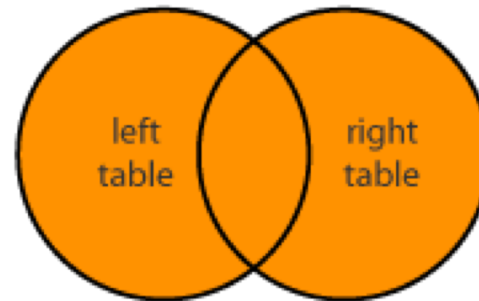
DP: GOOGLE IMAGE SEARCH

ONE SLIDE SQL JOIN VISUAL

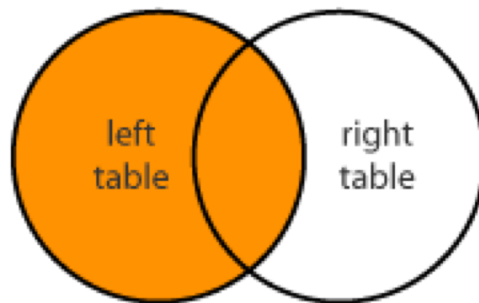
INNER JOIN



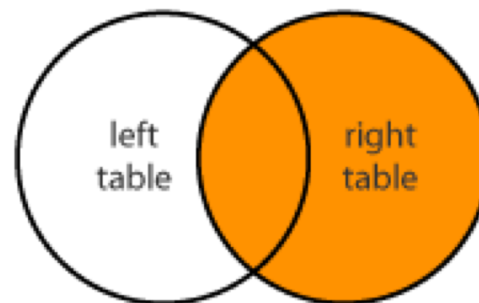
FULL JOIN



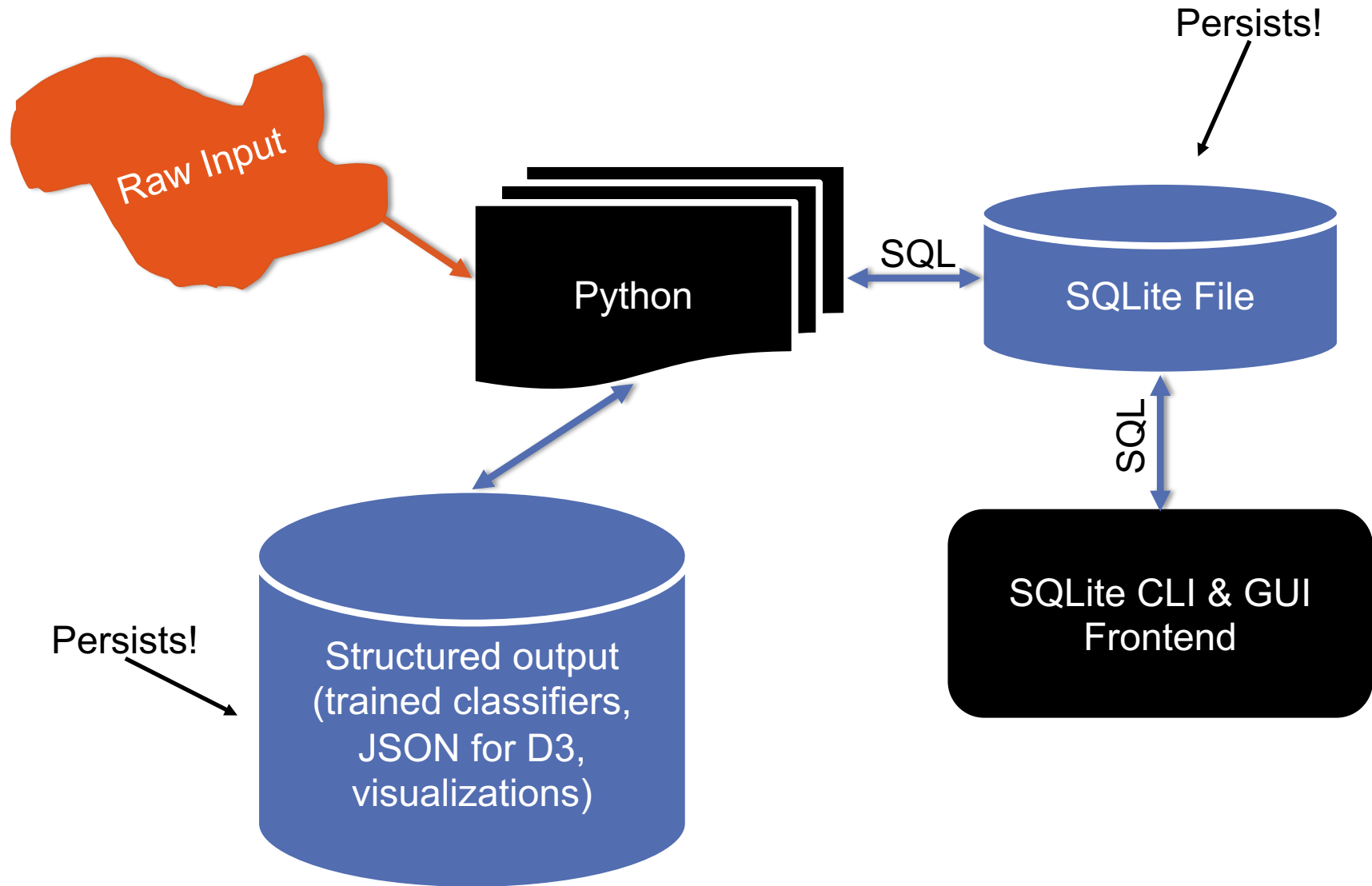
LEFT JOIN



RIGHT JOIN



DC/DP: HOW A RELATIONAL DB FITS INTO YOUR WORKFLOW



EDA & VIZ

Missing data

- MCAR
- MAR
- MNAR
- Single & multiple imputation

Analysis

- Basic linear regression
- Outlier detection
- Summary statistics / robust statistics
- Variance, stdev, covariance, Pearson's correlation coefficient
- Hypothesis testing
- Bayes' rule

EDA: MISSING DATA

Missing data is information that we want to know, but don't

It can come in many forms, e.g.:

- People not answering questions on surveys
- Inaccurate recordings of the height of plants that need to be discarded
- Canceled runs in a driving experiment due to rain

Could also consider missing columns (no collection at all) to be missing data ...

EDA: COMPLETE CASE ANALYSIS

Delete all tuples with any missing values at all, so you are left only with observations with all variables observed

```
# Clean out rows with nil values  
df = df.dropna()
```

Default behavior for libraries for analysis (e.g., regression)

- We'll talk about this much more during the Stats/ML lectures

This is the simplest way to handle missing data. In some cases, will work fine; in others, ??????????:

- Loss of sample will lead to variance larger than reflected by the size of your data
- May bias your sample



EDA: YOUR SAMPLE

Hair Color	Gender	Grade
Red	M	A
Brown	F	A
Black	F	B
Black	M	A
Brown	M	
Brown	M	
Brown	F	
Black	M	B
Black	M	B
Brown	F	A
Black	F	
Brown	F	C
Red	M	
Red	F	A
Brown	M	A
Black	M	A

Summary:

- 7 students received As
- 3 students received Bs
- 1 student received a C

Nobody is failing!

- But 5 students did not reveal their grade ...

EDA: WHAT INFLUENCES A DATA POINT'S PRESENCE?

Same dataset, but the values are replaced with a “0” if the data point is observed and “1” if it is not

Question: for any one of these data points, what is the probability that the point is equal to “1” ...?

What type of missing-ness do the grades exhibit?

Hair Color	Gender	Grade
0	0	0
0	0	0
0	0	0
0	0	0
0	0	1
0	0	1
0	0	1
0	0	0
0	0	0
0	0	0
0	0	1
0	0	0
0	0	1
0	0	0
0	0	0
0	0	0

EDA: MCAR: MISSING COMPLETELY AT RANDOM

If this probability is not dependent on **any** of the data, observed or unobserved, then the data is Missing Completely at Random (MCAR)

Suppose that X is the observed data and Y is the unobserved data. Call our “missing matrix” R

Then, if the data are MCAR, $P(R|X,Y) = \text{??????????}$

$$P(R|X,Y) = P(R)$$

Probability of those rows missing is **independent** of anything.

EDA: MAR: MISSING AT RANDOM

Missing at Random (MAR): probability of missing data is dependent on the observed data but not the unobserved data

Suppose that X is the observed data and Y is the unobserved data. Call our “missing matrix” R

Then, if the data are MAR, $P(R|X,Y) = \text{??????????}$

$$P(R|X,Y) = P(R|X)$$

Not exactly random (in the vernacular sense).

- There is a probabilistic mechanism that is associated with whether the data is missing
- Mechanism takes the observed data as input

EDA: MNAR: MISSING NOT AT RANDOM

MNAR: missing-ness has something to do with the missing data itself

Examples: ????????????

- Do you binge drink? Do you have a trust fund? Do you use illegal drugs? What is your sexuality? Are you depressed?

Said to be “non-ignorable”:

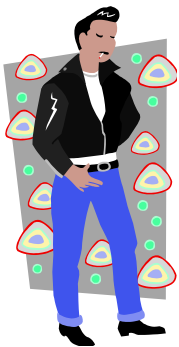
- Missing data mechanism must be considered as you deal with the missing data
- Must include model for why the data are missing, and best guesses as to what the data might be

EDA: BACK TO CSIC ...

