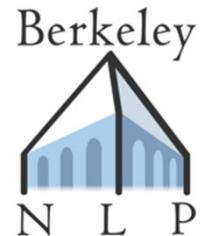


Natural Language Processing



Instructors: Dan Klein, Alane Suhr
GSIs: Jessy Lin, Kevin Yang
UC Berkeley

Logistics



Logistics

- **Enrollment**

- Class is full but we hope to fit waitlist
- We will process enrollments after P1
- Material access doesn't require enrollment
- <https://edstem.org/us/join/BfhEtz>

- **Requirements**

ML: A-level mastery,
eg CS189

NL: Care a lot about
natural language

PL: Ready to work in
PyTorch (Kaggle)

- **Course expectations**

- Readings, lectures, 5 projects
- No sections, no exams
- Engagement with the course
- Workload will be high, autonomy required
- Patience: class is under construction!

- **COVID/Attendance Policies**

- Webcasts posted (Berkeley-local)
- Expanded late day policy (14 day)
- Please do not come to lecture sick



Resources and Readings

- **Resources**

- Webpage (syllabus, readings, slides, links)
- EdStem Discussion (course communication)
- Gradescope (submission and grades)
- Compute via Kaggle notebooks
- Berkeley-internal recordings for main lectures

- **Readings (see webpage)**

- Individual papers will be linked
- Optional text: Jurafsky & Martin, 3rd (more NL)
- Optional text: Eisenstein (more ML)

CS 288	Schedule
Home	August 24: Introduction Project 1 released
Course Info	August 29: Language modeling: statistical models
Staff	August 31: Language modeling: early neural models

ed CS 288 – Ed Discussion

New Thread Search Filter ▾

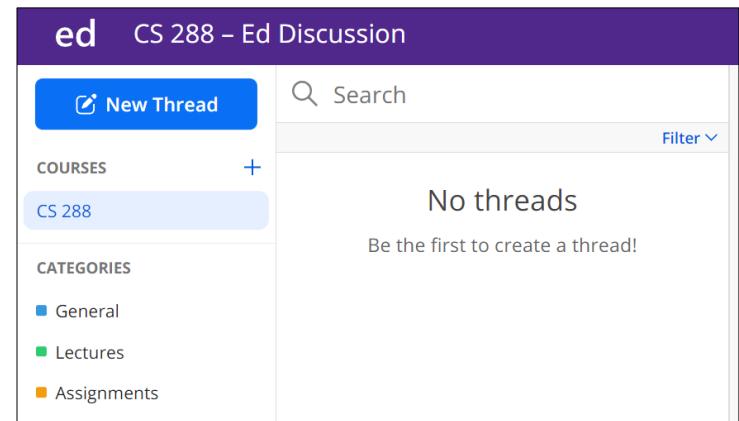
COURSES +

CS 288

CATEGORIES

General Lectures Assignments

No threads Be the first to create a thread!





Projects and Infrastructure

▪ Projects

- P1: Language Models
- P2: Machine Translation
- P3: Syntax and Parsing
- P4: LLMs and Structured Prediction
- P5: Multimodal Language Understanding

▪ Infrastructure

- Python / PyTorch
- Compute via Kaggle notebooks
- Grading via Gradescope

The screenshot shows a Kaggle notebook interface. On the left, there's a sidebar with options like 'Create', 'Home', 'Competitions', 'Datasets', 'Code', 'Discussions', 'Learn', and 'More'. Below that is a section for 'Your Work' and 'RECENTLY EDITED' notebooks. The main area is titled 'Project 1 Draft saved'. It contains a text block about regularization techniques and a list of requirements for the write-up. At the bottom, there's a code cell with a prompt to run it and some sample Python code.

```
## Feel free to copy your original LSTM solution down here to modify for your report if you'd like.
# YOUR CODE [optionally] HERE
##

#lstm_model = LSTMModel()
#lstm_model.train()

print('lstm validation perplexity:', lstm_model.dataset.perplexity(validation_dataset))
save_truncated_distribution(lstm_model, 'lstm_predictions.npy', short=False)
```

What is NLP?



Natural Language Processing



NLP



grep

Goal: Deep Understanding

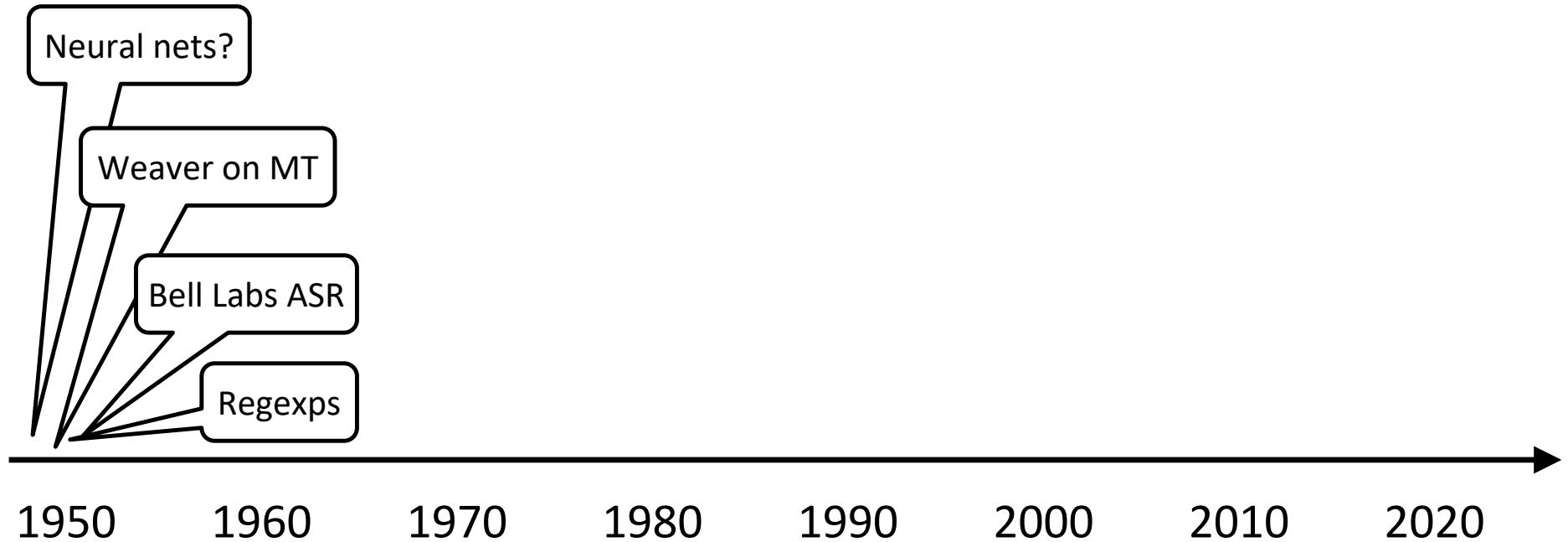
- Requires knowledge, context, and grounding
- Traditionally out of reach, but huge recent advances

