Goals of NLU

• Insights into human cognition
• Artificial agents as friends/slaves
• Solve a major subproblem of AI
• ...

Technological and cognitive goals


[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.
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
- ...
What is understanding?

• Turing tests
• Thought experiments
• Philosophical debate
• ...

What is understanding?

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.
Super-human partnerships

**Moderator:** How far are we away from human intelligence? Just take a gamble.

**Peter Norvig:** Well, first of all, I object to that, because I think that’s a low target to aim at. [Audience laughs.] Right, ’cause certainly there’s lots of things already that computers are much, much better than people at. [. . . ] We want to be able to say, “What is it that humans can’t do that computers can do better?” Now, part of that may be that the computers want to have some basic competency at the human-level in order to interact with us better. But the goal shouldn’t be human-level performance. The goal should be super-human partnership. [http://www.kqed.org/a/radiospecials/R201111302000]
“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.”
A brief history of NLU

• 1960s: Pattern-matching with small rule-sets
• 1970-80s: Linguistically rich, logic-driven, grounded systems; restricted applications
• 1990s: the statistical revolution in NLP leads to a decrease in NLU work
• 2010s: NLU returns to center stage, mixing techniques from previous decades
NLU today & tomorrow

• It’s an exciting time to be doing NLU!

• In academia, a resurgence of interest in NLU (after a long winter)

• Widespread perception that NLU is poised to break through & have huge impact

• Explosion in businesses, products, and services that rely on NLU (Siri, Google Now, Microsoft Cortana, Facebook Graph Search, …)

• Hot job market for Stanford grads with NLU skills!
Susan Bennett, a veteran voice actor, claimed that she is the original voice behind the popular digital assistant. Tight-lipped Apple officials won't confirm or deny the claim, but an audio forensics expert confirmed that the voices are a match. [http://nydn.us/1g6E0eR](http://nydn.us/1g6E0eR)
Siri

• The voice-driven personal assistant on your iPhone
• Perhaps the most visible & exciting application of NLU today
• A major breakthrough in artificial intelligence (AI)??
• The next generation of UI design??
How does Siri work?

NLU

- Automatic speech recognition (ASR)
- NLP annotation (tokenization, POS tagging, NER, …)
- Pattern-action mappings
- Response formulation
- Text-to-speech (TTS)

Service manager

Internal & external APIS
- email
- SMS
- maps
- weather
- stocks
- etc.
The promise of Siri

Where is The Hobbit playing in Mountain View?

The Hobbit 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 Siri

“Where is the hobbit playing in Mountain View”

OK, here’s ‘The Hobbit: An Unexpected Journey’ playing in Mountain View today:

“OK, here’s ‘The Hobbit: An Unexpected Journey’ playing a bit far from Palo Alto today:

Here’s ‘The Hobbit: An Unexpected Journey’ playing a bit far from Palo Alto today:

“Okay I like one adult and two children for the first show how much would that cost”

“Okay I like one adult and two children for the first show how much would that cost…”

Searching the web for ‘Okay I like one adult and two children for the first show how much would that cost’…
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?

http://thecolbertreport.cc.com/videos/h40j2n/talking-iphone-4s
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 3rd 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!

- **directions to SF by train**
  - (TravelQuery
    - (Destination /m/0d61p)
    - (Mode TRANSIT))

- **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))
Microsoft Cortana

- Microsoft’s answer to Siri
- Expected to debut in April
- Named after a character in Halo
- Probably not going to look like this

http://unleashtephones.com/2014/03/05/exclusive-cortana-voice-assistant-windows-phone-8-1-video/
http://www.theverge.com/2014/2/20/5430188/microsoft-cortana-personal-digital-assistant-windows-phone-8-1
Facebook’s graph search

- Structured language providing user guidance for query writing.
- Query terms interpreted by nodes and edge-types in the social graph.

“Restaurants in San Francisco, California liked by my friends from India.” [link]
two times two minus two

Input:
$$2 \times 2 - 2$$

Result:
2

Which states border California?

Assuming "California" is a US state | Use as an administrative division instead

Input interpretation:
California | bordering states

Result:
Oregon | Nevada | Arizona
Wolfram Alpha

**Which US states are islands?**

Assuming all US states with District of Columbia | Use all US states instead

**Input interpretation:**

notable islands in all US states with District of Columbia

**Which U.S. states border no U.S. states?**

Using closest Wolfram|Alpha interpretation: Which U.S. states border

More interpretations: country U.S.
Figure 6. DeepQA High-Level Architecture.
Watson
Watson and pragmatics

Answer: Grasshoppers eat it.
Watson: What is kosher?
Watson and discourse processing

Watson Almost Sneaks Wrong Response by Jeopardy’s Trebek:
Watson also tripped up on an “Olympic Oddities” answer, but so imperceptibly that Alex Trebek didn’t notice at first, raising an important point of clarification. After Jennings responded incorrectly that Olympian gymnast George Eyser was “missing a hand”, Watson responded, “What is a leg?”

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

@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 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!

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

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

These reviews are not critical of the book, but rather of the publisher’s decision by the publisher’s about an electronic edition.
Identifying the target of criticism

Beloved *Bob’s Burgers*:

*Commercials = No Sale ★★★★★*
by LeJimTR – Oct 22, 2013
Love this show but am not spending $50 to watch ads.

12 out of 12 viewers found this review helpful.

*Not happy about the ads. ★★★★★*
by Untaken Nickname 944289716 VN4 – Oct 8, 2013
The show is good, if you’re here you probably know that. I really think it’s a bad move to put ads before and/or after a tv episode that you pay for. It’s really turned me off to purchasing any other episodes. I will buy elsewhere.

7 out of 7 viewers found this review helpful.
Deep problems of sentiment analysis

1. There was an earthquake in LA
2. The team failed the physical challenge. (We win/lose!)
3. They said it would be great. They were right/wrong.
4. Many consider the masterpiece bewildering, boring, slow-moving or annoying.
5. The party fat-cats are sipping their expensive, imported wines.
6. Oh, you’re terrible!
Application: automated trading

- Most financial trading is now done by automated systems ("high-frequency trading", HFT)
- Most HFT 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 a few milliseconds faster 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/1dBzJSK
The 2013 @AP Twitter hack

@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
Application: business intelligence

- Extracting actionable intelligence from millions of unstructured documents
- Cataphora, H5: legal discovery, compliance, and information management
- Palantir, Quid: intelligence for government and business

Scene of legal discovery from the movie *Syriana*
The Army’s Robot Recruiter: Sgt. Star

Can respond to about 800 issues
Likely a simple, rule-based system using keywords
Social advantage: there are some questions recruits will ask a bot, but not a human

http://www.onthemedia.org/story/18-armys-robot-recruiter/
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 output representation

<table>
<thead>
<tr>
<th>Topic</th>
<th>Representation</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>sentiment analysis</td>
<td>scalars</td>
<td>- 📌 +</td>
</tr>
<tr>
<td>vector space models</td>
<td>vectors / topic distributions</td>
<td>(Larry Page, founder, Google)</td>
</tr>
<tr>
<td>relation extraction</td>
<td>relation instances / database triples</td>
<td>(Google, located in, Mountain View)</td>
</tr>
<tr>
<td>semantic parsing</td>
<td>logical forms / other rich structures</td>
<td>argmax(λx.state(x), λx.size(x))</td>
</tr>
</tbody>
</table>
NLU in this course

• Emphasis on semantic composition
• Blurred lines between lexical and sentence meanings
• Blurred lines between semantics and context of use
• Emerging learning-based framework for capturing linguistic meaning
• http://www.stanford.edu/class/cs224u/