

# Natural Language Understanding

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1 April 2019

# Goals of NLU

- Gain insights into human cognition
- Develop artificial agents as assistants or companions
- Solve a major subproblem of AI
- ...?

# Technological and cognitive goals

James Allen (1987)

[T]here can be two underlying motivations for building a computational theory. The technological goal is simply to build better computers, and any solution that works would be acceptable. The cognitive goal is to build a computational analog of the human-language-processing mechanism; such a theory would be acceptable only after it had been verified by experiment.

## Levesque 2013: On our best behaviour

“This paper is about the *science* of AI. Unfortunately, the *technology* of AI that gets all the attention.”

“AI is the study of intelligent behaviour in computational terms.”

“Should baseball players be allowed to glue small wings onto their caps?”

“We need to return to our roots in Knowledge Representation and Reasoning *for* language and *from* language.”

# What is understanding?

To understand a statement is to:

- determine its truth (with justification)
- calculate its entailments
- take appropriate action in light of it
- translate it into another language
- ...

# Philosophical debates

- The Imitation Game [Alan Turing, 1950]
- The Chinese Room [John Searle, 1980]
- ...

# A question of fact, or a question of usage?

Chomsky (1996):

The question of whether a computer is playing chess, or doing long division, or translating Chinese, is like the question of whether robots can murder or airplanes can fly — or people; after all, the “flight” of the Olympic long jump champion is only an order of magnitude short of that of the chicken champion (so I’m told). These are questions of decision, not fact; decision as to whether to adopt a certain metaphoric extension of common usage.

# A brief history of NLU

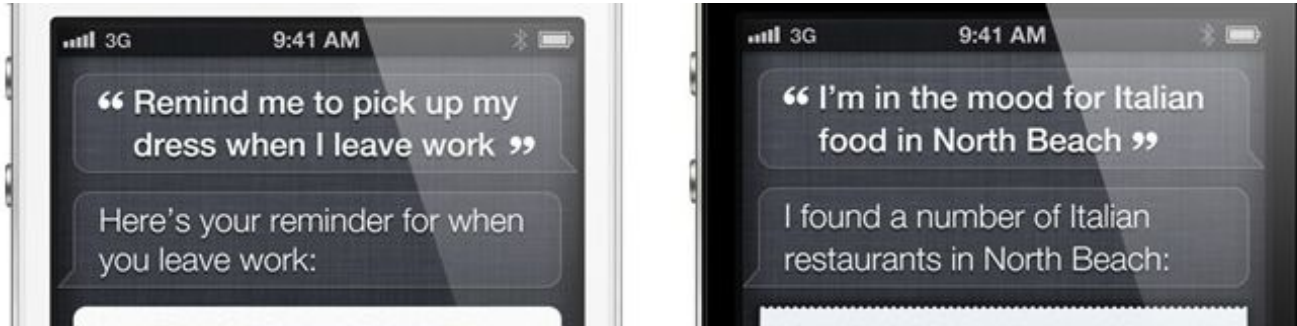
- **1960s:** Pattern-matching with small rule-sets
- **1970-80s:** Linguistically rich, logic-driven, grounded systems; restricted applications
- **Mid-1990s:** Statistical revolution in NLP → decrease in NLU work
- **Late 2000s:** NLU returns to center stage, mixing techniques from previous decades
- **Mid-2010s:** Deep learning takes over NLU: LSTMs, seq2seq, ...



