Natural Language Processing

Berkeley N L P

Dan Klein, GSI: Nick Tomlin
UC Berkeley

1

Logistics

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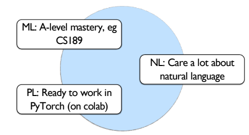
Logistics

- Enrollment
  - Class is "full" but we're scaling up
  - We will process waitlist after P1
  - No materials require enrollment
- Course expectations
  - Readings, lectures, ~8 projects
  - No sections, no exams
  - Engagement with the course
  - Workload will be high, self-direction
  - Patience: class is under construction
- Requirements



- COVID Policies
  - Remote lecture / chat format for now
  - Expanded late day policy (14 day)

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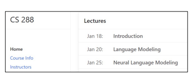
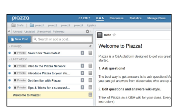
Resources and Readings

- Resources
  - Webpage (syllabus, readings, slides, links)
  - Piazza (course communication)
  - Gradescope (submission and grades)
  - Compute via Colab notebooks
  - Berkeley-internal webcasts / recordings



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



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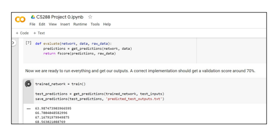
Projects and Infrastructure

- Projects
  - P1: Language Models
  - P2: Question Answering
  - P3: Machine Translation
  - P4: Speech
  - P5: Syntax and Parsing
  - P6: Semantics
  - P7: Grounding
  - P8: Historical Linguistics / TBD



- Infrastructure
  - Python / PyTorch
  - Compute via Colab notebooks
  - Grading via Gradescope

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What is NLP?

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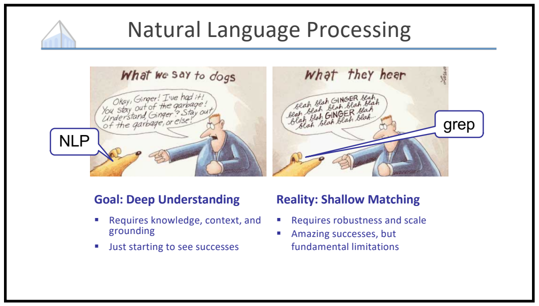
Natural Language Processing
What we say to dogs
Okay, Ginger! I've had it! You stay out of the garbage! Understand, Ginger? Stay out of the garbage, or else!
What they hear
blah blah GINGER blah blah blah blah blah blah blah blah GINGER blah blah blah blah blah
NLP
grep
Goal: Deep Understanding
Requires knowledge, context, and grounding
Just starting to see successes
Reality: Shallow Matching
Requires robustness and scale
Amazing successes, but fundamental limitations

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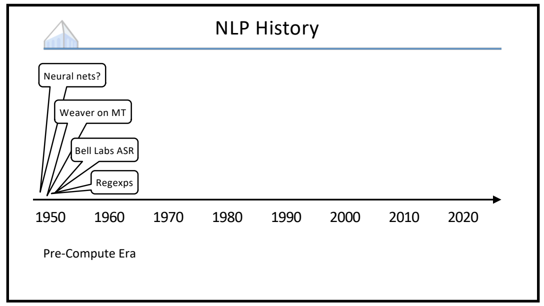
NLP History
Neural nets?
Weaver on MT
Bell Labs ASR
Regexps
1950
1960
1970
1980
1990
2000
2010
2020
Pre-Compute Era

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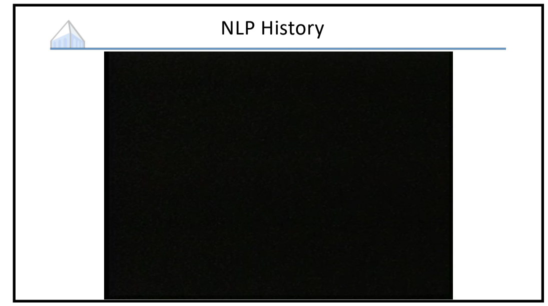
NLP History

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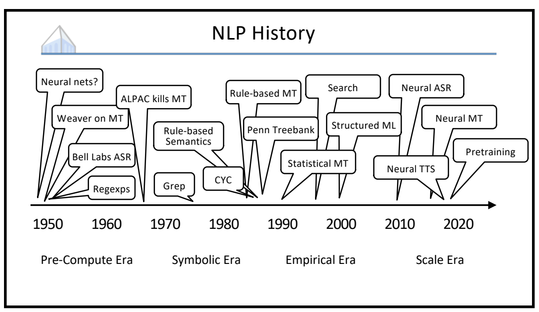
NLP History
Neural nets?
ALPAC kills MT
Weaver on MT
Rule-based Semantics
Bell Labs ASR
Regexps
Grep
CYC
Rule-based MT
Penn Treebank
Search
Structured ML
Statistical MT
Neural ASR
Neural MT
Neural TTS
Pretraining
1950
1960
1970
1980
1990
2000
2010
2020
Pre-Compute Era
Symbolic Era
Empirical Era
Scale Era

