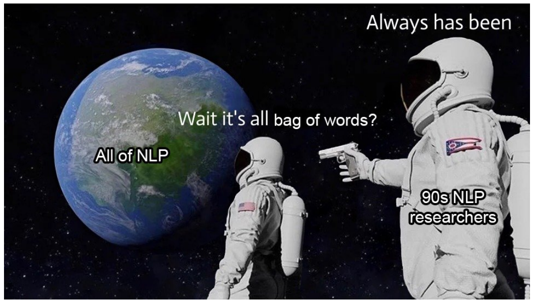
CS388: Natural Language Processing
Lecture 1: Introduction

Greg Durrett

TEXAS
The University of Texas at Austin



Credit: Stephen Roller

Administrivia

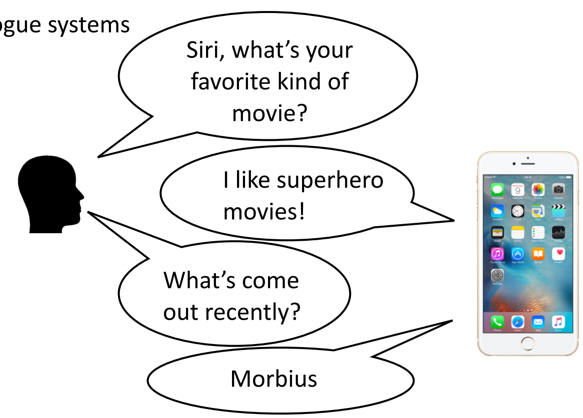
- Lecture: Tuesdays and Thursdays 9:30am - 10:45am; recordings made available
- Course website: http://www.cs.utexas.edu/~gdurrett/courses/sp2023/cs388.shtml
- Gradescope: you should've gotten an email
- Piazza: link on the course website
- TAs: Kaj Bostrom, Sophie Zhao
- See course website for OHs

Course Requirements

- 391L Machine Learning (or equivalent)
- 311 or 311H Discrete Math for Computer Science (or equivalent)
- Python experience
- Additional prior exposure to probability, linear algebra, optimization, linguistics, and NLP useful but not required
- Project 1 is out now — take a look at it soon if you have any doubts about the class (we will move quickly through basic classification and neural networks)

What's the goal of NLP?

- Be able to solve problems that require deep understanding of text
- Example: dialogue systems



Machine Translation

The Political Bureau of the CPC Central Committee | July 30 | hold a meeting

中共中央政治局7月30日召开会议，会议分析研究当前经济形势，部署下半年经济工作。

People's Daily, August 10, 2020

Translate

The Political Bureau of the CPC Central Committee held a meeting on July 30 to analyze and study the current economic situation and plan economic work in the second half of the year.

Question Answering

When was Abraham Lincoln born?

map to Birthday field

Name	Birthday
Lincoln, Abraham	2/12/1809
Washington, George	2/22/1732
Adams, John	10/30/1735

February 12, 1809

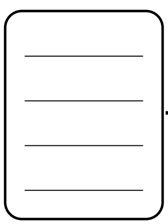
How many visitors centers are there in Rocky Mountain National Park?

The park has a total of five visitor centers

five

NLP Analysis Pipeline

Text



Text Analysis

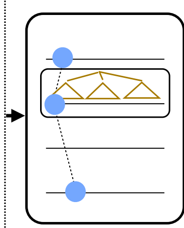
Syntactic parses

Coreference resolution

Entity disambiguation

Discourse analysis

Annotations



Applications

Summarize

Extract information

Answer questions

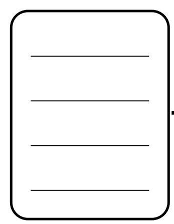
Identify sentiment

Translate

- NLP is about building these pieces!
- All of these components are modeled with statistical approaches trained with machine learning

How do we represent language?