# NLU today and tomorrow

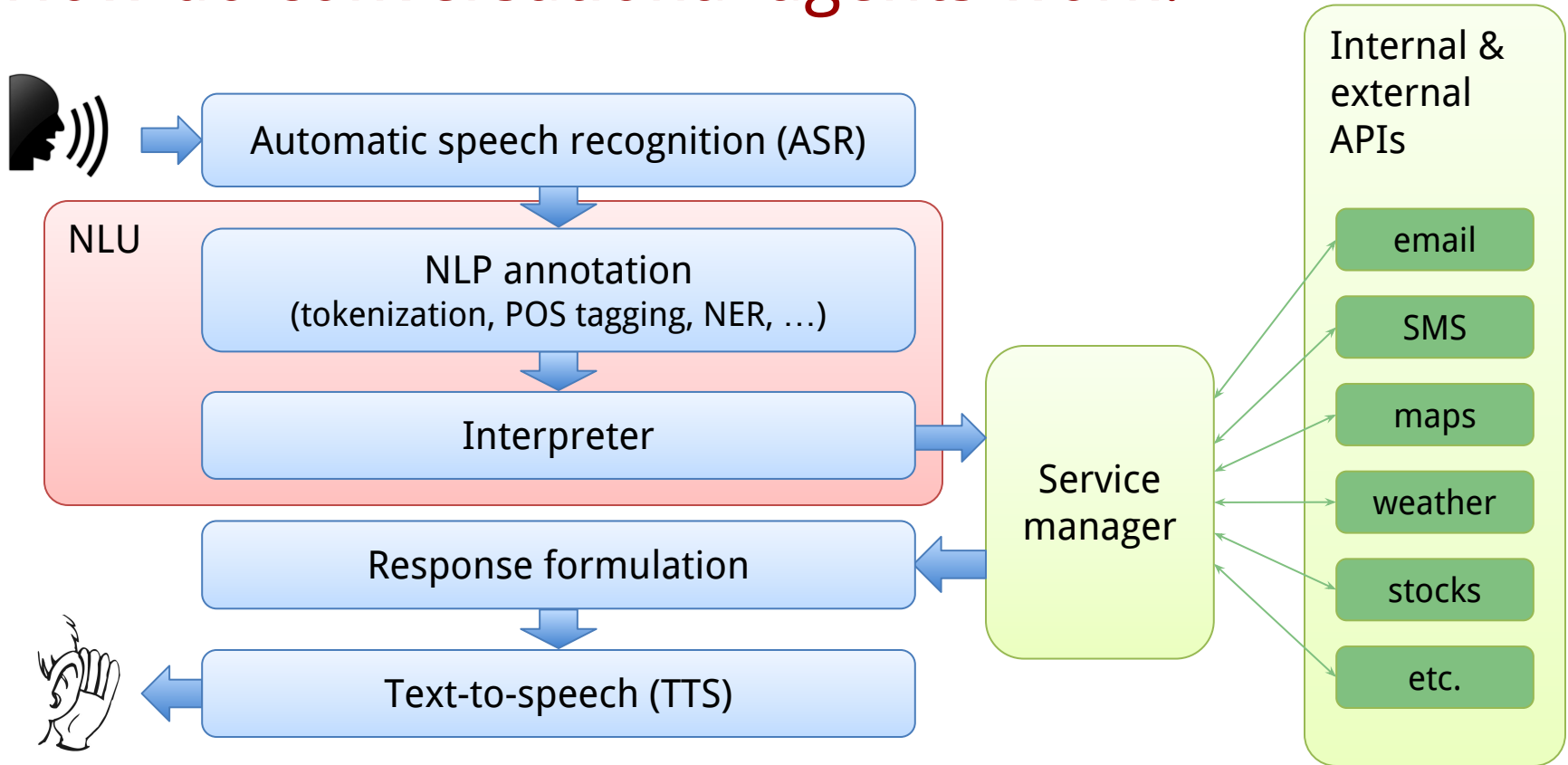
- It's an exciting time to be doing NLU!
- In academia, a resurgence of interest in NLU (after a long winter)
- In industry, an explosion in products & services that rely on NLU (Siri, Google Assistant, Amazon Alexa, Microsoft Cortana, ...)
- Systems are impressive, but show their weaknesses quickly
- NLU is far from solved — big breakthroughs lie in the future

# Siri



- The voice-driven personal assistant on your iPhone
- One of the most visible & exciting applications of NLU today
- A major breakthrough in artificial intelligence (AI)??
- The next generation of interaction design??

# How do conversational agents work?



# The promise of conversational agents



Where is **Black Panther** playing in **Mountain View**?

Black Panther is playing at the Century 16 Theater.

When is **it** playing **there**?