Is the the missing data:

- MCAR;
- MAR; or
- MNAR?

????????????



Hair Color	Gender	Grade
Red	M	A
Brown	F	A
Black	F	B
Black	M	A
Brown	M	
Brown	M	
Brown	F	
Black	M	B
Black	M	B
Brown	F	A
Black	F	
Brown	F	C
Red	M	
Red	F	A
Brown	M	A
Black	M	A

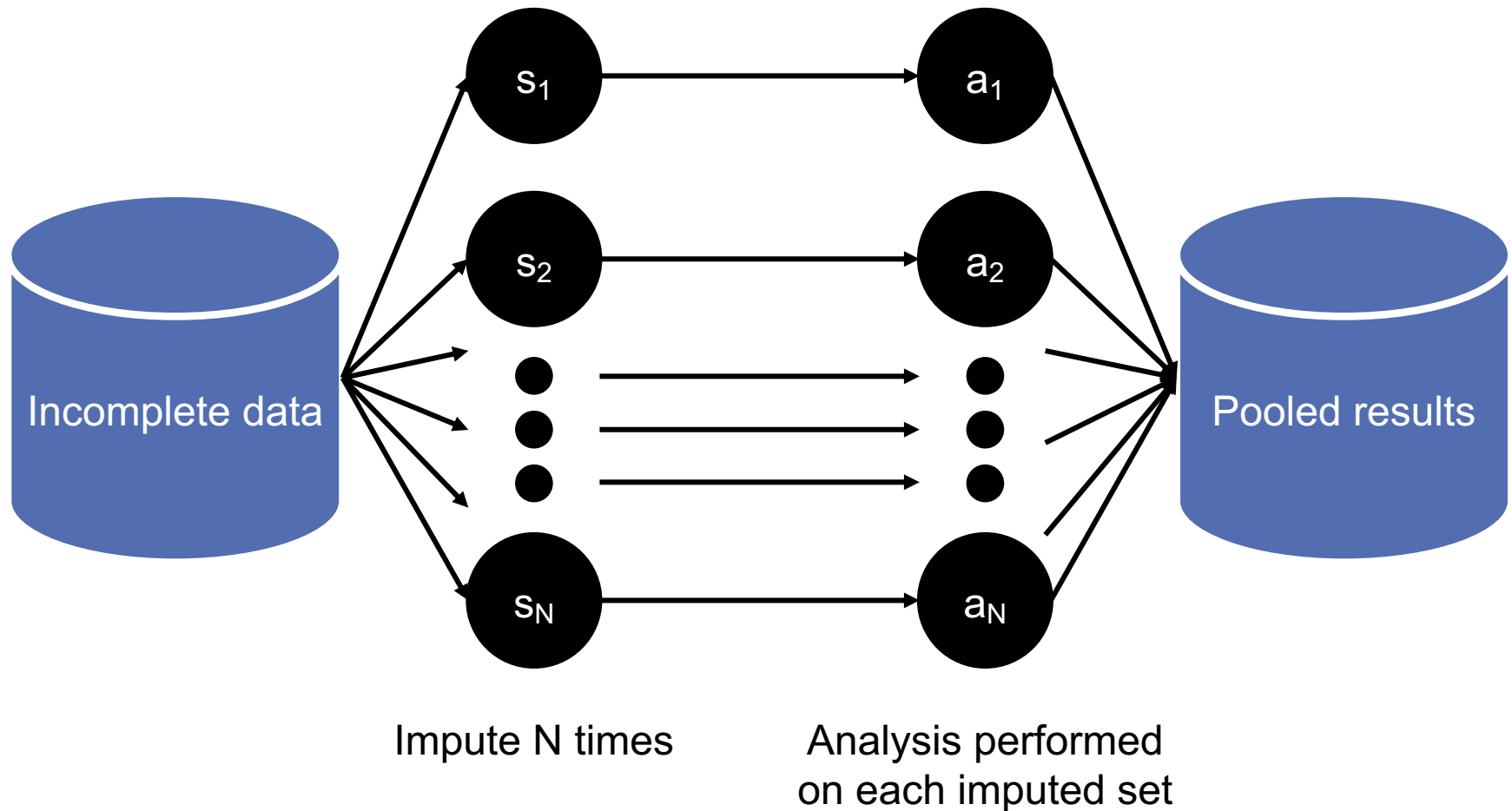
EDA: ADD A VARIABLE

Bring in the GPA:

Does this change anything?

Hair Color	GPA	Gender	Grade
Red	3.4	M	A
Brown	3.6	F	A
Black	3.7	F	B
Black	3.9	M	A
Brown	2.5	M	
Brown	3.2	M	
Brown	3.0	F	
Black	2.9	M	B
Black	3.3	M	B
Brown	4.0	F	A
Black	3.65	F	
Brown	3.4	F	C
Red	2.2	M	
Red	3.8	F	A
Brown	3.8	M	A
Black	3.67	M	A

EDA: MULTIPLE IMPUTATION PROCESS



ANALYSIS: IMPORTANCE OF VERTICES

Not all vertices are equally important

Centrality Analysis:

- Find out the most important node(s) in one network
- Used as a feature in classification, for visualization, etc ...

Commonly-used Measures

- Degree Centrality
- Closeness Centrality
- Betweenness Centrality
- Eigenvector Centrality

ANALYSIS: DEGREE CENTRALITY

The importance of a vertex is determined by the number of vertices adjacent to it

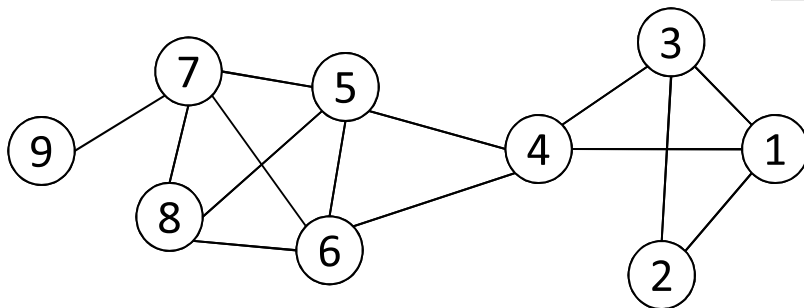
- The larger the degree, the more important the vertex is
- Only a small number of vertex have high degrees in many real-life networks

Degree Centrality:

$$C_D(v_i) = d_i = \sum_j A_{ij}$$

Normalized Degree Centrality:

$$C'_D(v_i) = d_i / (n - 1)$$



For vertex 1, degree centrality is 3;
Normalized degree centrality is
 $3/(9-1)=3/8$.

ANALYSIS: BETWEENNESS CENTRALITY

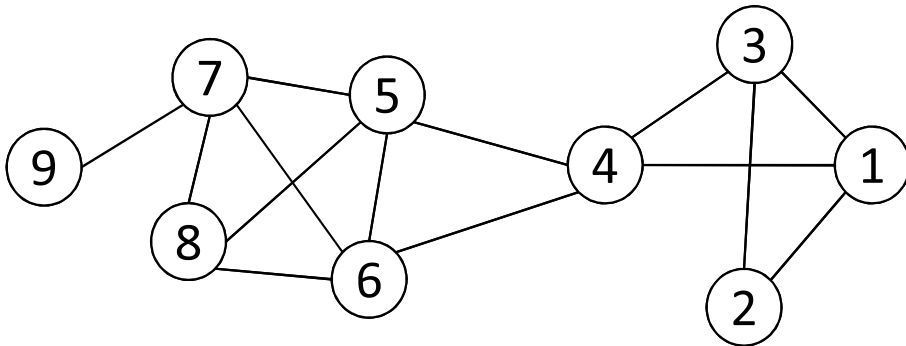


Table 2.2: $\sigma_{st}(4)/\sigma_{st}$

	$s = 1$	$s = 2$	$s = 3$
$t = 5$	1/1	2/2	1/1
$t = 6$	1/1	2/2	1/1
$t = 7$	2/2	4/4	2/2
$t = 8$	2/2	4/4	2/2
$t = 9$	2/2	4/4	2/2

σ_{st} : The number of shortest paths between s and t

$\sigma_{st}(v_i)$: The number of shortest paths between s and t that pass v_i

$$C_B(v_i) = \sum_{v_s \neq v_i \neq v_t \in V, s < t} \frac{\sigma_{st}(v_i)}{\sigma_{st}}$$

What is the betweenness centrality for node 4 ??????????