Classic Systems: Shallow Matching

- Focus on robustness, scale, and predictability
- Very useful, but has had fundamental limitations



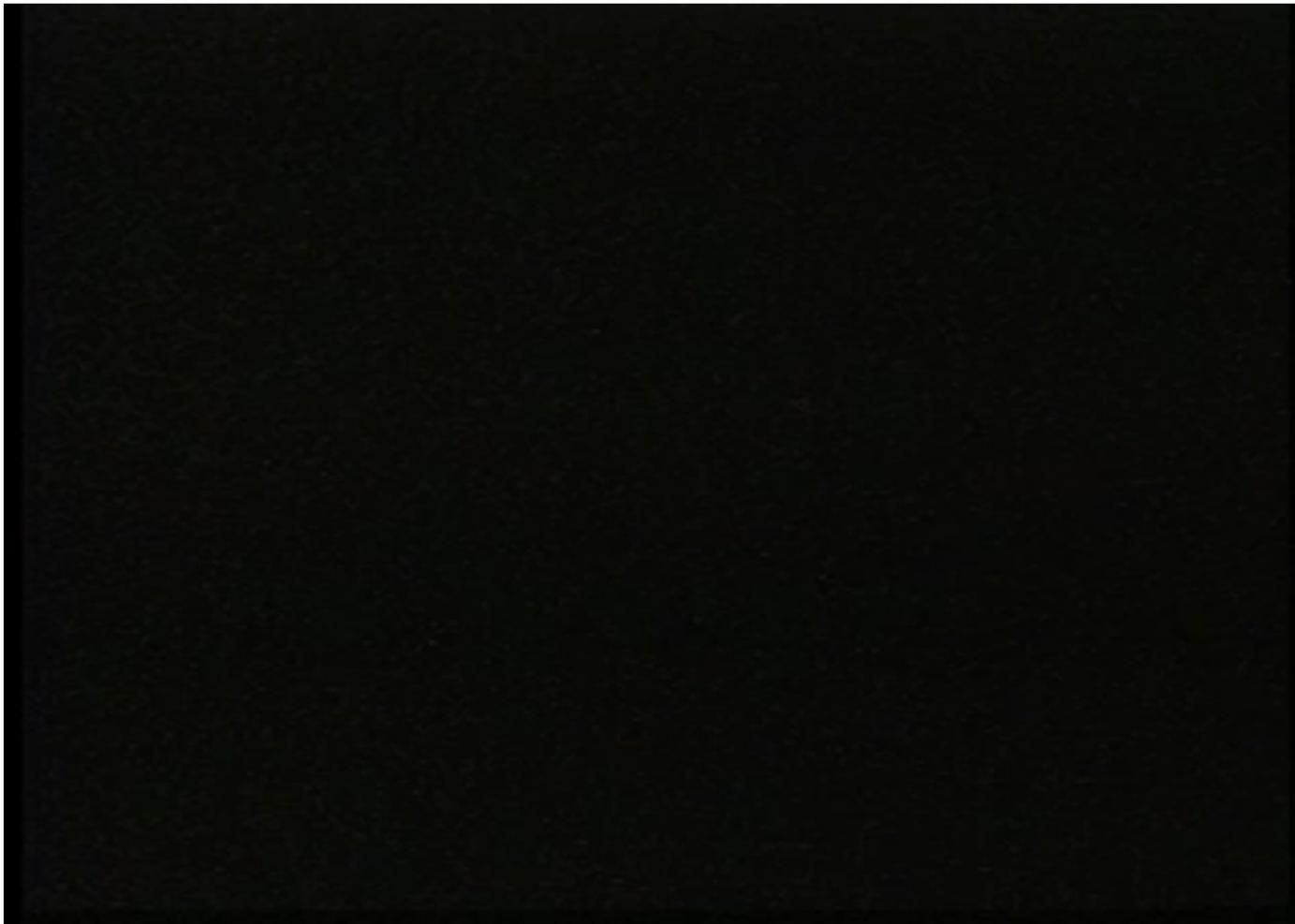
NLP History



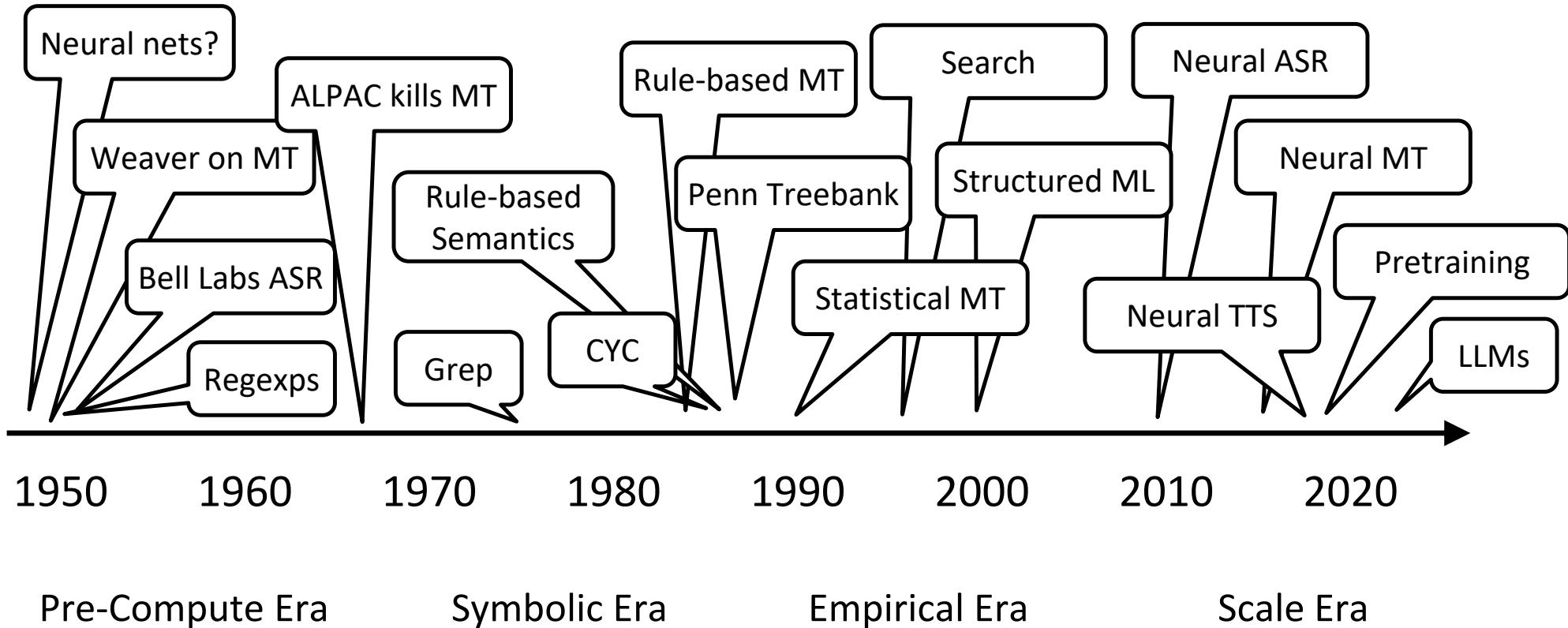
Pre-Compute Era



NLP History



NLP History



Designing NLP Systems



Role of Language Technologies

- What is their *intended* use?
 - Keeping users engaged?
 - Interacting with users as little as possible?
 - What kind of users?
- How does this influence their design?
 - The user interface
 - The underlying structure / model
 - The assumptions they are making
- How are they *actually* used?
 - Where do they fail?
 - How do users adapt?
- What other considerations should we make?
 - Resource efficiency
 - Fairness, ethics, social impact



Speech Systems

▪ Text to Speech (TTS)

- Text in, audio out
- SOTA: nearly perfect aside from prosody



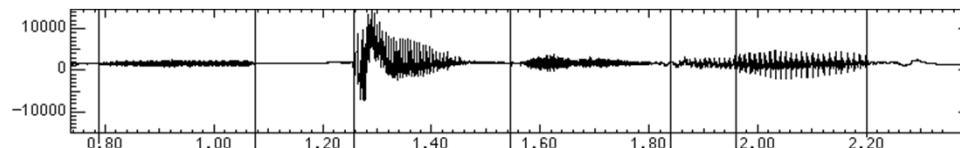
GOOGLE \ TECH \ ARTIFICIAL INTELLIGENCE

Google launches more realistic text-to-speech service powered by DeepMind's AI



▪ Automatic Speech Recognition (ASR)

- Audio in, text out
- SOTA: <<1% error for digit strings, 5% conversational speech, still >>20% hard acoustics



MICROSOFT \ TECH \ ARTIFICIAL INTELLIGENCE

Microsoft reaches 'human parity' with new speech recognition system

“Speech Lab”

Speak-N-Spell / Google WaveNet / The Verge



Machine Translation

EN CE MOMENT Impôts Kenya Syrie Pakistan Emploi Scandale Prism

Impôt sur le revenu : combien paierez-vous en 2014 ?



DÉCOUVREZ TOUS LES SERVICES ABONNÉS
S'abonner au Monde à partir de 1 €

APPEL À TÉMOIGNAGES

Adhérent(e) d'Europe Ecologie-Les Verts, partagez-vous le constat sévère de Noël Mamère sur EELV ?
Partagez votre expérience

En continu

- Comment le budget pour 2014 est-il réparti ? [VISUEL INTERACTIF](#)
- Budget : ces dépenses qu'aucun gouvernement ne peut diminuer
- Un budget 2014 soumis aux critiques
- Budget : les dépendances incompris
- Entendu à la "fashion week" de Paris
- Commande géante à Airbus