Text



Labels

the movie was good +

Beyoncé had one of the best videos of all time **subjective**

Sequences/tags

PERSON *Tom Cruise* *stars in the new* **WORK_OF_ART** *Mission Impossible* *film*

Trees

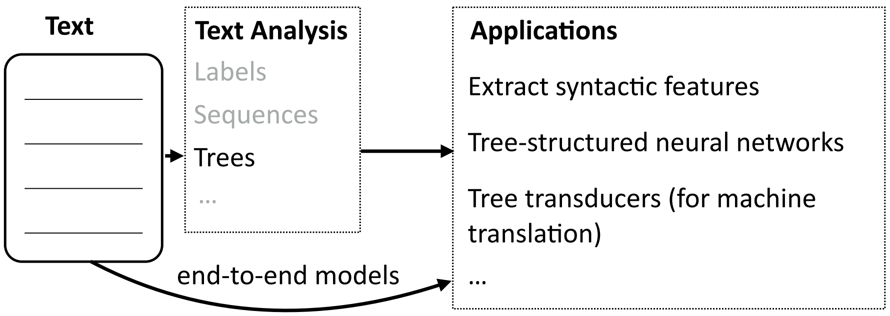
S, VP, NP, PP, NP, VBZ, NN

I eat cake with icing

λx. flight(x) ∧ dest(x)=Miami

flights to Miami

How do we use these representations?



- Main question: What representations do we need for language? What do we want to know about it?
- Boils down to: what ambiguities do we need to resolve?

Why is language hard?

(and how can we handle that?)

Language is Ambiguous!

- Hector Levesque (2011): "Winograd schema challenge" (named after Terry Winograd, the creator of SHRDLU)

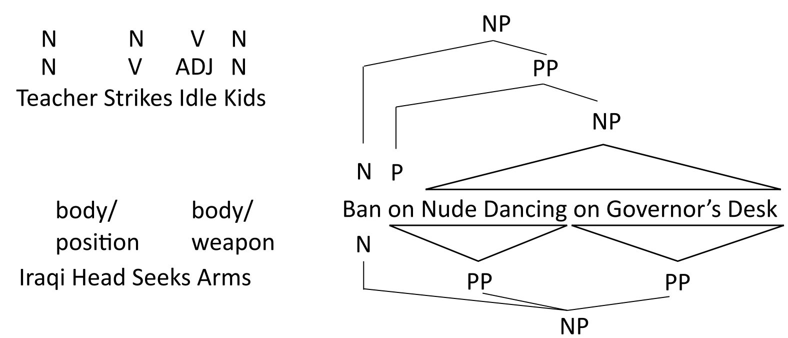
The city council refused the demonstrators a permit because they advocated violence

The city council refused the demonstrators a permit because they feared violence

The city council refused the demonstrators a permit because they _______ violence

- >5 datasets in the last few years examining this problem and commonsense reasoning
- Referential ambiguity

Language is Ambiguous!



- Syntactic and semantic ambiguities: parsing needed to resolve these, but need context to figure out which parse is correct

example credit: Dan Klein

Language is **Really** Ambiguous!

- There aren't just one or two possibilities which are resolved pragmatically

il fait vraiment beau ⟶
It is really nice out
It's really nice
The weather is beautiful
It is really beautiful outside
He makes truly beautiful
It fact actually handsome

- Combinatorially many possibilities, many you won't even register as ambiguities, but systems still have to resolve them

What do we need to understand language?

- Lots of data!

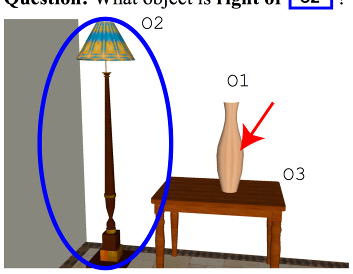
SOURCE	Cela constituerait une solution transitoire qui permettrait de conduire à terme à une charte à valeur contraignante.
HUMAN	That would be an interim solution which would make it possible to work towards a binding charter in the long term .
1x DATA	[this] [constituerait] [assistance] [transitoire] [who] [permettrait] [licences] [to] [terme] [to] [a] [charter] [to] [value] [contraignante] [.]
10x DATA	[it] [would] [a solution] [transitional] [which] [would] [of] [lead] [to] [term] [to a] [charter] [to] [value] [binding] [.]
100x DATA	[this] [would be] [a transitional solution] [which would] [lead to] [a charter] [legally binding] [.]
1000x DATA	[that would be] [a transitional solution] [which would] [eventually lead to] [a binding charter] [.]