Hypothesis testing

Using these basic statistical techniques, we can devise some tests to determine whether certain data gives evidence that some effect “really” occurs in the real world

Fundamentally, this is evaluating whether things are (likely to be) true about the population (all the data) given a sample

Lots of caveats about the precise meaning of these terms, to the point that many people debate the usefulness of hypothesis testing at all

But, still incredibly common in practice, and important to understand


Hypothesis testing basics

Posit a *null hypothesis* H_0 and an alternative hypothesis H_1 (usually just that “ H_0 is not true”)


Given some data x , we want to accept or reject the null hypothesis in favor of the alternative hypothesis

	H_0 true	H_1 true
Accept H_0	Correct	Type II error (false negative)
Reject H_0	Type I error (false positive)	Correct

$p(\text{reject } H_0 | H_0 \text{ true}) = \text{“significance of test”}$



$p(\text{reject } H_0 | H_1 \text{ true}) = \text{“power of test”}$



Basic approach to hypothesis testing

Basic approach: compute the probability of observing the data *under the null hypothesis* (this is the p-value of the statistical test)

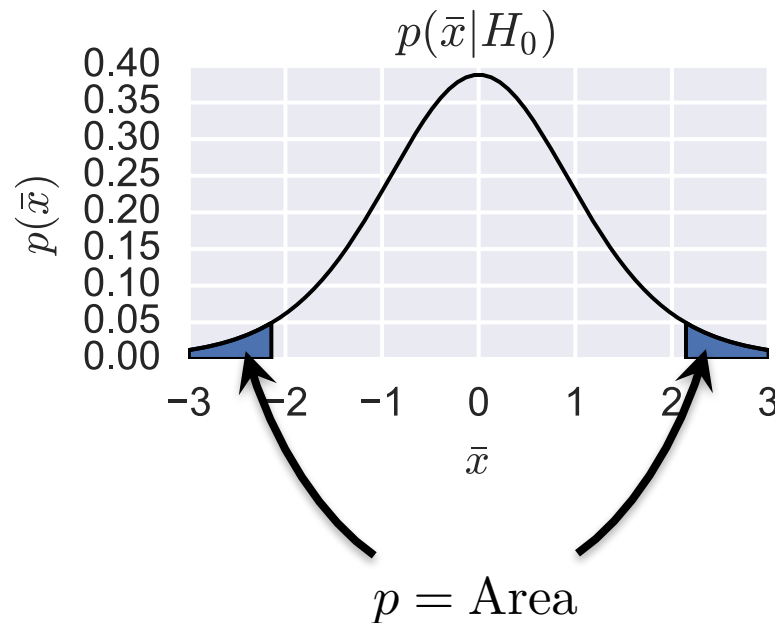
$$p = p(\text{data} | H_0 \text{ is true})$$

Reject the null hypothesis if the p-value is below the desired significance level (alternatively, just report the p-value itself, which is the lowest significance level we could use to reject hypothesis)

Important: p-value is $p(\text{data} | H_0 \text{ is true})$ not $p(H_0 \text{ not true} | \text{data})$

Visual example

What we are doing fundamentally is modeling the distribution $p(\bar{x}|H_0)$ and then determining the probability of the observed \bar{x} or a more extreme value

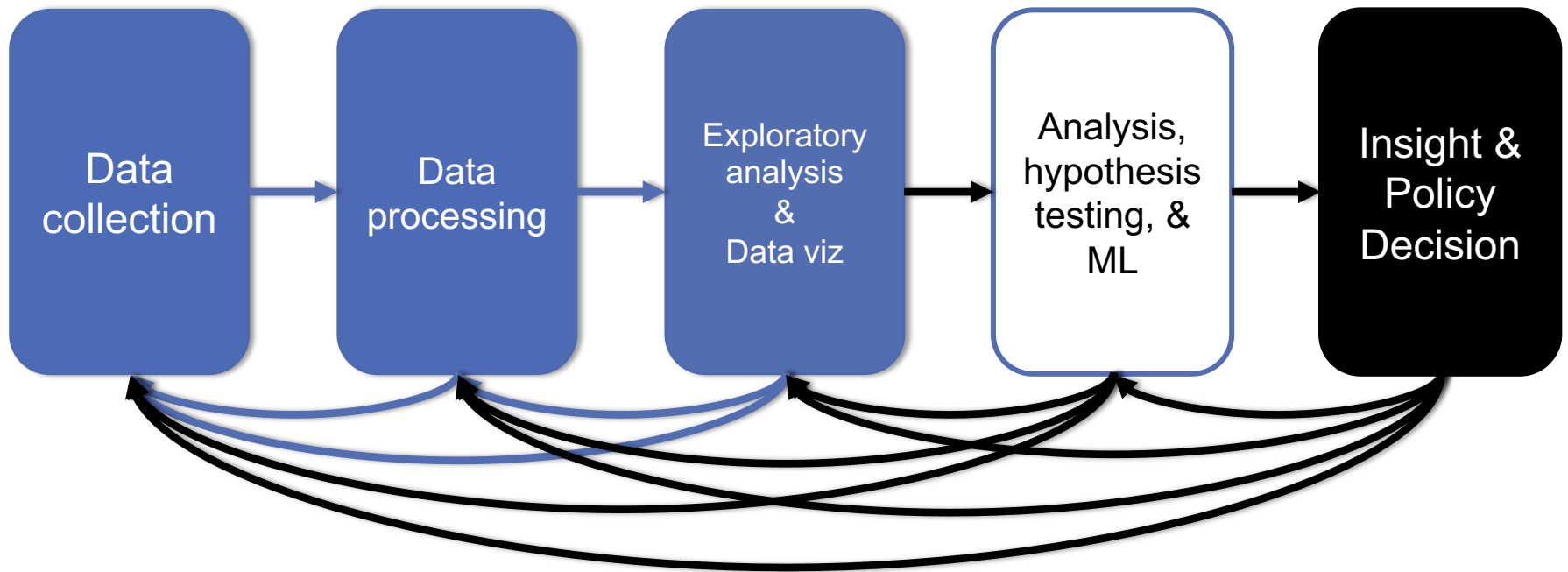


ONE LAST THING ...

Bring a writing utensil. You will need to it. To write.



THIS LECTURE



THIS LECTURE:

Words words words!

- Free text and natural language processing in data science
- Bag of words and TF-IDF
- N-Grams and language models
- Sentiment mining

Thanks to: Zico Kolter (CMU) & Marine Carpuat's 723 (UMD)



DuckDuckGo

PRECURSOR TO NATURAL LANGUAGE PROCESSING

For we can easily understand a machine's being constituted so that it can **utter words**, and even emit some responses to action on it of a corporeal kind, which brings about a change in its organs; for instance, if touched in a particular part it may **ask** what we wish **to say to it**; if in another part it may **exclaim** that it is being hurt, and so on.

(But it never happens that it arranges its speech in various ways, in order to reply appropriately to everything that may be said in its presence, as even the lowest type of man can do.)

-- René Descartes, 1600s

PRECURSOR TO NATURAL LANGUAGE PROCESSING

Turing's Imitation Game [1950]:

- Person A and Person B go into separate rooms
- Guests send questions in, read questions that come out – but they are not told who sent the answers
- Person A (B) wants to convince group that she is Person B (A)

We now ask the question, "What will happen when a machine takes the part of [Person] A in this game?" Will the interrogator decide wrongly as often when the game is played like this as he does when the game is played between [two humans]? These questions replace our original, "Can machines think?"

PRECURSOR TO NATURAL LANGUAGE PROCESSING

Mechanical translation started in the 1930s

- Largely based on dictionary lookups

Georgetown-IBM Experiment:

- Translated 60 Russian sentences to English
- Fairly basic system behind the scenes
- Highly publicized, system ended up spectacularly failing

Funding dried up; not much research in “mechanical translation” until the 1980s ...



STATISTICAL NATURAL LANGUAGE PROCESSING

Pre-1980s: primarily based on sets of hand-tuned rules

Post-1980s: introduction of machine learning to NLP

- Initially, **decision trees** learned what-if rules automatically
- Then, hidden Markov models (HMMs) were used for part of speech (POS) tagging
- Explosion of statistical models for language
- Recent work focuses on purely **unsupervised** or **semi-supervised** learning of models

We'll cover some of this in the machine learning lectures!



NLP IN DATA SCIENCE

In Mini-Project #1, you used `requests` and `BeautifulSoup` to scrape structured data from the web

Lots of data come as unstructured free text: ????????????

- Facebook posts
- Amazon Reviews
- Wikileaks dump

Data science: want to get some **meaningful information** from unstructured text

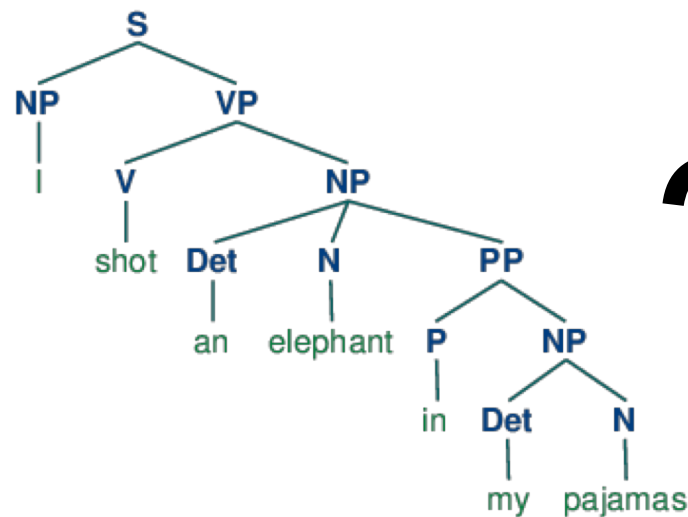
- Need to get **some level** of understanding what the text says

UNDERSTANDING LANGUAGE IS HARD

One morning I shot an elephant in my pajamas.

How he got into my pajamas, I'll never know.

Groucho Marx



UNDERSTANDING LANGUAGE IS HARD



The Winograd Schema Challenge:

- Proposed by Levesque as a complement to the Turing Test

Formally, need to pick out the antecedent of an ambiguous pronoun:

The city **councilmen** refused the **demonstrators** a permit because **they** [**feared/advocated**] violence.