- Plainte contre "Valeurs actuelles"
- Venezuela : 17 personnes arrêtées
- Vidberg : le budget nouveau est arrivé
- La "mission noble" de la NSA
- Roms : Joutes entre Bruxelles et Paris

AT THIS MOMENT Taxes Kenya Syria Pakistan Use Prism scandal

Income tax: how much do you pay in 2014?



DÉCOUVREZ TOUS LES SERVICES ABONNÉS
S'abonner au Monde à partir de 1 €

CALL FOR EVIDENCE

Member(s) of Europe Ecology-Greens, do you share the finding of severe Christmas Mamère EELV?
Share your experience

Continuous

- Budget : des dépenses incompris
- Entendu à la "fashion week" in Paris
- Actual Values" arrested
- Commande géante à Airbus
- Plainte contre "Valeurs actuelles"
- Venezuela : 17 personnes arrested
- Vidberg : the budget nouveau est arrivé
- La "mission noble" of the NSA
- Roms : Joutes entre Bruxelles et Paris

- Translate text from one language to another
- Challenges:
 - What's the mapping? [learning to translate]
 - How to make it efficient? [fast translation search]
 - Fluency (next class) vs fidelity (later)

Example: Yejin Choi



Spoken Language Translation



Image: Microsoft Skype via Yejin Choi



Summarization

- Condensing documents
 - Single or multiple docs
 - Extractive or abstractive
- Very context-dependent!

The screenshot shows a CNN International news article. At the top, there's a navigation bar with links for EDITION: INTERNATIONAL, U.S., MÉXICO, ARABIC, TV: CNN en Español, and Set edition preference. The main headline is "Official: Egypt balloon explosion probe can take 2 weeks". Below the headline, it says "By Adam Makary, Saad Abedine and Mariano Castillo, CNN" and "February 27, 2013 — Updated 1614 GMT (0014 HKT)". A "STORY HIGHLIGHTS" section lists several bullet points. To the left of the article, there's a Twitter sidebar with several tweets. Below the article, there are three video thumbnails with "Click to play" buttons: one showing tourists killed in a hot air balloon blast, another showing a 2009 balloon crash survivor speaking, and a third showing how to stay safe in a hot air balloon.