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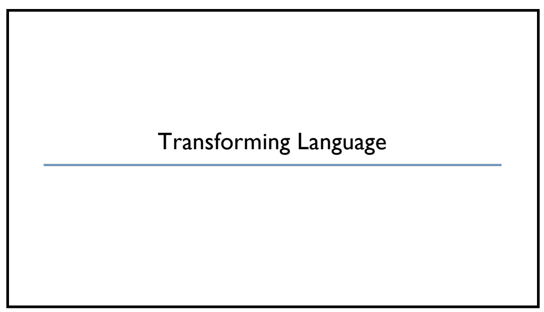
Transforming Language

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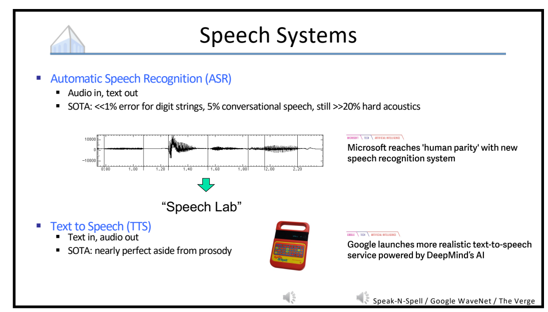
Speech Systems
Automatic Speech Recognition (ASR)
Audio in, text out
SOTA: <<1% error for digit strings, 5% conversational speech, still >>20% hard acoustics
Microsoft reaches 'human parity' with new speech recognition system
"Speech Lab"
Text to Speech (TTS)
Text in, audio out
SOTA: nearly perfect aside from prosody
Google launches more realistic text-to-speech service powered by DeepMind's AI
Speak-N-Spell / Google WaveNet / The Verge

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Machine Translation

- Translate text from one languag
- 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

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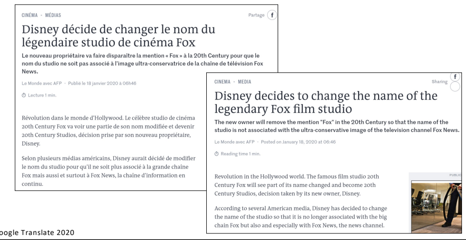
Machine Translation



Google Translate 2020

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Spoken Language Translation

Image: Microsoft Skype via Yejin Choi

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Summarization

- Condensing documents
  - Single or multiple docs
  - Extractive or synthetic
  - Aggregative or representative
- Very context-dependent!
- An example of analysis with generation

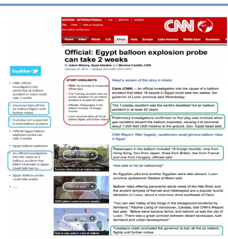

Image: CNN via Wei Gao

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Understanding Language

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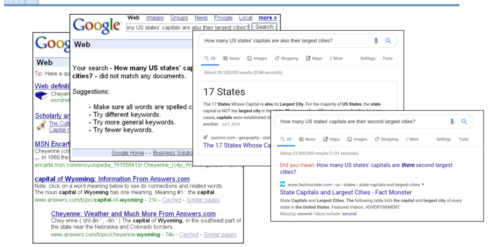
Search, Questions, and Reasoning



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Jeopardy!

Images: Jeopardy Productions

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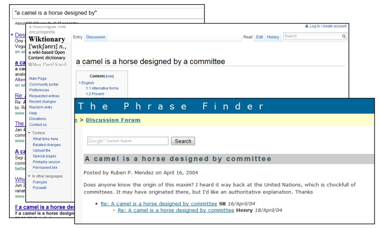
Question Answering: Watson



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Question Answering: Watson

Jeopardy!
World Champion

US Cities: Its largest airport is named for a World War II hero; its second largest, for a World War II battle.

Slide: Yejin Choi

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Language Comprehension?

Opera refers to a dramatic art form, originating in Europe, in which the emotional content is conveyed to the audience as much through music, both vocal and instrumental, as it is through the lyrics. By contrast, in musical theater an actor's dramatic performance is primary, and the music plays a lesser role. The drama in opera is presented using the primary elements of theater such as scenery, costumes, and acting. However, the words of the opera, or libretto, are sung rather than spoken. The singers are accompanied by a musical ensemble ranging from a small instrumental ensemble to a full symphonic orchestra.