Terry Winograd

Levesque argues that understanding such sentences requires more than NLP, but also commonsense reasoning and deep contextual reasoning

UNDERSTANDING LANGUAGE IS HARD?



I haven't played it that much yet, but it's shaping to be one of the greatest games ever made! It exudes beauty in every single pixel of it. It's a masterpiece. 10/10

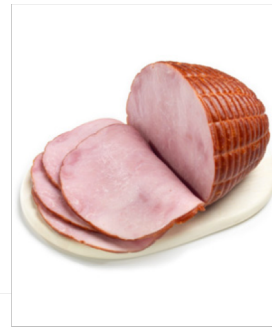
fabchan, March 3, 2017, Metacritic

a horrible stupid game,it's like 5 years ago game,900p 20~30f, i don't play this **** anymore it's like someone give me a **** to play ,no this time sorry,so Nintendo go f yourself pls

Nsucks7752, March 6, 2017, Metacritic

Perhaps we can get some signal (in this case, sentiment) without truly understanding the text ...

“SOME SIGNAL”



or



Replication (Part 2 #1)



Inbox x



CMSC 320 on Piazza <no-reply@piazza.com>

11:56 PM (1 minute ago) ☆

Reply ▾

to me ▾

-- Reply directly to this email above this line to add a comment to the follow up. Or [Click here](#) to view.--
A new feedback was posted by Josephine Chow.

does that mean we can use our solution to question 2 to answer question 1? Thank you!

Search or link to this question with @37.

Sign up for more classes at <http://piazza.com/umd>.

Tell a colleague about Piazza. It's free, after all.

Thanks,
The Piazza Team

--

Contact us at team@piazza.com

You're receiving this email because john@cs.umd.edu is enrolled in CMSC 320 at University of Maryland. [Sign in](#) to manage your email preferences or [un-enroll](#) from this class.

Possible signals ??????????

POLITICS

Trump's New Travel Ban Blocks Migrants From Six Nations, Sparing Iraq

[Leer en español](#)

By GLENN THRUSH MARCH 6, 2017



President Trump during a meeting in the Roosevelt Room of the White House last week. Al Drago/The New York Times

WASHINGTON — President Trump signed an executive order on Monday blocking citizens of six predominantly Muslim countries from entering the United States, the most significant hardening of immigration policy in generations, even with changes intended to blunt legal and political opposition.

The order was revised to avoid the tumult and protests that engulfed the nation's airports after Mr. Trump [signed his first immigration directive](#) on Jan. 27. That order [was ultimately blocked](#) by a federal appeals court.

The new order continued to impose a 90-day ban on travelers, but it removed Iraq, a redaction requested by Defense Secretary Jim Mattis, who feared it would hamper coordination to defeat the Islamic State, according to administration officials.

It also exempts permanent residents and current visa holders, and drops language offering preferential status to persecuted religious

“SOME SIGNAL”

What type of article is this?

- Sports
- Political
- Dark comedy

What entities are covered?

- And are they covered with positive or negative sentiment?

Possible signals ??????????

ASIDE: TERMINOLOGY

Documents: groups of free text

- Actual documents (NYT article, journal paper)
- Entries in a table

Corpus: a collection of documents

Terms: individual words

- Separated by whitespace or punctuation

NLP TASKS

Syntax: refers to the grammatical structure of language

- The rules via which one forms sentences/expressions

Semantics: the study of meaning of language

John is rectangular and a rainbow.

- Syntactically correct
- Semantically meaningless

SYNTAX

Tokenization

- Splitting sentences into tokens

Lemmatization/Stemming

- Turning “organizing” and “organized” into “organiz”

Morphological Segmentation

- How words are formed, and relationships of different parts
- Easy for English, but other languages are difficult

Part-of-speech (POS) Tagging

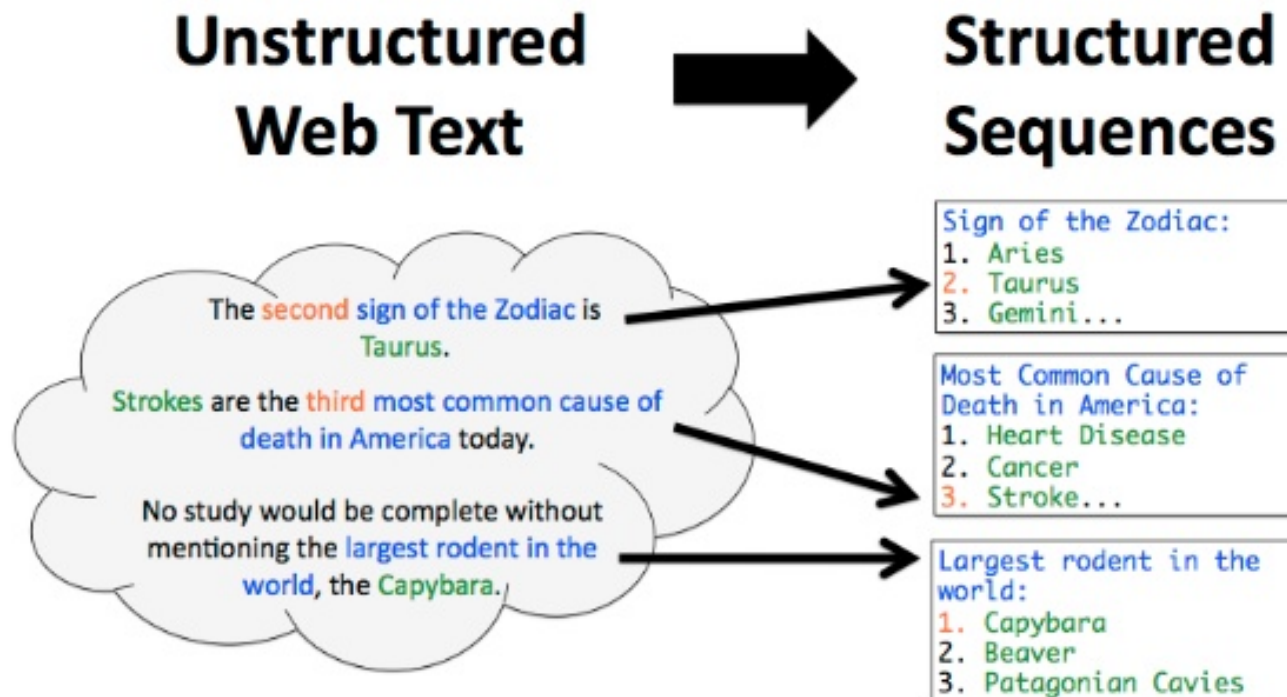
- Determine whether a word is a noun/adverb/verb etc.

Parsing

- Create a “parse tree” for a sentence

SEMANTICS: INFORMATION EXTRACTION

What is IE?



SEMANTICS: NAMED ENTITY RECOGNITION

Identifying key entities in text

In 1917, Einstein applied the general theory of relativity to model the large-scale structure of the universe. He was visiting the United States when Adolf Hitler came to power in 1933 and did not go back to Germany, where he had been a professor at the Berlin Academy of Sciences. He settled in the U.S., becoming an American citizen in 1940. On the eve of World War II, he endorsed a letter to President Franklin D. Roosevelt alerting him to the potential development of "extremely powerful bombs of a new type" and recommending that the U.S. begin similar research. This eventually led to what would become the Manhattan Project. Einstein supported defending the Allied forces, but largely denounced using the new discovery of nuclear fission as a weapon. Later, with the British philosopher Bertrand Russell, Einstein signed the Russell-Einstein Manifesto, which highlighted the danger of nuclear weapons. Einstein was affiliated with the Institute for Advanced Study in Princeton, New Jersey, until his death in 1955.

Tag colours:

LOCATION TIME PERSON ORGANIZATION MONEY PERCENT DATE

SEMANTICS: SENTIMENT ANALYSIS

Deciding if reviews/opinions are positive or negative

Heavily used by ad industry today

★★★★★ **An extremely versatile machine!**, November 22, 2006

By [Dr. Nickolas E. Jorgensen "njorgens3"](#)

This review is from: Cuisinart DGB-600BC Grind & Brew, Brushed Chrome (Kitchen)

This coffee-maker does so much! It makes weak, watery coffee! It grinds beans if you want it to! It inexplicably floods the entire counter with half-brewed coffee when you aren't looking! Perhaps it could be used to irrigate crops... It is time-consuming to clean, but in fairness I should also point out that the stainless-steel thermal carafe is a durable item that has withstood being hurled onto the floor in rage several times. And if all these features weren't enough, it's pretty expensive too. If faced with the choice between having a car door repeatedly slamming into my genitalia and buying this coffee-maker, I'd unhesitatingly choose the Cuisinart! The coffee would be lousy, but at least I could still have children...

SEMANTICS: MACHINE TRANSLATION

Translating from one language to another

Simple substitution of words doesn't work very well



(Image: Google)

<i>Input sentence:</i>	<i>Translation (PBMT):</i>	<i>Translation (GNMT):</i>	<i>Translation (human):</i>
李克強此行將啟動中加總理年度對話機制，與加拿大總理杜魯多舉行兩國總理首次年度對話。	Li Keqiang premier added this line to start the annual dialogue mechanism with the Canadian Prime Minister Trudeau two prime ministers held its first annual session.	Li Keqiang will start the annual dialogue mechanism with Prime Minister Trudeau of Canada and hold the first annual dialogue between the two premiers.	Li Keqiang will initiate the annual dialogue mechanism between premiers of China and Canada during this visit, and hold the first annual dialogue with Premier Trudeau of Canada.