STORY HIGHLIGHTS

- NEW: No foul play is suspected, official says
- The Tuesday accident was the world's deadliest hot air balloon accident in at least 20 years
- Officials: Passengers in the balloon included 19 foreign tourists
- Luxor province bans all hot air balloon flights until further notice

Read a version of this story in Arabic.

Cairo (CNN) -- An official investigation into the cause of a balloon accident that killed 19 people in Egypt could take two weeks, the governor of Luxor province said Wednesday.

The Tuesday accident was the world's deadliest hot air balloon accident in at least 20 years.

Preliminary investigations confirmed no foul play was involved when gas canisters aboard the balloon exploded, causing it to plummet about 1,000 feet (300 meters) to the ground, Gov. Ezzat Saad said.

CNN iReport: After tragedy, vacationers recall glorious balloon rides in Egypt

Tourists killed in hot air balloon blast

2009 balloon crash survivor speaks

How to stay safe in a hot air balloon

Image: CNN via Wei Gao



Search, Questions, and Reasoning

Google Web Search results for "How many US states' capitals are also their largest cities?"

Tip: Have a question? Ask the Google Assistant.

Web definitions for capital

Scholarly articles for What is a capital city?

MSN Encarta - Cheyenne

capital of Wyoming: Information and facts

Cheyenne: Weather and climate

How many US states' capitals are also their second largest cities?

As of my last knowledge update in September 2021, there are two US states where the second largest city serves as the state capital:

1. Texas: The second largest city in Texas is San Antonio, which is also the state capital.
2. Florida: The second largest city in Florida is Miami, which is also the capital of Florida.

Please verify this information since circumstances may have changed after September 2021.

A large red 'X' is overlaid on the bottom right of the search results.



Text to Image

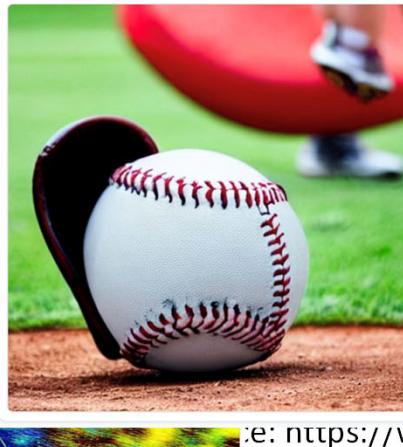


Amsterdam canal in post-impressionist brush reflection of narrow houses and bicycles, swirl channelling van Gogh's 'Starry Night', engulf from pedestrian-eye vie



a baseball sitting to the left of a basketball

Generate image



source: <https://www.linkedin.com/pulse/prompt-hack-midjourney-stable-diffusion-mareenco-kemp>



Virtual Assistants

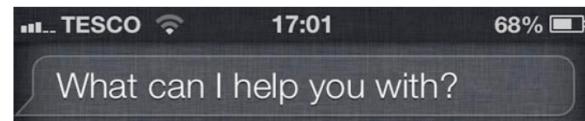


- Virtual assistants must do
 - Speech recognition
 - Language analysis
 - Dialog processing
 - Text to speech
 - ... and back-end actions!

Image: Wikipedia



Conversations with Devices?





ELIZA

```
ELIZA: You're not really talking about me -- are you ?
YOU: What?
ELIZA: What do you think ?
YOU: I mean, I feel happy to be writing right now, to be typing this as we speak. Lately, I've had writer's block.
ELIZA: You say you mean ?
YOU: That's what I said.
ELIZA: Can you elaborate on that ?
YOU: I only really feel happy when I'm writing.
ELIZA: How long have you been writing ?
YOU: Always, but I've been writing seriously since I was eighteen.
ELIZA: What incident are you thinking of ?
YOU: Um.
ELIZA: What does that suggest to you ?
YOU: I don't think it's enough, to only be happy when you write.
ELIZA: Does that trouble you ?
YOU: ...Um, because you can't write all the time. And then there's the real world, and you still have to deal with real people.
ELIZA: What are your feelings now ?
YOU: I've been thinking a lot of that poem by Yeats: "The Man and the Echo."
Do you know it?
ELIZA: Do you say you've been thinking a lot of that poem by yeats: "the man and the echo for some special reason ?
YOU: Yes █
```



Chatbot Competitions!



- Alexa Prize competition to build chatbots that keep users engaged
 - First winner in 2017: UW's Sounding Board (Fang, Cheng, Holtzman, Ostendorf, Sap, Clark, Choi)
- Compare to the Turing test (eg Loebner Prize) where the goal is to fool people



SoundingBoard Example

Turn	User	Sounding Board
1	Let's chat	Hi! This is an Alexa Prize socialbot. How's your day?
2	I'm <u>five</u> .	Glad to hear it! We could talk about robots, batman, or superman. Say "next", to chat about other things.
3	Superman.	It looks like you wanna chat about superman. I was high up in the cloud when I realized: If people don't recognize Clark Kent as Superman because of his glasses, does his eye doctor know his identity?
4	I guess so.	Did you know that Henry Cavill almost missed the call for the role of Superman cause he was playing "World of Warcraft"
5	Really, I didn't know that.	Weird, right? Speaking of superman, Did you see: Superman? It was released in 1997. It's a comedy.
6	Yes, it was hilarious.	I'm glad you feel this is hilarious. Which part was about this movie?
7	The part when he met lewis leah.	Interesting. meccartin, and raffi co-directed this film. The movie has a 6.3 out of 10 on IMDB. which seems pretty good! do you like the movie's director?
8	Yeah, he's cool.	Cool! By the way, do you wanna know something interesting about raffi?
9	Okay, go ahead.	Super! My friend told me that Raffi is a worldwide children's rights activist and has fought against exploitative advertising to children.