slide credit: Dan Klein

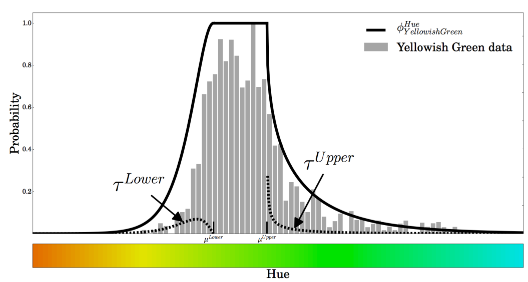
What do we need to understand language?

- Grounding: learn what fundamental concepts actually mean in a data-driven way

Question: What object is **right of** $\boxed{\text{O2}}$?



Golland et al. (2010)



McMahan and Stone (2015)

What do we need to understand language?

- Linguistic structure
- ...but computers probably won't understand language the same way humans do
- However, linguistics tells us what phenomena we need to be able to deal with and gives us hints about how language works

a. John has been having a lot of trouble arranging his vacation.

b. He cannot find anyone to take over his responsibilities. (he = John)
C_b = John; C_f = {John}

c. He called up Mike yesterday to work out a plan. (he = John)
C_b = John; C_f = {John, Mike} (CONTINUE)

d. Mike has annoyed him a lot recently.
C_b = John; C_f = {Mike, John} (RETAIN)

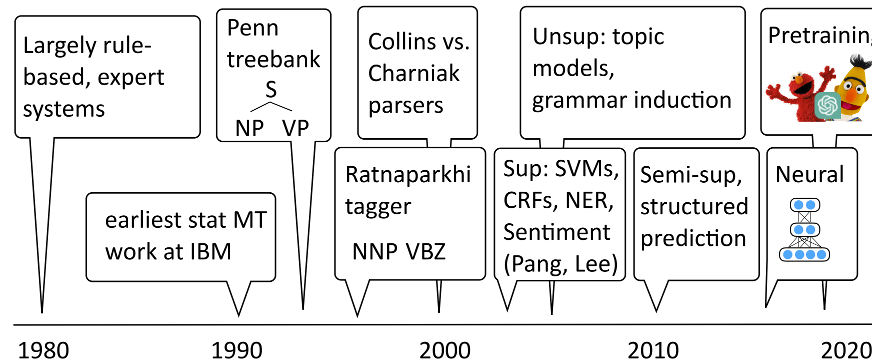
e. He called John at 5 AM on Friday last week. (he = Mike)
C_b = Mike; C_f = {Mike, John} (SHIFT)

Centering Theory
Grosz et al. (1995)

What techniques do we use?

(to combine data, knowledge, linguistics, etc.)

A brief history of (modern) NLP



Pretraining

- Language modeling: predict the next word in a text $P(w_i | w_1, \ldots, w_{i-1})$

  P(w | I want to go to) = 0.01 Hawai'i
  0.005 LA
  0.0001 class

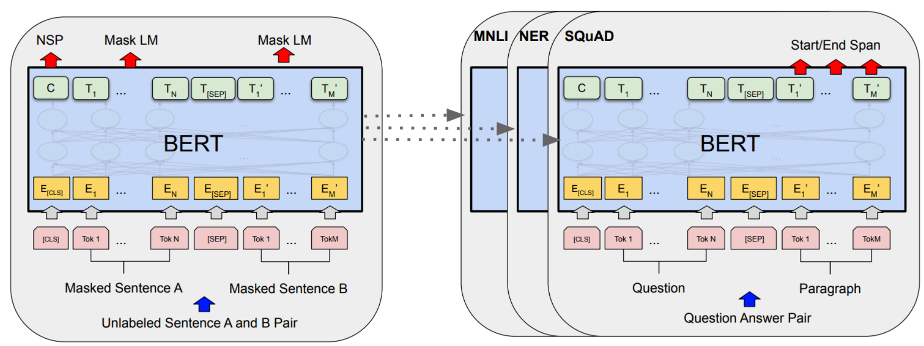

: use this model for other purposes

  P(w | the acting was horrible, I think the movie was) = 0.1 bad
  0.001 good

- Model understands some sentiment?
- Train a neural network to do language modeling on massive unlabeled text, fine-tune it to do {tagging, sentiment, question answering, ...}