SEMANTICS: MACHINE TRANSLATION

- 0> how long before the next flight to Alice Springs?
- 1> wie lang vor dem folgenden Flug zu Alice Springs?
- 2> how long before the following flight to Alice jump?
- 3> wie lang vor dem folgenden Flug zu Alice springen Sie?
- 4> how long before the following flight to Alice do you jump?
- 5> wie lang, bevor der folgende Flug zu Alice tun, Sie springen?
- 6> how long, before the following flight to Alice does, do you jump?
- 7> wie lang bevor der folgende Flug zu Alice tut, tun Sie springen?
- 8> how long before the following flight to Alice does, do you jump?
- 9> wie lang, bevor der folgende Flug zu Alice tut, tun Sie springen?
- 10> how long, before the following flight does to Alice, do do you jump?
- 11> wie lang bevor der folgende Flug zu Alice tut, Sie tun Sprung?
- 12> how long before the following flight does leap to Alice, does you?

SEMANTICS: QUESTION ANSWERING

Answer questions posed a user with specific answers

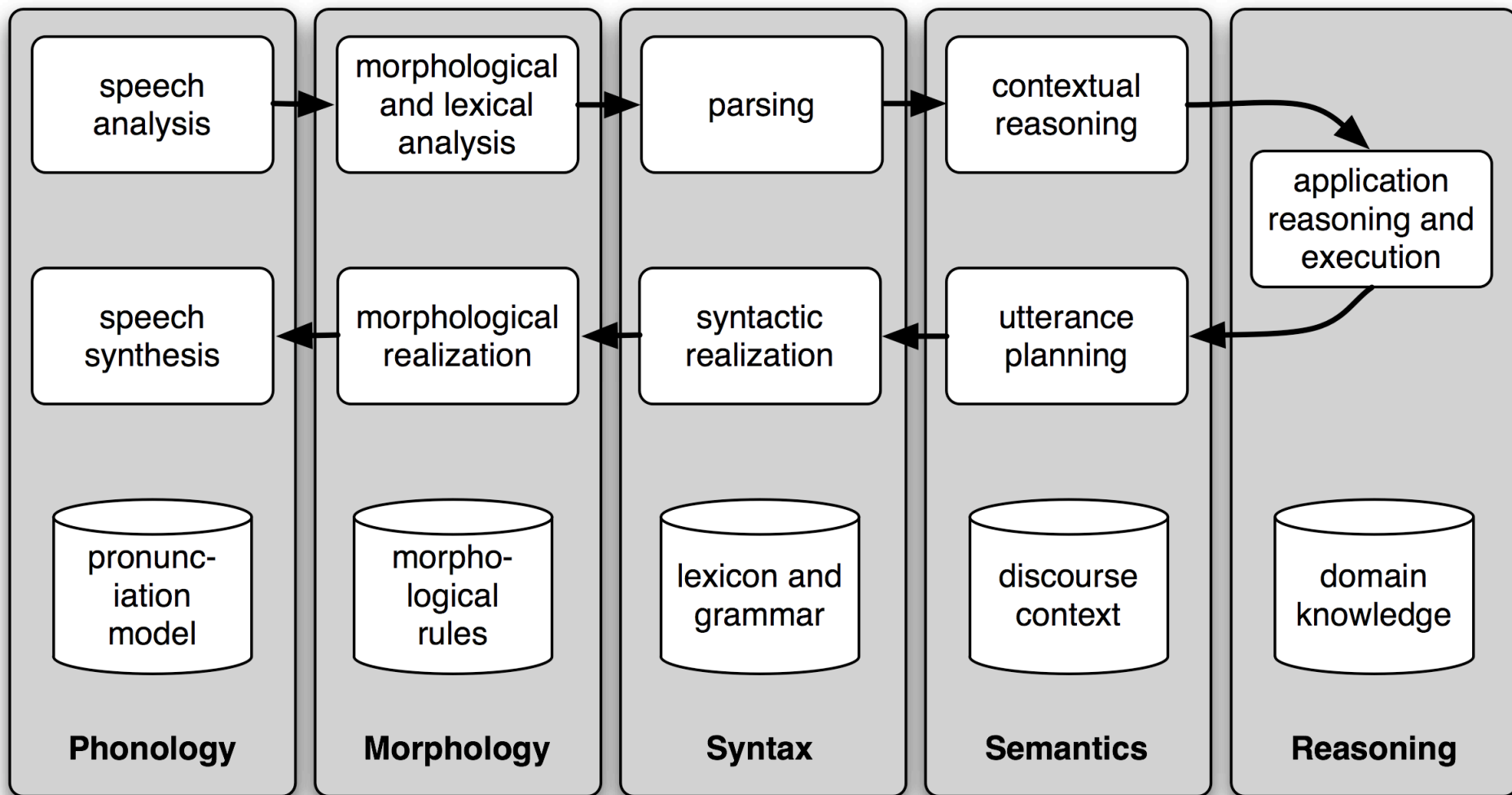


WILLIAM WILKINSON'S
"AN ACCOUNT OF THE PRINCIPALITIES OF
WALLACHIA AND MOLDOVA"
INSPIRED THIS AUTHOR'S
MOST FAMOUS NOVEL

Bram
Stoker



SEMANTICS: SPOKEN DIALOGUE SYSTEMS



SEMANTICS: TEXTUAL ENTAILMENT

Given two text fragments, determine if one being true entails the other, entails the other's negation, or allows the other to be either true or false

TEXT	HYPOTHESIS	ENTAILMENT
<i>Eyeing the huge market potential, currently led by Google, Yahoo took over search company Overture Services Inc last year.</i>	• Yahoo bought Overture.	• TRUE
<i>Microsoft's rival Sun Microsystems Inc. bought Star Office last month and plans to boost its development as a Web-based device running over the Net on personal computers and Internet appliances.</i>	• Microsoft bought Star Office.	• FALSE
<i>The National Institute for Psychobiology in Israel was established in May 1971 as the Israel Center for Psychobiology by Prof. Joel.</i>	• Israel was established in May 1971.	• FALSE

SEMANTICS: DOCUMENT SUMMARIZATION

Quite a few tools out there today... e.g., SMMRY

autotldr commented on a post in r/SkydTech



After Supreme Court detour, Apple v. Samsung goes to a fourth jury trial (arstechnica.com)
submitted 6 hours ago by cryoskyd to r/SkydTech

autotldr • 1 point • submitted 36 minutes ago

This is the best tl;dr I could make, [original](#) reduced by 86%. (I'm a bot)

The Apple v. Samsung lawsuit is getting a big "Reset," thanks to last year's Supreme Court ruling on design patents. The US Supreme Court said that it was wrong to give Apple damages on the entire phone because of a few design patents. Apple and Samsung made their arguments over what the test should be, but Judge Koh ended up going with the test suggested by the US solicitor general, which has four factors to determine the right "Article of manufacture." It's closer to Apple's suggestion-Samsung had suggested basically taking only the part of the product that had the patented design physically applied to it, a test that Koh said wouldn't even pass the basics of what the Supreme Court had asked for.

[Extended Summary](#) | [FAQ](#) | [Feedback](#) | Top keywords: **design**^{#1} **patent**^{#2} **Apple**^{#3} **Court**^{#4} **product**^{#5}

OTHER TASKS

Speech Recognition

Caption Generation

Natural Language Generation

Optical Character Recognition

Word Sense Disambiguation

- serve: help with food or drink; hold an office; put ball into play

...

Doing all of these for many different languages



SEMANTICS: TEXT CLASSIFICATION

Is it spam?

Who wrote this paper? (Author identification)

- https://en.wikipedia.org/wiki/The_Federalist_Papers#Authorship
- <https://www.uwgb.edu/dutchs/pseudosc/hidncode.htm>

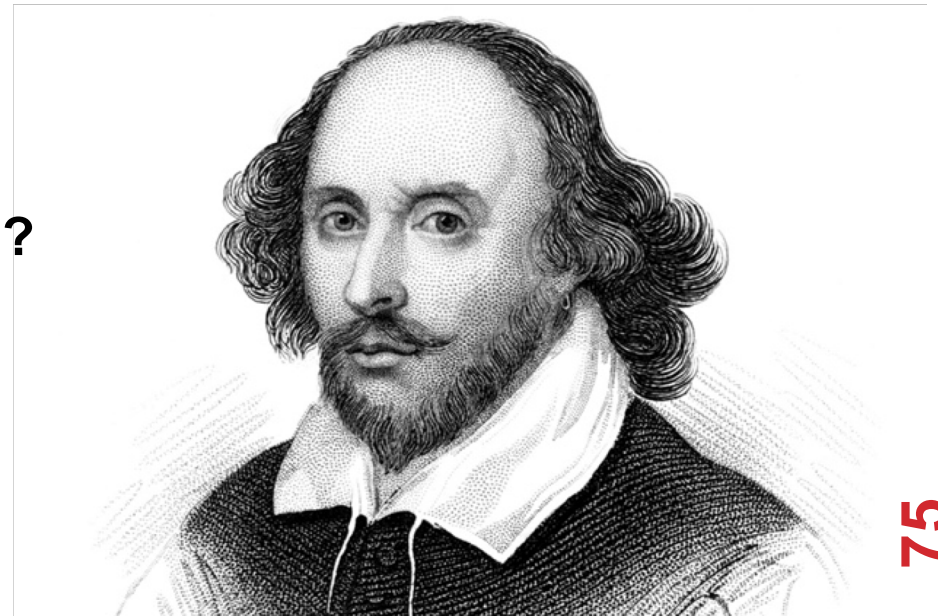
¡Identificación del idioma!