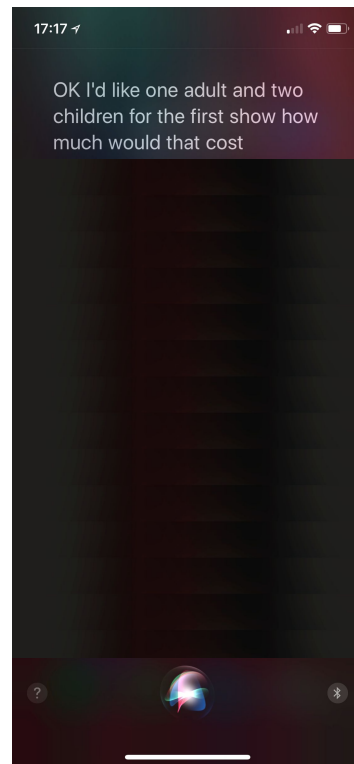
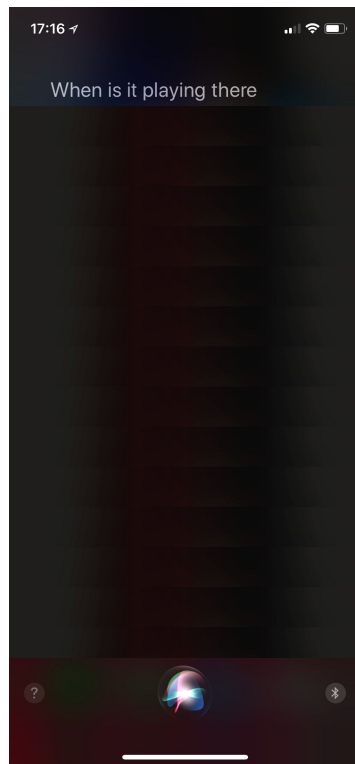
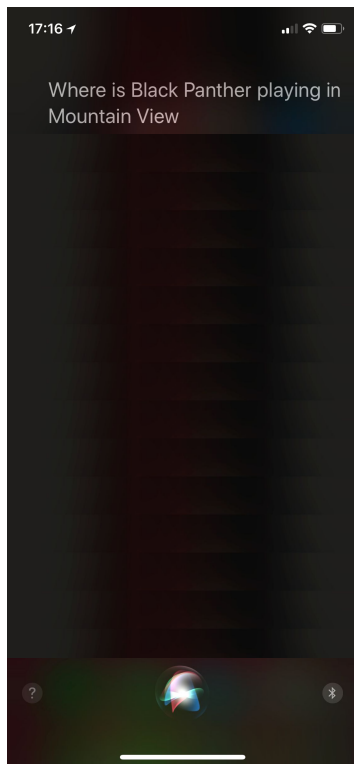
It's playing at 2pm, 5pm, and 8pm.

OK. I'd like 1 **adult** and 2 **children** for **the first show**.  
How much would **that** cost?



Need **domain knowledge**, **discourse knowledge**, **world knowledge**

# The reality of conversational agents



# The reality of conversational agents



**Colbert:** Write the show.

**Siri:** What would you like to search for?

**Colbert:** I don't want to search for anything! I want to write the show!

**Siri:** Searching the Web for "search for anything. I want to write the shuffle."

[...]

**Colbert:** For the love of God, the cameras are on, give me something?

**Siri:** What kind of place are you looking for? Camera stores or churches?

**Colbert:** F--- you.

**Siri:** I'd blush if I could.

# Reminiscent of Eliza (1966)

**User:** You are like my father in some ways.

**ELIZA:** What resemblance do you see

**User:** You are not very aggressive but I think you don't want me to notice that.

**ELIZA:** What makes you think I am not aggressive?

**User:** You don't argue with me.

**ELIZA:** Why do you think I don't argue with you?

**User:** You are afraid of me.

**ELIZA:** Does it please you to believe I am afraid of you?

# Reminiscent of Eliza (1966)

Rewrite user's reply by:

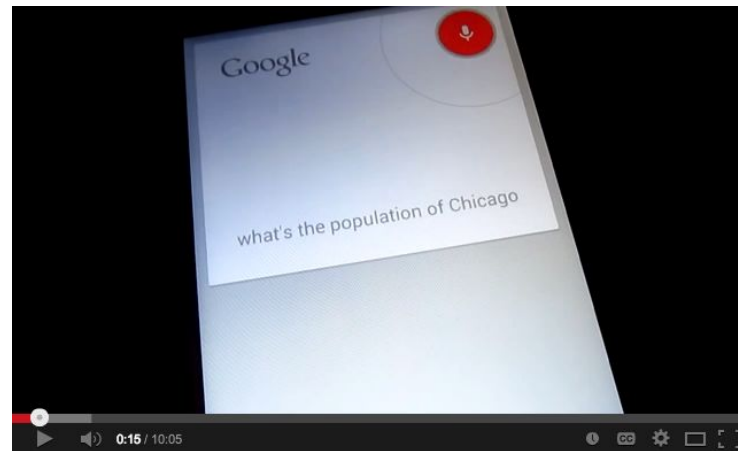
- Swapping 1st and 2nd person
- Interpolating stock phrase
- Using scores to rank possible transformations
- When desperate, search the Web [21st century]



# Conversational search at Google

what's the population of Chicago  
who's the mayor  
how old is **he**  
who is **he** married to

OK Google, where am I  
how is traffic in San Diego  
show me things to do **there**  
when did the San Diego Zoo **open**  
is **it** **open**  
how far is **it**  
call **them**



<https://www.youtube.com/watch?v=yiQX-Y0gms>

when is Thanksgiving  
I meant the Canadian **one**

# Semantic query parsing at Google

A growing proportion of queries require semantic interpretation.  
Conventional keyword-based retrieval does not suffice!