1. It is pointed out in the reading that opera ----.

- ○ A) has developed under the influence of musical theater
- ○ B) is a drama sung with the accompaniment of an orchestra
- ○ C) is not a high-budget production
- ○ D) is often performed in Europe
- ○ E) is the most complex of all the performing arts

[From GrammarBank]

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Interactive Language

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Example: Virtual Assistants

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

Image: Wikipedia

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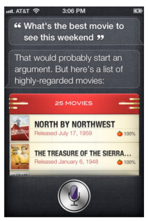
Conversations with Devices?



Slide: Yejin Choi

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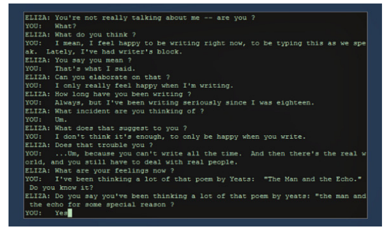
ELIZA



[Weizenbaum 1966]. Image: https://thoughtcatalog.com/oliver-miller/2012/08/a-conversation-with-eliza

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Social AIs and Chatbots

Session 1

1 [Human] Hello, Xiaoice.
[Xiaoice] Hello, your profile pic is interesting. Like I've seen it somewhere.
2 [Human] Really?
[Xiaoice] Is it a comic character?
3 [Human] How do you know that?
[Xiaoice] Guess.
4 [Human] Are you human?
[Xiaoice] Well, you'll know it after chatting with me more.
5 [Human] Aren't you an AI chatbot?
[Xiaoice] So what? I won't be indifferent to you.
6 [Human] What functions do you have?
[Xiaoice] I have over 200 skills. Just name one you need.
……

Session 6

1 [Human] Have you watched Inuyasha? (Note: A Japanese comic)
[Xiaoice] Every time Kagome comes back to the modern world, a math test is waiting for her
2 [Human] Bravo, well, do you know how Naraku died?
[Xiaoice] Naraku is not dead and Shikon Jewel does not disappear.
3 [Human] So amazing!
[Xiaoice] Why amazed?
4 [Human] Awesome! Surprised that you also like comic
……

XiaoIce, developed by Microsoft

Source: Microsoft

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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

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SoundingBoard Example

Turn	User	Sounding Board
1	Let's chat	Hi! This is an Alexa Prize socialbot. How's your day?
2	I'm five.	Glad to hear it! We could talk about robots, batman, or supe… 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 … est 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

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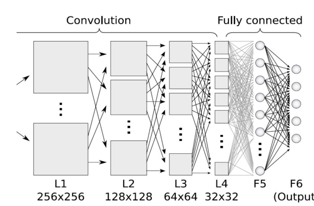
Sounding Board's Architecture?



Source: Yejin Choi

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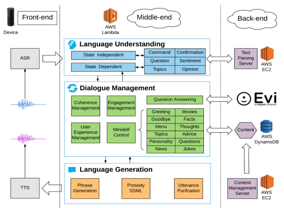
Sounding Board's Architecture



Source: Yejin Choi

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Related Areas

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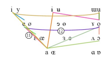
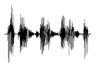
What is Nearby NLP?

- Computational Linguistics
  - Using computational methods to learn more about how language works
  - We end up doing this and using it



- Cognitive Science
  - Figuring out how the human brain works
  - Includes the bits that do language
  - Humans: the only working NLP prototype!

- Speech Processing
  - Mapping audio signals to text
  - Traditionally separate from NLP, converging



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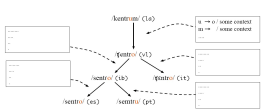
Example: NLP Meets CL



Gloss	Latin	Italian	Spanish	Portuguese
Word/verb	verbum	verbo	verbo	verbu
Center	centrum	centro	centro	centro

- Example: Language change, reconstructing ancient forms, phylogenies
  … just one example of the kinds of linguistic models we can build

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Why is Language Hard?

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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.

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Problem: Ambiguity

- Headlines:
  - Enraged Cow Injures Farmer with Ax
  - Teacher Strikes Idle Kids
  - Hospitals Are Sued by 7 Foot Doctors
  - Ban on Nude Dancing on Governor's Desk
  - Iraqi Head Seeks Arms
  - Stolen Painting Found by Tree
  - Kids Make Nutritious Snacks
  - Local HS Dropouts Cut in Half
- Why are these funny?

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What Do We Need to Understand Language?