Sentiment analysis

What type of document is this?

When was this document written?

Readability assessment



TEXT CLASSIFICATION

Input:

- A document w
- A set of classes $Y = \{y_1, y_2, \dots, y_J\}$

Output:

- A predicted class $y \in Y$

(You will spend much more time on **classification** problems throughout the program, this is just a light intro!)

TEXT CLASSIFICATION

Hand-coded rules based on combinations of terms (and possibly other context)

If email w :

- Sent from a DNSBL (DNS blacklist) **OR**
- Contains “Nigerian prince” **OR**
- Contains URL with Unicode **OR ...**

Then: $y_w = \text{spam}$

Pros: ??????????

- Domain expertise, human-understandable

Cons: ??????????

- Brittle, expensive to maintain, overly conservative

TEXT CLASSIFICATION

Input:

- A document w
- A set of classes $Y = \{y_1, y_2, \dots, y_J\}$
- A training set of m hand-labeled documents
 $\{(w_1, y_1), (w_2, y_2), \dots, (w_m, y_m)\}$

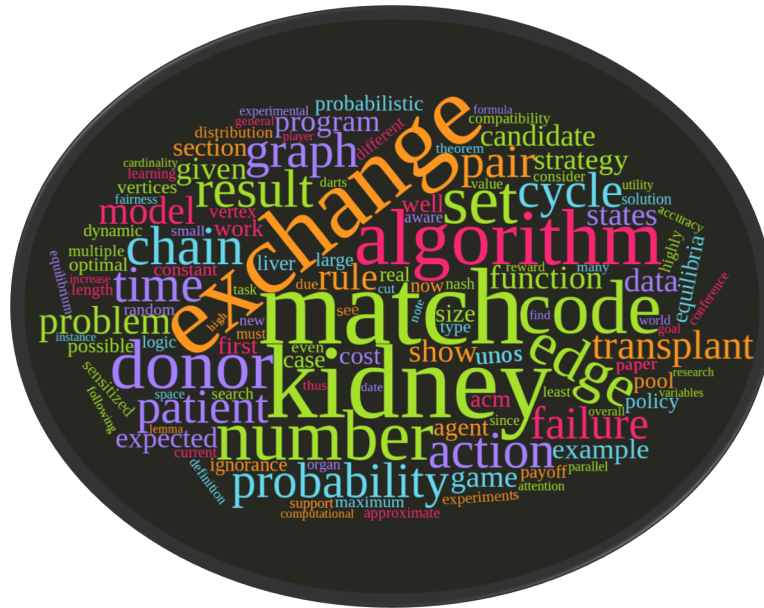
Output:

- A learned classifier $w \rightarrow y$

This is an example of **supervised learning**

REPRESENTING A DOCUMENT “IN MATH”

Simplest method: bag of words



Represent each document as a vector of word frequencies

- Order of words does not matter, just #occurrences

BAG OF WORDS EXAMPLE

the quick brown fox jumps over the lazy dog

I am he as you are he as you are me

he said the CMSC320 is 189 more CMSCs than the CMSC131

	the	CMSC320	you	he	I	quick	dog	me	CMSCs	:	than
Document 1	2	0	0	0	0	1	1	0	0		0
Document 2	0	0	2	2	1	0	0	1	0	...	0
Document 3	2	1	0	1	0	0	0	0	1		1

TERM FREQUENCY

Term frequency: the number of times a term appears in a specific document

- tf_{ij} : frequency of word j in document i

This can be the raw count (like in the BOW in the last slide):

- $tf_{ij} \in \{0, 1\}$ if word j appears or doesn't appear in doc i
- $\log(1 + tf_{ij})$ – reduce the effect of outliers
- $tf_{ij} / \max_j tf_{ij}$ – normalize by document i 's most frequent word

What can we do with this?

- Use as features to learn a classifier $w \rightarrow y \dots!$

DEFINING FEATURES FROM TERM FREQUENCY

Suppose we are classifying if a document was written by The Beatles or not (i.e., **binary** classification):

- Two classes $y \in Y = \{0, 1\} = \{\text{not_beatles}, \text{beatles}\}$

Let's use $\text{tf}_{ij} \in \{0, 1\}$, which gives:

	the	CMSC641	you	he	_	quick	dog	me	CMSCs	..	than
$x_1^T =$	1	0	0	0	0	1	1	0	0		0
$x_2^T =$	0	0	1	1	1	0	0	1	0	...	0
$x_3^T =$	1	1	0	1	0	0	0	0	1		1



$$y_1 = 0$$

$$y_2 = 1$$

$$y_3 = 0$$

Then represent documents with a **feature function**:

$$f(\mathbf{x}, y = \text{not_beatles} = 0) = [\mathbf{x}^T, \mathbf{0}^T, 1]^T$$

$$f(\mathbf{x}, y = \text{beatles} = 1) = [\mathbf{0}^T, \mathbf{x}^T, 1]^T$$

LINEAR CLASSIFICATION

We can then define **weights** θ for each feature

$$\theta = \{ \begin{aligned} <\text{CMSC320}, \text{not_beatles}> = +1, \\ <\text{CMSC320}, \text{beatles}> = -1, \\ <\text{walrus}, \text{not_beatles}> = -0.3, \\ <\text{walrus}, \text{beatles}> = +1, \\ <\text{the}, \text{not_beatles}> = 0, \\ <\text{the}, \text{beatles}>, 0, \dots \end{aligned} \}$$

Write weights as vector that aligns with feature mapping

Score ψ of an instance \mathbf{x} and class y is the sum of the weights for the features in that class:

$$\begin{aligned} \psi_{xy} &= \sum \theta_n f_n(\mathbf{x}, y) \\ &= \boldsymbol{\theta}^\top \mathbf{f}(\mathbf{x}, y) \end{aligned}$$

LINEAR CLASSIFICATION

We have a feature function $f(\mathbf{x}, y)$ and a score $\psi_{xy} = \theta^\top f(\mathbf{x}, y)$

And return the class with highest score!

Compute the score of the document for that class

$$\hat{y} = \arg \max_y \theta^\top f(\mathbf{x}, y)$$

For each class $y \in \{\text{not_beatles}, \text{beatles}\}$

(... and also this whole “linear classifier” thing.)

Where did these weights come from? We’ll talk about this in the ML lectures ...

EXPLICIT EXAMPLE

We are interested in classifying documents into one of two classes $y \in Y = \{ 0, 1 \} = \{ \text{hates_cats}, \text{likes_cats} \}$

Document 1: I like cats

Document 2: I hate cats

	_	like	hate	cats
$x_1^T =$	1	1	0	1
$x_2^T =$	1	0	1	1



$y_1 = ?$

$y_2 = ?$

Now, represent documents with a feature function:

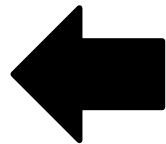
$$f(\mathbf{x}, y = \text{hates_cats} = 0) = [\mathbf{x}^T, \mathbf{0}^T, 1]^T$$

$$f(\mathbf{x}, y = \text{likes_cats} = 1) = [\mathbf{0}^T, \mathbf{x}^T, 1]^T$$

EXPLICIT EXAMPLE

$$f(\mathbf{x}, y = 0) = [\mathbf{x}^T, 0^T, 1]^T$$

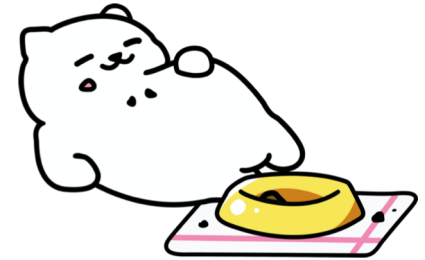
$$f(\mathbf{x}, y = 1) = [0^T, \mathbf{x}^T, 1]^T$$



$$\mathbf{x}_1^T =$$

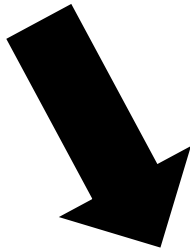
$$\mathbf{x}_2^T =$$

	like	hate	cats
\mathbf{x}_1^T	1	0	1
\mathbf{x}_2^T	0	1	1



$y_1 = ?$

$y_2 = ?$



$y=0: \text{hates_cats}$

$y=1: \text{likes_cats}$

(1)

$$f(\mathbf{x}_1, y = \text{hates_cats} = 0) =$$

$$f(\mathbf{x}_1, y = \text{likes_cats} = 1) =$$

$$f(\mathbf{x}_2, y = \text{hates_cats} = 0) =$$

$$f(\mathbf{x}_2, y = \text{likes_cats} = 1) =$$

	like	hate	cats		like	hate	cats	:
\mathbf{x}_1^T	1	0	1	0	0	0	0	1
\mathbf{x}_2^T	0	1	1	0	0	0	0	1