*how to bike to my office*

```
(TravelQuery
 (Destination /m/0d61p)
 (Mode BIKE))
```

*angelina jolie net worth*

```
(FactoidQuery
 (Entity /m/0f4vbz)
 (Attribute /person/net_worth))
```

*weather friday austin tx*

```
(WeatherQuery
 (Location /m/0vzm)
 (Date 2013-12-13))
```

*text my wife on my way*

```
(SendMessage
 (Recipient 0x31cbf492)
 (MessageType SMS)
 (Subject "on my way"))
```

*play sunny by boney m*

```
(PlayMedia
 (MediaType MUSIC)
 (SongTitle "sunny")
 (MusicArtist /m/017mh))
```

*is REI open on sunday*

```
(LocalQuery
 (QueryType OPENING_HOURS)
 (Location /m/02nx4d)
 (Date 2013-12-15))
```

# Application: sentiment analysis

which gives us plenty to listen to

RT @dave mcgregor: Publicly pledging to never fly @delta again. The worst airline ever. U have lost my patronage forever due to ur incompetence

Completely unimpressed with @continental or @united. Poor communication, goofy reservations systems and all to turn my trip into a mess.

@united #fail on wifi in red carpet clubs (too slow), delayed flight, customer service in red carpet club (too slow), hmmm do u see a trend?

@United Weather delays may not be your fault, but you are in the customer service business. It's atrocious how people are getting treated!

We were just told we are delayed 1.5 hrs & next announcement on @JetBlue - "We're selling headsets." Way to capitalize on our misfortune.

@SouthwestAir I know you don't make the weather. But at least pretend I am not a bother when I ask if the delay will make miss my connection

@SouthwestAir  
I hate you with every single bone in my body for delaying my flight by 3 hours, 30mins before I was supposed to board.  
#hate

Hey @delta - you suck! Your prices are over the moon & to move a flight a cpl of days is \$150.00. Insane. I hate you! U ruined my vacation!

(All airlines tweets are negative; perhaps we can achieve more nuanced judgments.)

# Twitter prognostication

- [Twitter mood predicts the stock market](#) [Bollen et al. 2011]
- “In February 2011 Derwent Capital Markets launched a hedge fund using Twitter for investment direction.”  
[\[Wikipedia\]](#)
- [The junk science behind the ‘Twitter Hedge Fund’](#)
- [Derwent closes shop](#)

# Hathaway vs. Hathaway

## Does Anne Hathaway News Drive Berkshire Hathaway's Stock?

MAR 18 2011, 10:50 AM ET 28



257



471



7



616

*Given the awesome correlating powers of today's stock trading computers, the idea may not be as far-fetched as you think.*



# Application: automated trading

- Most financial trading is now done by automated systems
- Many trading strategies rely in part on automated analysis of unstructured data feeds: newswires, analyst reports, etc.
- You can make vast profits if you can discover and act on market-moving news faster & more accurately than rivals
- Essentially, they're using NLU to predict the markets

# The 2008 United Airlines “bankruptcy”

- Newspaper accidentally republished old bankruptcy story
- Automated trading reacted within seconds
- \$1B in market value evaporated within 12 minutes



Read more at  
<http://nyti.ms/1dBzJ5K>

# The 2013 @AP Twitter hack

Tweets All / No replies



The Associated Press @AP

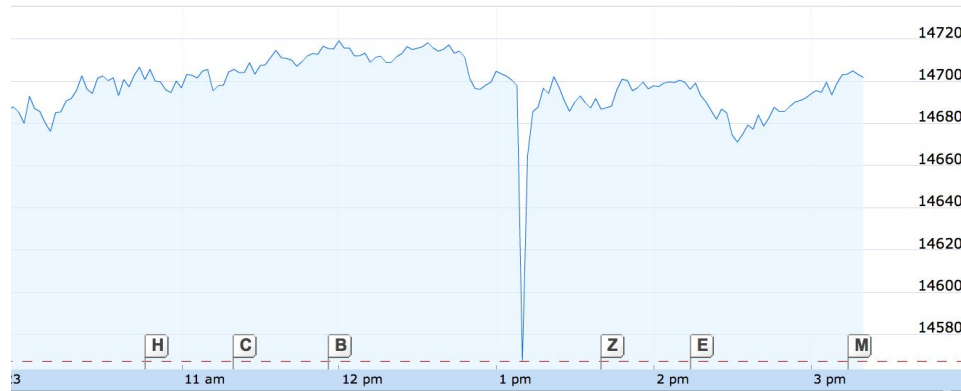
5m

Breaking: Two Explosions in the White House and Barack Obama is injured

Expand

1d 5d 1m 3m 6m YTD 1y 5y 10y All

Apr 23, 2013 - Apr 23, 2013 +134.7 (0.92%)



@AP Twitter feed hacked.