Negotiation

Thought

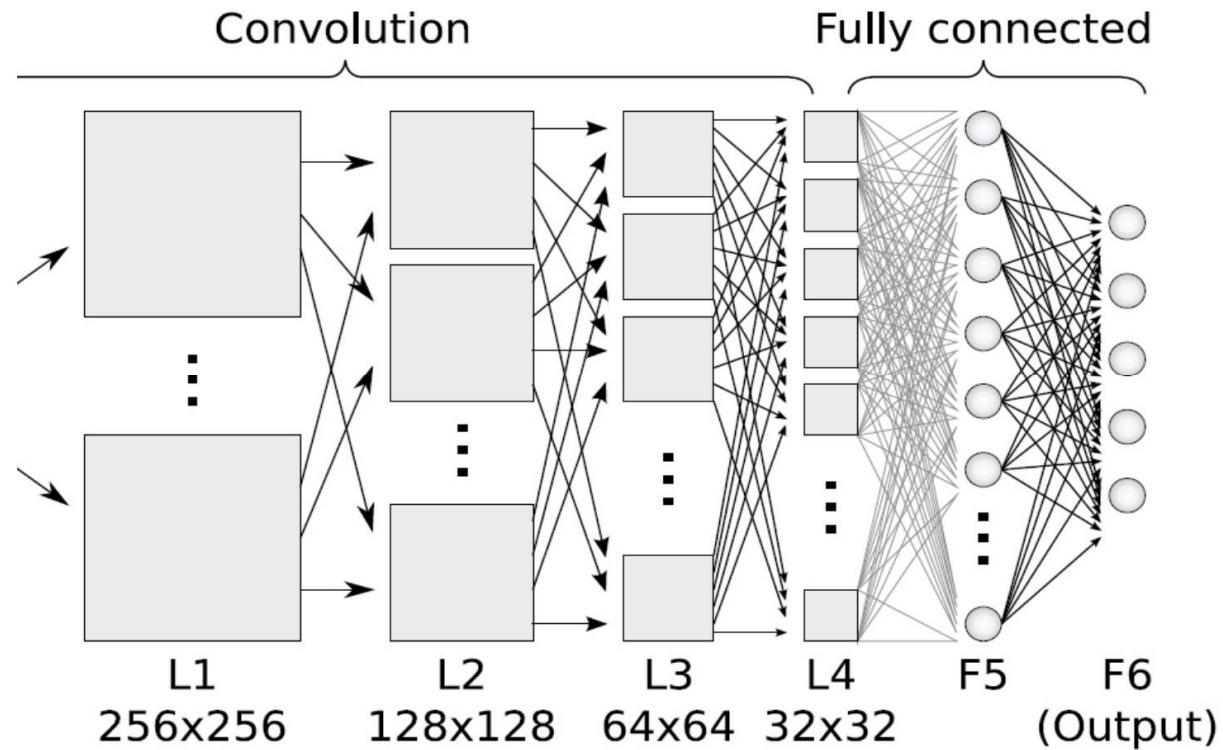
Movie

Fact

Source: Mari Ostendorf



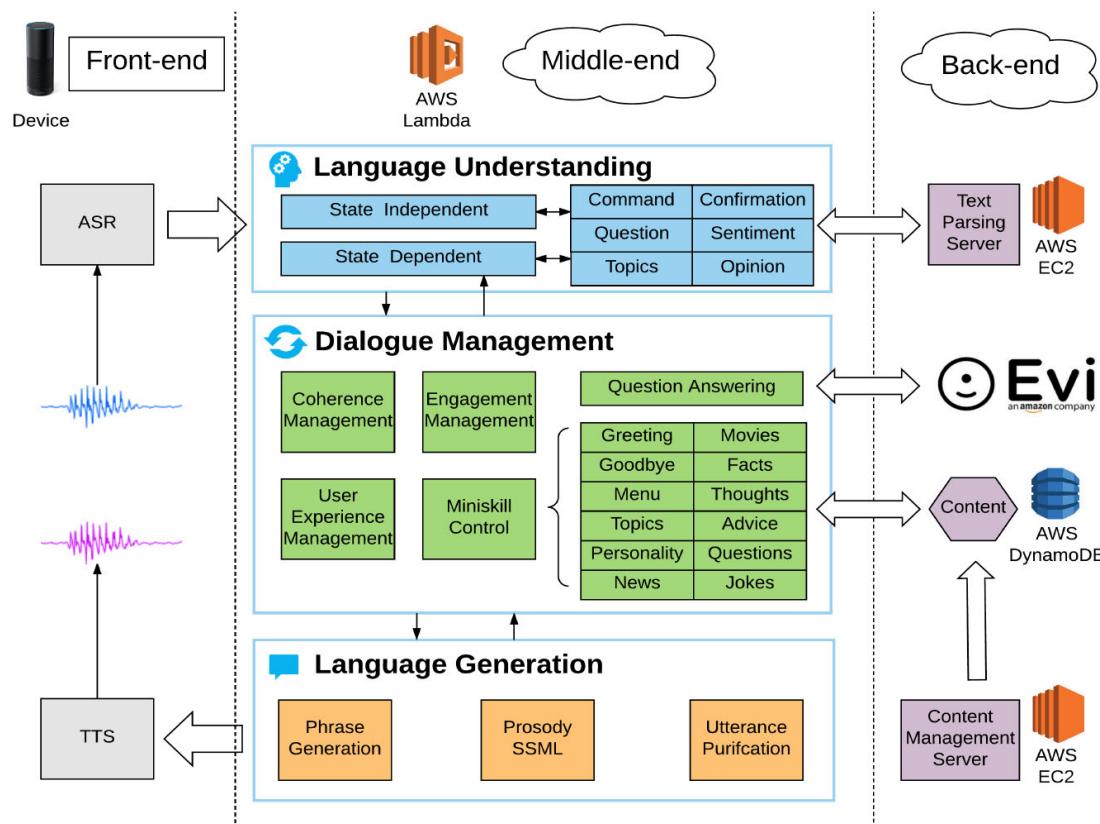
Sounding Board's Architecture?



