14. Question-Answering (QA)

Most slides were adapted from Stanford CS 276 course.
“Information retrieval”

The name **information retrieval** is standard, but as traditionally practiced, it’s not really right

All you get is **document retrieval**, and beyond that the job is up to you
Getting information

The common person’s view? [From a novel]

“I like the Internet. Really, I do. Any time I need a piece of shareware or I want to find out the weather in Bogota ... I’m the first guy to get the modem humming. But as a source of information, it sucks. You got a billion pieces of data, struggling to be heard and seen and downloaded, and anything I want to know seems to get trampled underfoot in the crowd.”

Web Search in 2025?

The web, it is a changing.

What will people do in 2025?
- Type key words into a search box?
- Use the Semantic Web?
- Ask questions to their computer in natural language?
- Use social or “human powered” search?
What do we know that’s happening?

- Much of what is going on is in the products of companies, and there isn’t exactly careful research explaining or evaluating it.
- So most of this is my own meandering observations giving voice over to slides from others.
Google

What’s been happening? 2013–2017

- Many updates a year ... and 3rd party sites try to track them
  - e.g., [https://moz.com/google-algorithm-change](https://moz.com/google-algorithm-change) by & aimed at SEOs
  - I just mention a few changes here

- New search index at Google: “Hummingbird” (2013)
  - Answering long, “natural language” questions better
  - Partly to deal with spoken queries on mobile

- More use of the Google Knowledge Graph (2014)
  - Concepts versus words

- RankBrain (second half of 2015):
  - A neural net helps in document matching for the long tail
Google

What’s been happening? 2013–2017

- “Pigeon” update (July 2014):
  - More use of distance and location in ranking signals
- “Mobilegeddon” (Apr 21, 2015):
  - “Mobile friendliness” as a major ranking signal
- “App Indexing” (Android, iOS support May 2015)
  - Search results can take you to an app
- Mobile-friendly 2 (May 12, 2016):
  - About half of all searches are now from mobile
- “Fred” (1st quarter 2017)
  - Various changes discounting spammy, clickbaity, fake? sites
The role of knowledge bases

- Google Knowledge Graph
- Facebook Graph Search
- Bing’s Satori
- Things like Wolfram Alpha

Common theme: Doing graph search over structured knowledge rather than traditional text search
What’s been happening

- More semi-structured information embedded in web pages
- schema.org
Mobile

Move to mobile favors a move to **speech** which favors **natural language information search**

- Will we move to a time when over half of searches are spoken?
Mobile

- Mobile proved importance of NLU/QA
- [What is the best time for wildflowers in the bay area]

**Where to See Wildflowers in the Bay Area - Bay Area Parent**

www.bayareaparent.com/Article/Where-to-See-Wildflowers-in-the-Bay-Area/

This is a great time of year to find wildflowers in the Bay Area. Call parks ... Loop Trail, known for being flat, moderate in difficulty and best for viewing the blooms.

**Best Bay Area hikes into wildflower country - Bay Nature**

baynature.org/article/best-bay-area-hikes-into-wildflower-country/

Mar 28, 2013 - It's spring, and all you nature lovers know what that means ... time to go see wildflowers! You've probably already noticed them popping in little ...

**Bay Area Wildflower Hikes | EveryTrail**

www.everytrail.com/guide/bay-area-wildflower-hikes

⭐⭐⭐⭐⭐ Rating: 5 - 2 votes

Download the Bay Area Wildflower Hikes mobile travel guide to your iPhone or ... Even in lean years, wildflower season offers hikers beautiful reminders of the .... The best bloom is on the Chisnantuk Peak Trail, which is deep in the park and ...
Information quality

- There have always been concerns about information provenance (the source) and information reliability, especially among “information professionals” (reporters, lawyers, spies, ...)

- It wasn’t ignored on the web: ideas like PageRank were meant to find good content, and there has been a decade of work targeting link farms, etc.

- However, a lot of recent events have shown the limited effectiveness of that work, and how “fake” information easily gets upvoted and spreads
Towards intelligent agents

Two goals

- Things not strings
- Inference not search
Two paradigms for question answering

- **Text-based approaches**
  - TREC QA, IBM Watson, DrQA

- **Structured knowledge-based approaches**
  - Apple Siri, Wolfram Alpha, Facebook Graph Search

(And, of course, there are hybrids, including some of the above.)