Peters et al. (2018), Devlin et al. (2019)

BERT



Pre-training Fine-Tuning

- Key parts which we will study: (1) Transformer architecture; (2) what data is used (both for pre-training and fine-tuning)

Devlin et al. (2019)

GPT and In-Context Learning

- Even more "extreme" setting: no gradient updates to model, instead large language models "learn" from examples in their context
- Many papers studying why this works. We will read some!

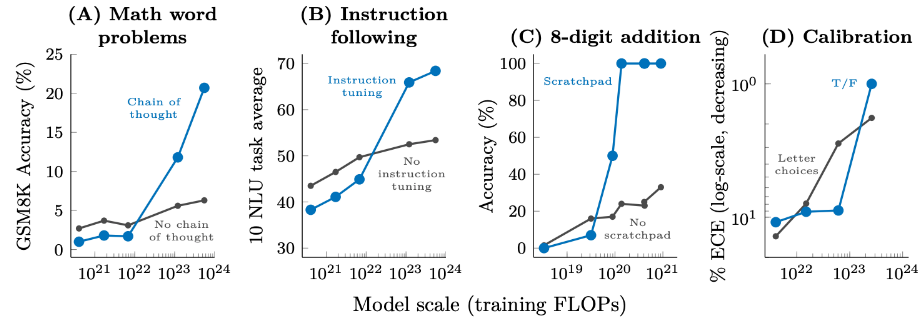
Few-shot

In addition to the task description, the model sees a few examples of the task. No gradient updates are performed.

```
Translate English to French:        ← task description
sea otter => loutre de mer          ← examples
peppermint => menthe poivrée
plush girafe => girafe peluche
cheese => ..................        ← prompt
```

Brown et al. (2020)

Scaling Laws



- Many of the ideas that are big in 2023 only make sense and only work because the models are so big!

Kaplan et al. (2020), Jason Wei et al. (2022)

Interpretability

- When we have complex models, how do we understand their decisions?

The movie is mediocre, maybe even bad.	Negative 99.8%
The movie is mediocre, maybe even ~~bad~~.	Negative 98.0%
The movie is ~~mediocre~~, maybe even bad.	Negative 98.7%
The movie is ~~mediocre~~, maybe even ~~bad~~.	Positive 63.4%
The movie is ~~mediocre~~, ~~maybe~~ even ~~bad~~.	Positive 74.5%
The ~~movie~~ is mediocre, maybe even ~~bad~~.	Negative 97.9%

The movie is mediocre, maybe even bad.

Wallace, Gardner, Singh
Interpretability Tutorial at EMNLP 2020

Where are we?

- We have very powerful neural models that can fit lots of datasets
- Data: we need data that is not just correctly labeled, but reflects what we actually want to be able to do
- Users: systems are not useful unless they do something we want
- Language/outreach: who are we building this for? What languages/dialects do they speak?

Ethics

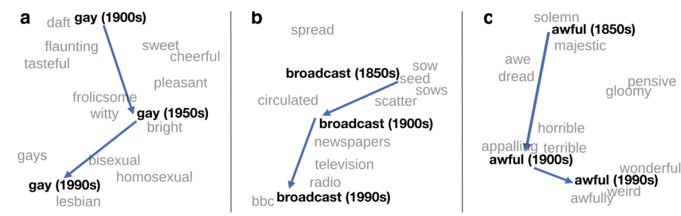
- E.g., "toxic degeneration": systems can generate {racist, sexist, ...} content

https://toxicdegeneration.allenai.org/

- We will touch on ethical issues throughout the course, with a substantial discussion on the last "real" class