EXPLICIT EXAMPLE

Now, assume we have **weights** θ for each feature

$$\theta = \{ \begin{array}{l} \langle I, \text{hates_cats} \rangle = 0, \langle I, \text{likes_cats} \rangle = 0, \\ \langle \text{like}, \text{hates_cats} \rangle = -1, \langle \text{like}, \text{likes_cats} \rangle = +1, \\ \langle \text{hate}, \text{hates_cats} \rangle = +1, \langle \text{hate}, \text{likes_cats} \rangle = -1, \\ \langle \text{cats}, \text{hates_cats} \rangle = -0.1, \langle \text{cats}, \text{likes_cats} \rangle = +0.5 \end{array} \}$$

Write weights as vector that aligns with feature mapping:

	<i>y=0: hates_cats</i>				<i>y=1: likes_cats</i>				(1)
Parameter vector $\theta^T =$	0	-1	1	-0.1	0	1	-1	0.5	1
	I	like	hate	cats	I	like	hate	cats	:
$f(\mathbf{x}_1, y = \text{hates_cats} = 0) =$	1	1	0	1	0	0	0	0	1
$f(\mathbf{x}_1, y = \text{likes_cats} = 1) =$	0	0	0	0	1	1	0	1	1
$f(\mathbf{x}_2, y = \text{hates_cats} = 0) =$	1	0	1	1	0	0	0	0	1
$f(\mathbf{x}_2, y = \text{likes_cats} = 1) =$	0	0	0	0	1	0	1	1	1

EXPLICIT EXAMPLE

Score ψ of an instance \mathbf{x} and class y is the sum of the weights for the features in that class:

$$\begin{aligned}\psi_{xy} &= \sum \theta_n f_n(\mathbf{x}, y) \\ &= \boldsymbol{\theta}^T \mathbf{f}(\mathbf{x}, y)\end{aligned}$$

Let's compute $\psi_{\mathbf{x}_1, y=\text{hates_cats}}$...

- $\psi_{\mathbf{x}_1, y=\text{hates_cats}} = \boldsymbol{\theta}^T \mathbf{f}(\mathbf{x}_1, y = \text{hates_cats} = 0)$
- $= 0*1 + -1*1 + 1*0 + -0.1*1 + 0*0 + 1*0 + -1*0 + 0.5*0 + 1*1$
- $= -1 - 0.1 + 1 = \mathbf{-0.1}$

$$\boldsymbol{\theta}^T = \begin{bmatrix} 0 & -1 & 1 & -0.1 & 0 & 1 & -1 & 0.5 & 1 \end{bmatrix} \bullet \begin{bmatrix} 1 & \text{I} \\ 1 & \text{like} \\ 0 & \text{hate} \\ 1 & \text{cats} \\ 0 & \text{I} \\ 0 & \text{like} \\ 0 & \text{hate} \\ 0 & \text{cats} \\ 1 & - \end{bmatrix} \begin{matrix} \text{hates_cats} \\ \text{likes_cats} \\ (1) \end{matrix}$$

$\mathbf{f}(\mathbf{x}_1, y = 0)$

EXPLICIT EXAMPLE

Saving the boring stuff:

- $\psi_{\mathbf{x}_1, y=\text{hates_cats}} = -0.1$; $\psi_{\mathbf{x}_1, y=\text{likes_cats}} = +2.5$ Document 1: I like cats
- $\psi_{\mathbf{x}_2, y=\text{hates_cats}} = +1.9$; $\psi_{\mathbf{x}_2, y=\text{likes_cats}} = +0.5$ Document 2: I hate cats

We want to predict the class of each document:

$$\hat{y} = \arg \max_y \theta^\top \mathbf{f}(\mathbf{x}, y)$$

Document 1: $\operatorname{argmax}\{\psi_{\mathbf{x}_1, y=\text{hates_cats}}, \psi_{\mathbf{x}_1, y=\text{likes_cats}}\}$?????????

Document 2: $\operatorname{argmax}\{\psi_{\mathbf{x}_2, y=\text{hates_cats}}, \psi_{\mathbf{x}_2, y=\text{likes_cats}}\}$?????????



INVERSE DOCUMENT FREQUENCY

Recall:

- tf_{ij} : frequency of word j in document i

Any issues with this ????????????

- Term frequency gets **overloaded** by common words

Inverse Document Frequency (IDF): weight individual words negatively by how frequently they appear in the corpus:

$$idf_j = \log \left(\frac{\#documents}{\#documents \text{ with word } j} \right)$$

IDF is just defined for a word j , not word/document pair j, i

INVERSE DOCUMENT FREQUENCY

	the	CMSC320	you	he	I	quick	dog	me	CMSCs	..	than
Document 1	2	0	0	0	0	1	1	0	0	...	0
Document 2	0	0	2	2	1	0	0	1	0		0
Document 3	2	1	0	1	0	0	0	0	1		1

$$\text{idf}_{\text{the}} = \log \left(\frac{3}{2} \right) = 0.405$$

$$\text{idf}_{\text{you}} = \log \left(\frac{3}{1} \right) = 1.098$$

$$\text{idf}_{\text{CMSC320}} = \log \left(\frac{3}{1} \right) = 1.098$$

$$\text{idf}_{\text{he}} = \log \left(\frac{3}{2} \right) = 0.405$$

TF-IDF

How do we use the IDF weights?

Term frequency inverse document frequency (TF-IDF):

- TF-IDF score: $tf_{ij} \times idf_j$

	the	CMSC320	you	he	I	quick	dog	me	CMSCs	..	than
Document 1	0.8	0	0	0	0	1.1	1.1	0	0		0
Document 2	0	0	2.2	0.8	1.1	0	0	1.1	0	...	0
Document 3	0.8	1.1	0	0.4	0	0	0	0	1.1		1.1

This ends up working better than raw scores for classification and for computing similarity between documents.

SIMILARITY BETWEEN DOCUMENTS

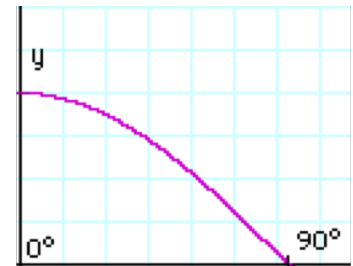
Given two documents x and y , represented by their TF-IDF vectors (or any vectors), the **cosine similarity** is:

$$\text{similarity}(x, y) = \frac{x^T y}{|x| \times |y|}$$

Formally, it measures the cosine of the angle between two vectors x and y :

- $\cos(0^\circ) = 1$, $\cos(90^\circ) = 0$????????????

**Similar documents have high cosine similarity;
dissimilar documents have low cosine similarity.**



TOKENIZATION

First step towards text processing

For English, just split on non-alphanumeric characters

- Need to deal with cases like: I'm, or France's, or Hewlett-Packard
- Should "San Francisco" be one token or two?

Other languages introduce additional issues

- L'ensemble → one token or two?
- German noun compounds are not segmented
 - Lebensversicherungsgesellschaftsangestellter
- Chinese/Japanese more complicated because of white spaces

OTHER BASIC TERMS

Lemmatization

- Reduce inflections or variant forms to base form
 - am, are, is → be
 - car, cars, car's, cars' → car
- the boy's cars are different colors → the boy car be different color

Morphology/Morphemes

- The small meaningful units that make up words
- Stems: The core meaning-bearing units
- Affixes: Bits and pieces that adhere to stems
 - Often with grammatical functions

STEMMING

Reduce terms to their stems in information retrieval

Stemming is crude chopping of affixes

- language dependent
- e.g., **automate(s), automatic, automation** all reduced to **automat**.

*for example compressed
and compression are both
accepted as equivalent to
compress.*



for exampl compress and
compress ar both accept
as equal to compress

(MINIMUM) EDIT DISTANCE

How similar are two strings?

Many different distance metrics (as we saw earlier when discussing entity resolution)

- Typically based on the number of edit operations needed to transform from one to the other

Useful in NLP context for spelling correction, information extraction, speech recognition, etc.

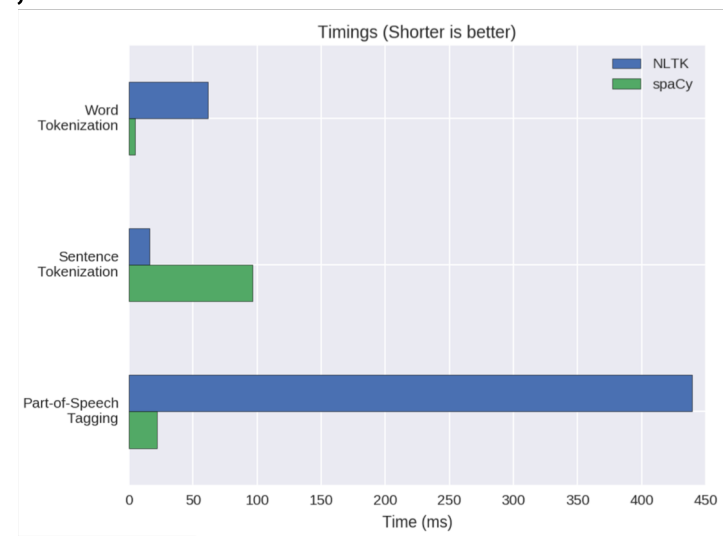
NLP IN PYTHON

Two majors libraries for performing basic NLP in Python:

- Natural Language Toolkit (**NLTK**): started as research code, now widely used in industry and research
- **Spacy**: much newer implementation, more streamlined