Source: Yejin Choi



Sounding Board's Architecture



Source: Yejin Choi

 My roomba seems to be broken	 The light on the roomba is white	 I tried resetting it with the clean button and it's still spinning	 The roomba isn't moving at all because it won't respond to the clean button
 I'd be happy to help you try to diagnose and potentially fix the issue! Here are some steps you can take to address the problem: <ol style="list-style-type: none"> Check for Obstructions: Inspect the Roomba's path or brush guard for any obstructions that might be causing erratic movement. Clean the Roomba: Dust and debris can accumulate in the Roomba's internal components, causing it to move erratically. Clean the Roomba's sensors and brush guards. 	 If the light on your Roomba is white, it could indicate that the Roomba is attempting to dock or it's trying to locate the dock for the first time. This behavior is accompanied by the Roomba making a series of beeps. Here's what you can do to address this: <ol style="list-style-type: none"> Check Dock Placement: Ensure the charging dock is properly positioned and connected to a power source. Check Sensors: Inspect the sensors on the Roomba, including the bumper sensors. These sensors help the Roomba navigate obstacles. 	 If resetting the Roomba using the "Clean" button doesn't resolve the issue, it's possible that there might be a more serious issue with its internal components or sensors. In this case, you may need to consider additional steps: <ol style="list-style-type: none"> Check Sensors: Inspect the sensors on the Roomba, including the bumper sensors. These sensors help the Roomba navigate obstacles. 	 If your Roomba isn't responding to the "Clean" button and isn't moving at all, it's possible that there might be a more serious issue with its internal components. Here are some steps you can take to address this situation: <ol style="list-style-type: none"> Check Battery: Make sure your Roomba has a sufficient battery charge. If the battery is completely drained, the Roomba won't respond. If necessary, connect the Roomba to the charging dock and let it charge for a while before attempting to power it on again.
<p> that was extremely helpful and not at all too verbose or irrelevant to my situation</p>			
<p> I'm glad to hear that you found the information helpful and relevant! If you have any more questions or need further assistance in the future, feel free to reach out. Good luck with resolving the issue with your Roomba, and take care!</p>			
<p>electronics, you might attempt to repair it yourself. However, if you're unsure about a step, it's best to consult with professionals.</p> <p>Remember, safety is important! If you're unsure about a step, it's best to consult with professionals or the manufacturer's support team.</p>	<p>attempt to repair it yourself. However, if you're unsure about a step, it's best to consult with professionals.</p> <p>If the issue is not resolved after attempting to repair it yourself, it might be a hardware issue with your Roomba. In this case, you may need to consider replacement options.</p>	<p>Professional Repair: If your Roomba is not responding to the "Clean" button and it's not a simple issue like an obstruction or connectivity problem, it might be more cost-effective to consider replacing it with a newer model. Given that your Roomba isn't responding at all, and it's not a simple issue like an obstruction or connectivity problem, it's best to involve the manufacturer's support team or a professional technician who specializes in repairing Roombas. They will have the expertise and tools necessary to diagnose and fix the issue correctly.</p>	<p>Contact Customer Support: If you're unsure about a step, it's best to consult with professionals or the manufacturer's support team.</p> <p>Remember that electronic devices can be sensitive to handling. If you're not experienced with electronics, you might consider opening up the Roomba to attempt repairs that could potentially cause damage. However, if you're not experienced with electronics, it's best to leave it to professionals.</p> <p>Given that your Roomba isn't responding at all, and it's not a simple issue like an obstruction or connectivity problem, it's best to involve the manufacturer's support team or a professional technician who specializes in repairing Roombas. They will have the expertise and tools necessary to diagnose and fix the issue correctly.</p>



Ambiguities

CNN Live TV ≡

Stevie Wonder announces he'll be having kidney surgery during London concert

By Amir Vera, CNN

Updated 11:16 PM EDT, Sat July 06, 2019



(CNN) — Stevie Wonder will be taking a break from music.

The legendary singer-songwriter announced during a concert in London Saturday that he will be undergoing kidney surgery.



Problem: Ambiguity

- Headlines:
 - Teacher Strikes Idle Kids
 - Hospitals Are Sued by 7 Foot Doctors
 - Ban on Nude Dancing on Governor's Desk
 - Stolen Painting Found by Tree
 - Kids Make Nutritious Snacks
 - Iraqi Head Seeks Arms
 - Local HS Dropouts Cut in Half

- Why are these funny?

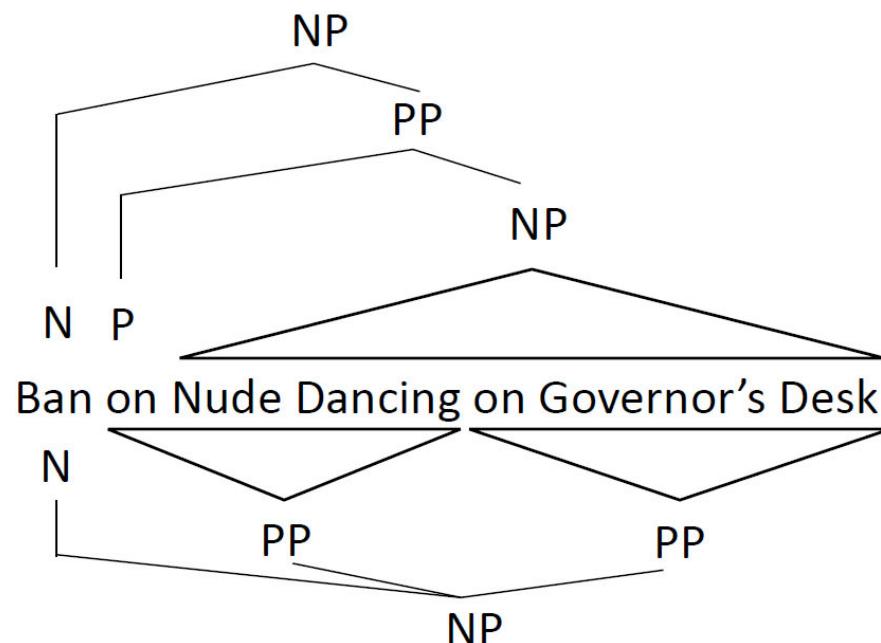
What Do We Need to Understand Language?



We Need Representation: Linguistic Structure?