NLP vs. Computational Linguistics

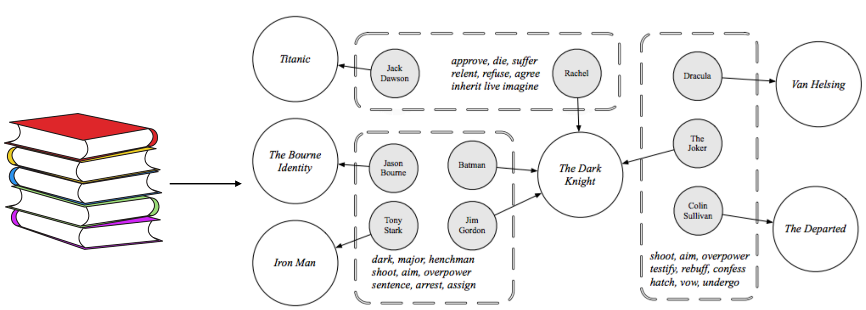
- NLP: build systems that deal with language data
- CL: use computational tools to study language



Hamilton et al. (2016)

NLP vs. Computational Linguistics

- Computational tools for other purposes: literary theory, political science...



Bamman, O'Connor, Smith (2013)

Outline

- Classification: linear and neural, word representations (2 weeks)
- Language modeling, transformers, and pre-training (2 weeks)
- Dataset biases, interpretability, rationales, advanced pre-training (3 weeks)
- Structured prediction, tagging, parsing (1.5 weeks)
- Applications and misc (3 weeks)

Course Goals

- Cover fundamental machine learning and deep learning techniques used in NLP
- Understand how to look at language data and approach linguistic phenomena
- Cover modern NLP problems encountered in the literature: what are the active research topics in 2023?
- Make you a “producer” rather than a “consumer” of NLP tools
  - The assignments should teach you what you need to know to understand nearly any system in the literature (classification layers from Project 1, Transformer backbones from Project 2, datasets and what gets learned from Project 3)

Assignments

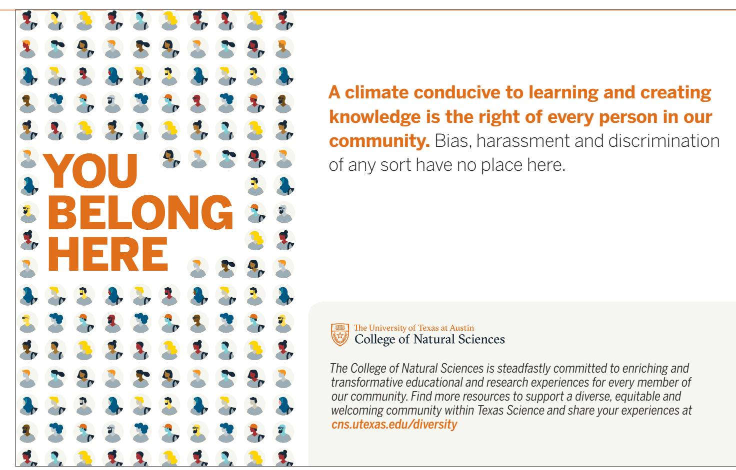
- Three projects (15%/20%/20%)
  - Implementation-oriented, with an open-ended component to each
  - Project 1 (linear and neural classification) is out NOW
  - ~2 weeks per project, 5 “slip days” for automatic extensions
- Projects are graded on a mix of code performance, writeup, and “extensions” that you explore on top of what’s required

These projects require understanding of the concepts, ability to write performant code, and ability to think about how to debug complex systems. **They are challenging, so start early!**

Assignments

- Final project (45%)
  - Groups of 2 preferred, 1 is possible
  - (Brief!) proposal to be approved by me by the midpoint of the semester
  - Written in the style and tone of an ACL paper
- Compute:
  - Google Colab is a nice resource for projects (especially Colab Pro, $9.99/mo)
  - Unfortunately, we cannot provide GPT-3 / etc. credits
  - When you propose projects, we will discuss feasibility given your compute resources available

Conduct



Survey (on Instapoll)