Pros and cons to both:

- NLTK has more “stuff” implemented, is more customizable
 - This is a blessing and a curse
- Spacy is younger and feature sparse, but can be **much** faster
- Both are Anaconda packages



NLTK EXAMPLES

```
import nltk
```

```
# Tokenize, aka find the terms in, a sentence
```

```
sentence = "A wizard is never late, nor is he early.  
He arrives precisely when he means to."
```

```
tokens = nltk.word_tokenize(sentence)
```

```
LookupError:
```

```
*****
```

```
Resource 'tokenizers/punkt/PY3/english.pickle' not found.
```

```
Please use the NLTK Downloader to obtain the resource: >>>
```

```
nltk.download()
```

```
Searched in:
```

- '/Users/spook/nltk_data'
- '/usr/share/nltk_data'
- '/usr/local/share/nltk_data'
- '/usr/lib/nltk_data'
- '/usr/local/lib/nltk_data'
- ''

```
*****
```



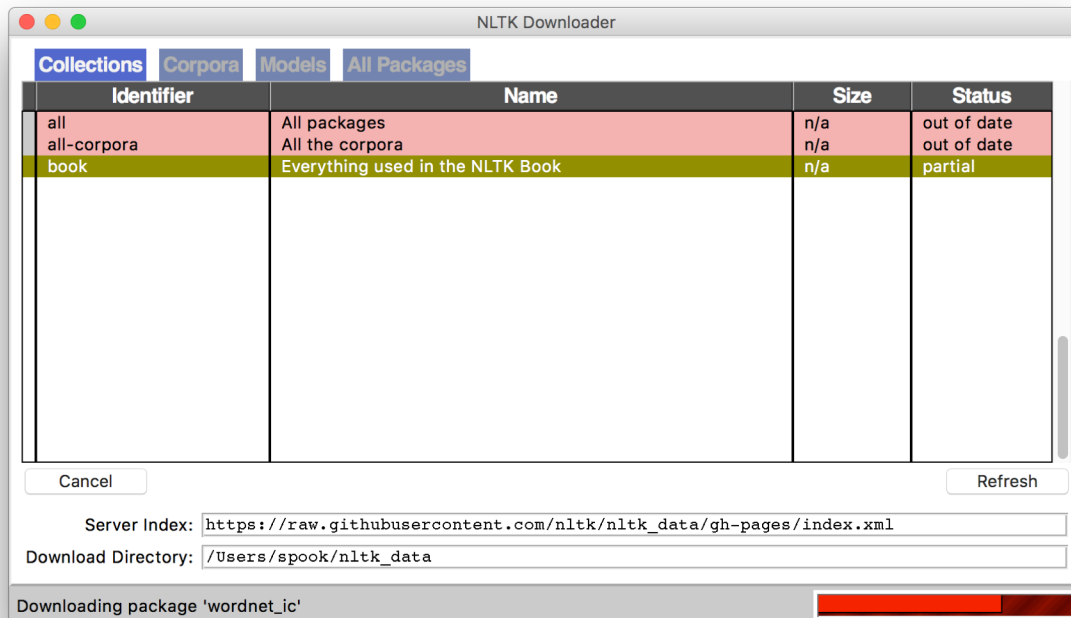
Fool of a Took!

NLTK EXAMPLES

Corpora are, by definition, large bodies of text

- NLTK relies on a large corpus set to perform various functionalities; you can pick and choose:

```
# Launch a GUI browser of available corpora  
nltk.download()
```



```
# Or download  
everything at once!  
nltk.download("all")
```


NLTK EXAMPLES



ptb	Penn Treebank	0.1 KB	not installed
punkt	Punkt Tokenizer Models	13.0 MB	installed
qa	Experimental Data for Question Classification	122.5 KB	not installed

```
import nltk

# Tokenize, aka find the terms in, a sentence
sentence = "A wizard is never late, nor is he early.
He arrives precisely when he means to."
tokens = nltk.word_tokenize(sentence)
```

```
['A', 'wizard', 'is', 'never', 'late', ',', 'nor',
'is', 'he', 'early', '.', 'He', 'arrives',
'precisely', 'when', 'he', 'means', 'to', '.']
```

(This will also tokenize words like “o’clock” into one term, and “didn’t” into two term, “did” and “n’t”).)

NLTK EXAMPLES

```
# Determine parts of speech (POS) tags
tagged = nltk.pos_tag(tokens)
tagged[:10]
```

```
[('A', 'DT'), ('wizard', 'NN'), ('is', 'VBZ'),
('never', 'RB'), ('late', 'RB'), (',', ','), ('nor',
'CC'), ('is', 'VBZ'), ('he', 'PRP'), ('early', 'RB')]
```

Abbreviation	POS
DT	Determiner
NN	Noun
VBZ	Verb (3 rd person singular present)
RB	Adverb
CC	Conjunction
PRP	Personal Pronoun

Full list: <https://cs.nyu.edu/grishman/jet/guide/PennPOS.html>

NLTK EXAMPLES

```
# Find named entities & visualize
```

```
entities = nltk.chunk.ne_chunk( nltk.pos_tag(
nltk.word_tokenize("""
```

```
    The Shire was divided into four quarters, the Farthings already referred
    to. North, South, East, and West; and these again each into a number of
    folklands, which still bore the names of some of the old leading families,
    although by the time of this history these names were no longer found only in
    their proper folklands. Nearly all Took's still lived in the Tookland, but
    that was not true of many other families, such as the Bagginses or the
    Boffins. Outside the Farthings were the East and West Marches: the Buckland
    (see beginning of Chapter V, Book I); and the Westmarch added to the Shire in
    S.R. 1462.
```

```
    """))
```

```
entities.draw()
```



BRIEF ASIDE: N-GRAMS

n-gram: Contiguous sequence of n tokens/words etc.

- Unigram, bigram, trigram, “four-gram”, “five-gram”, ...

Figure 1 *n*-gram examples from various disciplines

Field	Unit	Sample sequence	1-gram sequence	2-gram sequence	3-gram sequence
Vernacular name			unigram	bigram	trigram
Order of resulting Markov model			0	1	2
Protein sequencing	amino acid	... Cys-Gly-Leu-Ser-Trp ...	..., Cys, Gly, Leu, Ser, Trp, ...	..., Cys-Gly, Gly-Leu, Leu-Ser, Ser-Trp, ...	..., Cys-Gly-Leu, Gly-Leu-Ser, Leu-Ser-Trp, ...
DNA sequencing	base pair	...AGCTTCGA...	..., A, G, C, T, T, C, G, A, ...	..., AG, GC, CT, TT, TC, CG, GA, ...	..., AGC, GCT, CTT, TTC, TCG, CGA, ...
Computational linguistics	character	...to_be_or_not_to_be...	..., t, o, _, b, e, _, o, r, _, n, o, t, _, t, o, _, b, e, ...	..., to, o_, _b, be, e_, _o, or, r_, _n, no, ot, t_, _t, to, o_, _b, be, ...	..., to_, o_b, _be, be_, e_o, _or, or_, r_n, _no, not, ot_, t_t, _to, to_, o_b, _be, ...
Computational linguistics	word	... to be or not to be ...	..., to, be, or, not, to, be, ...	..., to be, be or, or not, not to, to be, ...	..., to be or, be or not, or not to, not to be, ...

LANGUAGE MODELING

Assign a probability to a sentence

- Machine Translation:
 - $P(\text{high winds tonite}) > P(\text{large winds tonite})$
- Spell Correction
 - The office is about fifteen **minuets** from my house
 - $P(\text{about fifteen minutes from}) > P(\text{about fifteen minuets from})$
- Speech Recognition
 - $P(\text{I saw a van}) \gg P(\text{eyes awe of an})$
- + Summarization, question-answering, etc., etc.!!

LANGUAGE MODELING

Goal: compute the probability of a sentence or sequence of words:

- $P(W) = P(w_1, w_2, w_3, w_4, w_5 \dots w_n)$

Related task: probability of an upcoming word:

- $P(w_5 | w_1, w_2, w_3, w_4)$

A model that computes either of these:

- $P(W)$ or $P(w_n | w_1, w_2 \dots w_{n-1})$ is called a language model.

(We won't talk about this much further in this class.)

SIMPLEST CASE: UNIGRAM MODEL

$$P(w_1 w_2 \dots w_n) \approx \prod_i P(w_i)$$

Some automatically generated sentences from a unigram model

fifth, an, of, futures, the, an, incorporated, a,
a, the, inflation, most, dollars, quarter, in, is,
mass

thrift, did, eighty, said, hard, 'm, july, bullish

that, or, limited, the

BIGRAM MODEL

Condition on the previous word:

$$P(w_i | w_1 w_2 \dots w_{i-1}) \approx P(w_i | w_{i-1})$$

texaco, rose, one, in, this, issue, is, pursuing, growth, in,
a, boiler, house, said, mr., gurria, mexico, 's, motion,
control, proposal, without, permission, from, five, hundred,
fifty, five, yen

outside, new, car, parking, lot, of, the, agreement, reached

this, would, be, a, record, november

N-GRAM MODELS

We can extend to trigrams, 4-grams, 5-grams

In general this is an insufficient model of language

- because language has long-distance dependencies:
- “The computer which I had just put into the machine room on the fifth floor crashed.”

But we can often get away with N-gram models