N N V N
N V ADJ N
Teacher Strikes Idle Kids

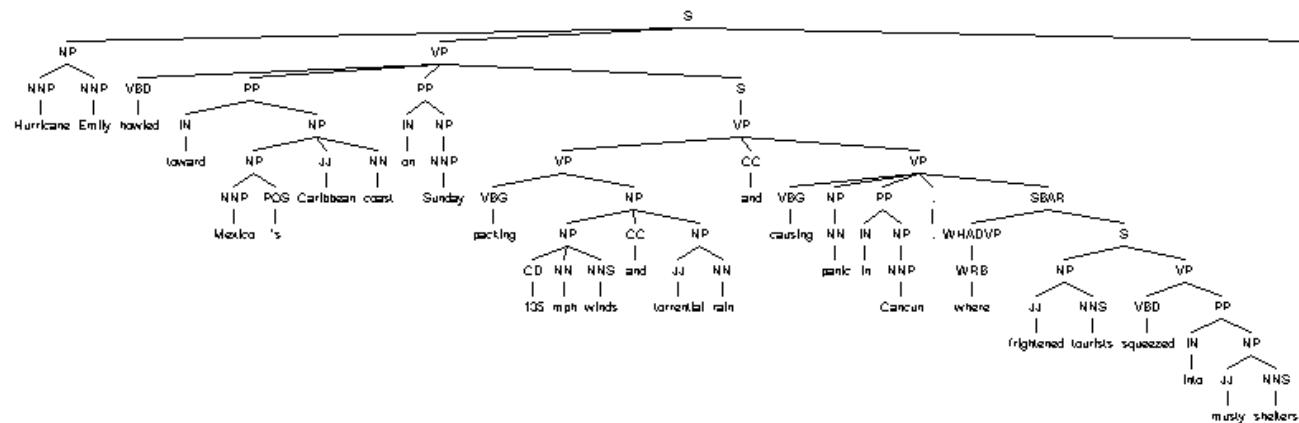
body/
position body/
weapon
Iraqi Head Seeks Arms



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



Example: Syntactic Analysis



Hurricane Emily howled toward Mexico 's Caribbean coast on Sunday packing 135 mph winds and torrential rain and causing panic in Cancun, where frightened tourists squeezed into musty shelters .

Accuracy: 95+



Latent Representations

Personal Pronouns (PRP)

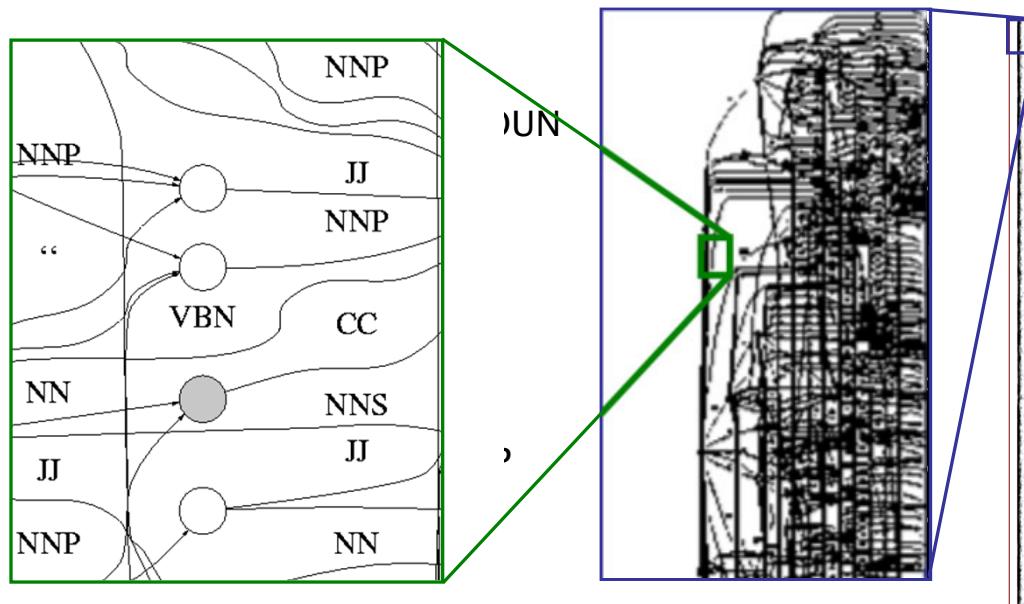
PRP-1	it	them	him
PRP-2	it	he	they
PRP-3	It	He	I

Proper Nouns (NNP)

NNP-14	Oct.	Nov.	Sept.
NNP-12	John	Robert	James
NNP-2	J.	E.	L.
NNP-1	Bush	Noriega	Peters
NNP-15	New	San	Wall
NNP-3	York	Francisco	Street



We Need Data





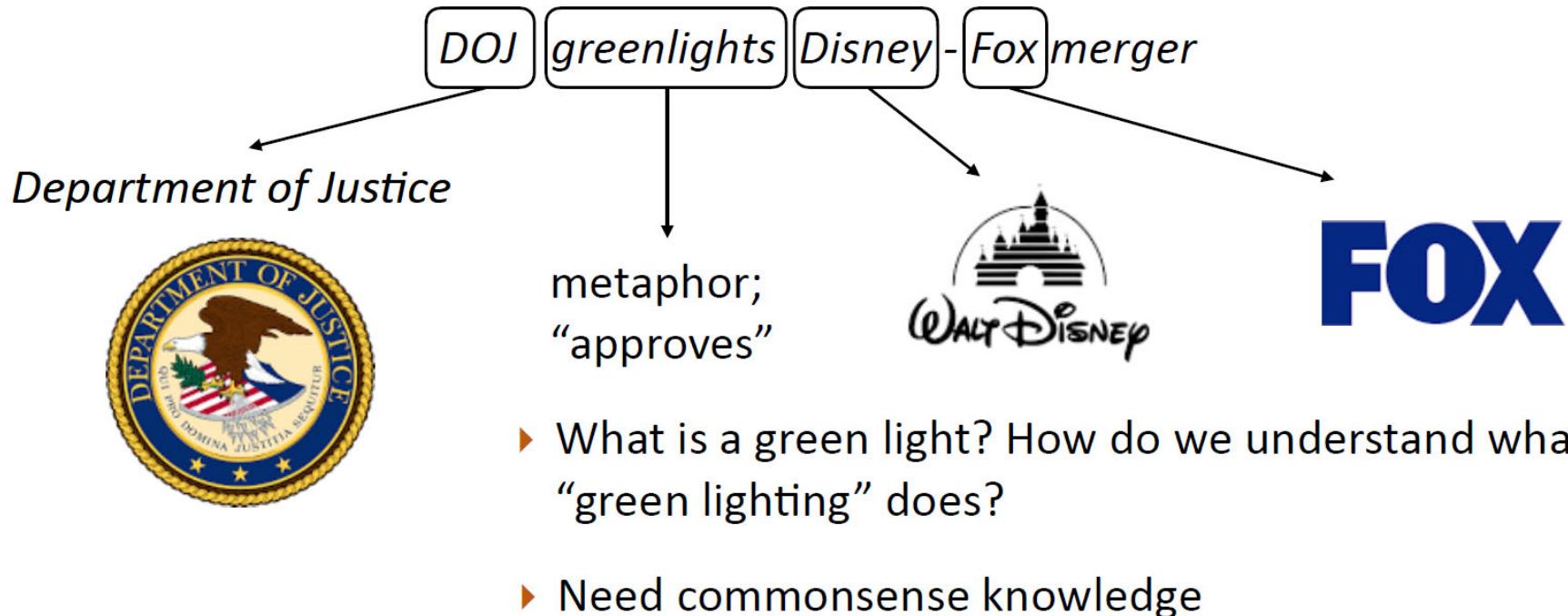
We Need A Lot of Data

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] [.]