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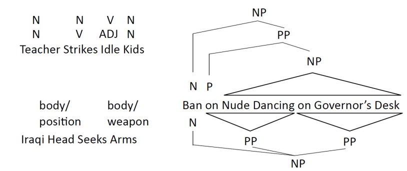
We Need Representation: Linguistic Structure



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

Slide: Greg Durrett

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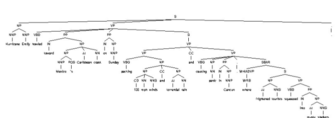
Example: Syntactic Analysis



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+

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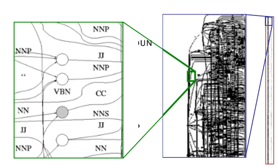
We Need Data



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We Need Lots of Data: MT

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] [.]

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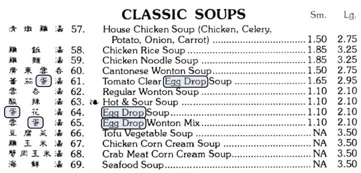
We Need Models: Data Alone Isn't Enough!


CLASSIC SOUPS — Sm. Lg.

		Sm.	Lg.
57.	House Chicken Soup (Chicken, Celery, Potato, Onion, Carrot)	1.50	2.75
58.	Chicken Rice Soup	1.85	3.25
59.	Chicken Noodle Soup	1.85	3.25
60.	Cantonese Wonton Soup	1.50	2.75
61.	Tomato Clear Egg Drop Soup	1.65	2.95
62.	Regular Wonton Soup	1.10	2.10
63.	Hot & Sour Soup	1.10	2.10
64.	Egg Drop Soup	1.10	2.10
65.	Egg Drop Wonton Mix	1.10	2.10
66.	Tofu Vegetable Soup	NA	3.50
67.	Chicken Corn Cream Soup	NA	3.50
68.	Crab Meat Corn Cream Soup	NA	3.50
69.	Seafood Soup	NA	3.50

Example from Adam Lopez

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Learning Latent Syntax

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

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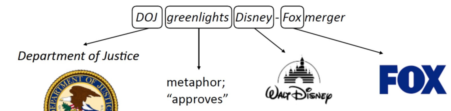
We Need Knowledge

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



- What is a green light? How do we understand what "green lighting" does?
- Need commonsense knowledge

Slide: Greg Durrett

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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 data

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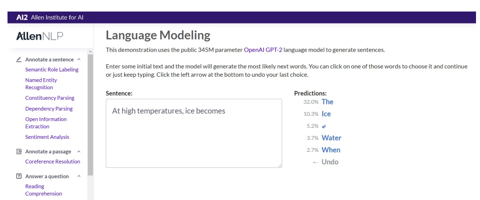
Knowledge from Pretraining?



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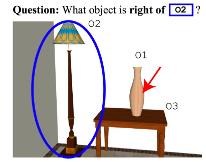
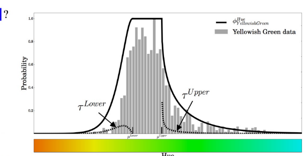
We Need Grounding

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

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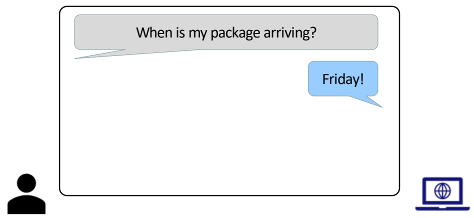
Example: Grounded Dialog



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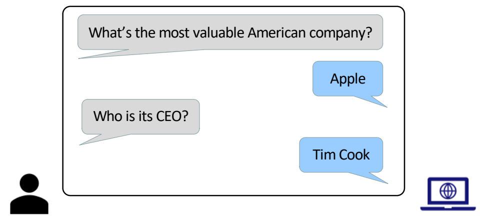
Example: Grounded Dialog



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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

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What is this Class?

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What is this Class?

- Three aspects to the course:
  - Linguistic Issues
    - What are the range of language phenomena?
    - What are the knowledge sources that let us disambiguate?
    - What representations are appropriate?
    - How do you know what to model and what not to model?
  - Modeling Methods
    - Increasingly sophisticated model structures
    - Learning and parameter estimation
    - Efficient inference: dynamic programming, search, sampling
  - Engineering Methods
    - Issues of scale
    - Where the theory breaks down (and what to do about it)
- We'll focus on what makes the problems hard, and what works in practice…

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Class Requirements and Goals

- Class requirements
  - Uses a variety of skills / knowledge:
    - Probability and statistics, graphical models (parts of cs281a)
    - Basic linguistics background (ling100)
    - Strong coding skills (Python, ML libraries)
  - Most people are probably missing one of the above
  - You will often have to work on your own to fill the gaps
- Class goals
  - Learn the issues and techniques of modern NLP
  - Build realistic NLP tools
  - Be able to read current research papers in the field
  - See where the holes in the field still are!
- This semester: new projects, new topics, lots under construction!

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