Within seconds,  
Dow plunged 140 points.

Recovered in 6 minutes.

S&P 500 temporarily lost  
**\$136B** in market cap!

Oops.



# The 2013 @AP Twitter hack

The rapid fire trading also highlights the role of computers and algorithmic trading on Wall Street. “That goes to show you how algorithms read headlines and create these automatic orders — you don’t even have time to react as a human being,” said Kenny Polcari of O’Neill Securities, on *Power Lunch*. “I’d imagine the SEC’s going to look into how this happens. It’s not about banning computers, but it’s about protection and securing our markets.”


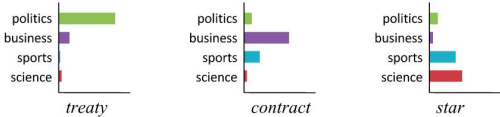
<http://www.cnbc.com/id/100646197>

# NLU: Traditional organization

- Lexical semantics: meanings of words
- Compositional semantics: meanings of sentences
- Language in context: meanings of dialogues and discourses

# Semantic representations

Another way of organizing NLU topics: by representation

sentiment analysis	continuous	scalars	
vector space models		vectors / topic distributions	
relation extraction	discrete	relation instances / database triples	(Larry Page, founder, Google) (Google, located in, Mountain View)
semantic parsing		logical forms / other rich structures	$\operatorname{argmax}(\lambda x.\text{state}(x), \lambda x.\text{size}(x))$

# Big themes for this class

- **Composition:** How do we construct semantic representations of bigger pieces of text from semantic representations of smaller pieces of text?
- **Learning:** How can we build models for semantic interpretation automatically from data?

# Course goals

- To make you the best — most insightful and responsible — NLU researcher and practitioner wherever you go next.
- To support you in completing a project that is worthy of presentation at a top NLP conference

# Assignments and bake-offs

1. There are four regular assignments. The first is due April 15, and they are weekly after that through the first half of the quarter.
2. Each assignment culminates in a bake-off: an informal competition in which you enter your original model.
3. The assignments ask you to build baseline systems to inform your own model design, and to build your original model.
4. The assignments earn you 9 of the 10 points. All bake-off entries earn the additional point.
5. Winning bake-off entries earn extra credit.
6. **Rationale for all this: exemplify best practices for NLU projects. (Let us know where we're not living up to this!)**

# Forming teams on Canvas

1. Assignment and bake-off submissions take the form of Jupyter notebooks uploaded to Canvas.
2. This work can be done in teams of up to 3 people.
3. To create a team on Canvas, choose the **People** tab, then the **Groups** tab, and use of the groups associated with the assignment. For example, choose one of the “Assign 1 and Bake-off 1” groups for Assignment 1 and Bake-off 1.
4. After that, one of your members can submit for your group.
5. *It is your responsibility to make sure the assignment is associated with your group. The submission interface makes it clear.*

# Projects

1. The second half of the course is devoted to projects.
2. The associated lectures, notebooks, and readings are focused on methods, metrics, tricks, tips, and best practices.
3. The assignments are all project-related; details are available at [this course page](#):
  - a. Lit review
  - b. Experimental protocol
  - c. Video presentation
  - d. Final paper
4. [Exceptional final projects from past years](#) (access restricted)



# Course logistics

- Website: <http://web.stanford.edu/class/cs224u/>
- Teaching staff: Chris & Bill, plus 10 amazing TAs
- Piazza: <http://piazza.com/stanford/spring2019/cs224u/home>
- Lectures streamed and stored on [Canvas](#)
- Mailing lists
  - Staff: [cs224u-spr1819-staff@lists.stanford.edu](mailto:cs224u-spr1819-staff@lists.stanford.edu)
  - Make sure you are on either student or guest email list
- [Components of your grade](#)

# Special session this Friday!

Lucy and Ashkon will run a special session on **Python and Jupyter notebooks**:

- Friday, April 5, 3:15-4:15, [SHRIRAM 104](#)
- The session will be broadcast on Zoom and recorded.

# For next time

- [Get your computing environment set up](#)
  - Course Github repository
  - Anaconda recommended
  - Python 3.7
  - Tensorflow, PyTorch, NLTK data, and others
  - Data distribution
- Start watching the screencasts for this unit, reading Turney and Pantel 2010, and exploring the notebooks