We Need Knowledge

- ▶ World knowledge: have access to information beyond the training data





Data and Knowledge

- Classic knowledge representation worries: How will a machine ever know that...
 - Ice is frozen water?
 - Beige looks like this: 
 - Chairs are solid?
- Answers:
 - 1980: write it all down
 - 2000: get by without it
 - 2020: learn it from web data



Knowledge from Large LMs?

AI2 Allen Institute for AI

AllenNLP

>Annotate a sentence ^

Semantic Role Labeling

Named Entity
Recognition

Constituency Parsing

Dependency Parsing

Open Information
Extraction

Sentiment Analysis

Annotate a passage ^

Coreference Resolution

Answer a question ^

Reading
Comprehension

Semantic parsing ^

Language Modeling

This demonstration uses the public 345M parameter OpenAI GPT-2 language model to generate sentences.

Enter some initial text and the model will generate the most likely next words. You can click on one of those words to choose it and continue or just keep typing. Click the left arrow at the bottom to undo your last choice.

Sentence:

At high temperatures, ice becomes

Predictions:

32.0% The

10.3% Ice

5.2% ←

3.7% Water

2.7% When

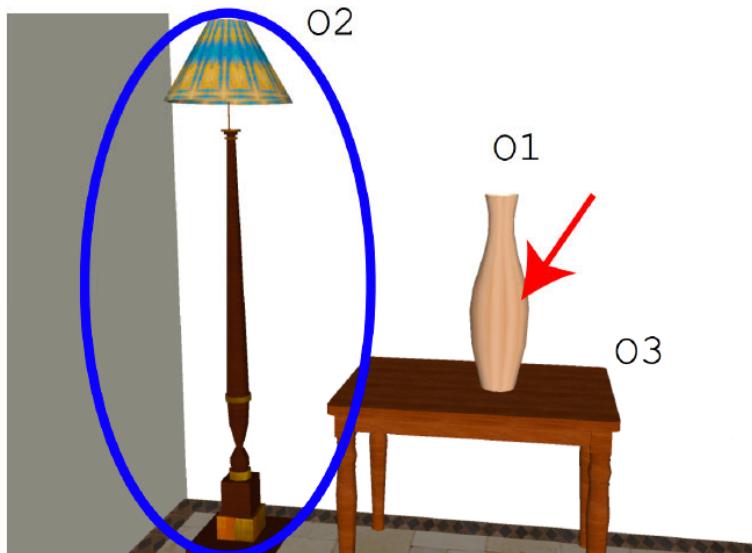
← Undo



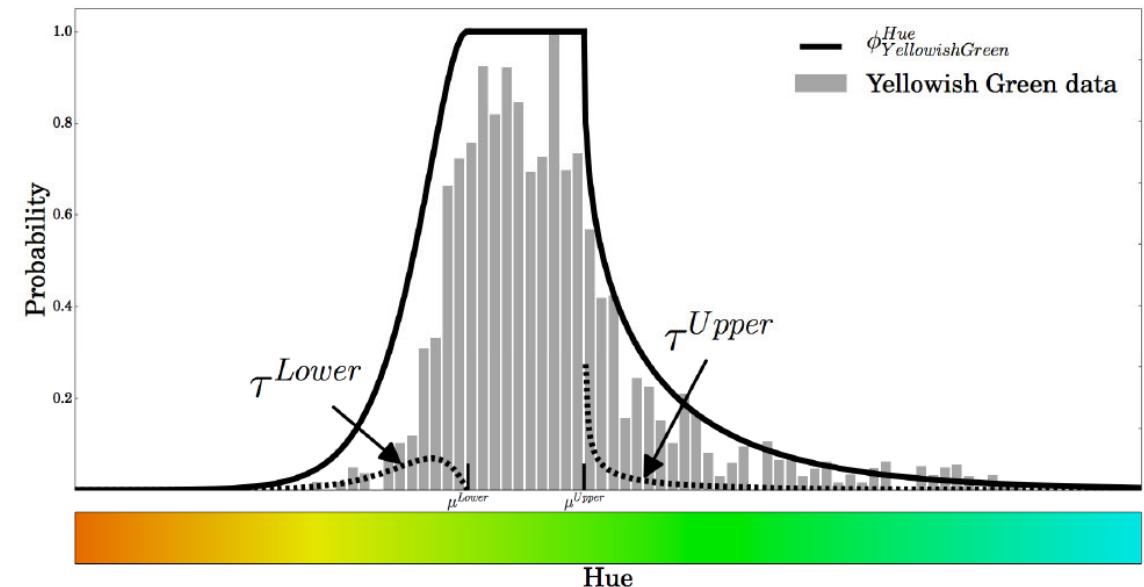
We Need Grounding

Grounding: linking linguistic concepts to non-linguistic ones

Question: What object is right of **O2** ?



Golland et al. (2010)



McMahan and Stone (2015)

Slide: Greg Durrett



Example: Grounded Dialog



A diagram illustrating a grounded dialog exchange. A large rectangular frame represents the conversation space. On the left side, a black person icon is positioned below the frame. On the right side, a blue laptop icon is positioned above the frame. Inside the frame, a grey speech bubble contains the text "When is my package arriving?". A blue speech bubble on the right side contains the text "Friday!". A thin grey line connects the two speech bubbles, indicating they are part of the same conversation. The entire diagram is set against a white background.





Why is Language Hard?

- We Need:
 - Representations
 - Models
 - Data
 - Grounding
 - Learning
 - Scale
 - Efficient Algorithms
- ... and often we need all these things at the same time



Course Overview (Subject to Change)

- 6 Lectures: Language / Sequence Modeling
- 2 Lectures: NLP Tasks, Data, and Evaluation
- 5 Lectures: Structured Prediction
- 4 Lectures: Transformers and LLMs
- 5 Lectures: NLP Beyond Text
- 5 Lectures: Panels on Current Topics