At the moment, structured knowledge is back in fashion, but it may or may not last.
Example from Fernando Pereira (GOOG)

```
painkillers that don't thin blood
painkillers that don't cause constipation
painkillers that don't cause nausea
**painkillers that don't upset stomach**
painkillers that don't

About 89,300 results (0.14 seconds)
```

frequent query
painkillers that don't upset stomach

About 29,700 results (0.15 seconds)

Symptoms of Crohn's

Best Pain Reliever, Over the Counter Pain Relievers, Prescription ...
For stomach upset, eating or drinking milk before you take a painkiller can help. ... Don't expect painkillers to relieve all your pain, but the best pain ...
www.healthblurbs.com/best-pain-reliever-over-the-counter-pain-relievers-prescription-analgesic-painkillers/ - Cached - Similar

Why do painkillers make your stomach hurt? - Yahoo! Answers
Aug 30, 2008 ... stomach upset, reflux/indigestion, or if severe ulcers ... I often take painkillers FOR stomach aches lol. Don't do this again. 2 years ago ...
answers.yahoo.com › Health › Other - Health - Cached - Similar

  How are painkillers bad for you? - Apr 13, 2010
  What effect do painkillers have on you? - Sep 30, 2009
  What's the difference between OTC painkillers? (Advil, Aleve ... - Nov 19, 2008
  Is it bad to take painkillers on an empty stomach? - Aug 20, 2008

More results from answers.yahoo.com »

Phys Ed: Does Ibuprofen Help or Hurt During Exercise? - NYTimes.com
Sep 1, 2009 ... When are ibuprofen and other anti-inflammatory painkillers justified? ... Can't take NSAIDS due to upset stomach. — bonemri ... Perhaps part of the problem is that you don't always have the option to rest your injury if ...
Introduction to Information Retrieval

**class** negation synonyms

painkillers that don't upset stomach

About 29,700 results (0.15 seconds)

**Symptoms of Crohn's**

**Best Pain Reliever, Over the Counter Pain Relievers, Prescription**
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"painkillers such as * tylenol"

About 19,200 results (0.21 seconds)

TYLENOL® Official Site
Tylenol.com Pain Relief from TYLENOL. Get Information and Coupons Here.
Head & Body Pain - Arthritis Pain - Sinus - Cold & Flu

Ovarian hyperstimulation syndrome (OHSS): Treatments and drugs ...
To ease abdominal discomfort, take over-the-counter painkillers such as acetaminophen (Tylenol) or ibuprofen (Advil, Motrin, others). ...
www.mayoclinic.com/.../DSECTION=treatments-and-drugs - Cached - Similar

tylenol ⇒ painkiller
upset stomach \implies \text{adverse effect (on stomach)}
tylenol $\Rightarrow$ no adverse effects (on stomach)
$\Rightarrow$ no upset stomach
| painkiller | upset | stomach |
“Things, not strings”

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Requires</th>
</tr>
</thead>
<tbody>
<tr>
<td>Term</td>
<td>Concept</td>
<td>Parsing, disambiguation, coreference</td>
</tr>
<tr>
<td>Term identity</td>
<td>Entailment</td>
<td>Concept relations</td>
</tr>
<tr>
<td>Co-occurrence</td>
<td>Syntactic relation</td>
<td>Document structure, parsing</td>
</tr>
<tr>
<td>Term index</td>
<td>Semantic index</td>
<td>Concept disambiguation, inference</td>
</tr>
</tbody>
</table>
Entity Detection

Structured Recommendations

Play trailer

Structured Data
How old is Mariah Carey

45 years (March 27, 1970)
Mariah Carey, Age

Madonna 56 years
Nick Cannon 34 years
Jennifer Lopez 45 years

Mariah Carey - Wikipedia, the free encyclopedia
Mariah Carey was born on March 27, 1970 in Huntington, New York. Her father, Alfred Roy, was of African American and Venezuelan (including Afro-Venezuelan) descent, while her mother, Patricia (Hickey), is of White Irish descent.

Nick Cannon - Tommy Mottola - Albums - Me. I Am Mariah... The Elusive...

Nick Cannon & Mariah Carey Fighting: Split Caused By... hollywoodlife.com/...nick-cannon-mariah-carey-fighting... Hollywood Life
Aug 22, 2014 - Nick Cannon and Mariah Carey announced their separation after six years of marriage, and now HollywoodLife.com has learned EXCLUSIVELY what caused the power couple to split up. Nick Cannon, 33, and Mariah Carey, 44, have separated after six years of marriage, and two beautiful children together.

Mariah Carey - Biography - Music Producer, Film Actress... www.biography.com/people/mariah-carey-9542177 - FYI
Mariah Carey was born March 27, 1970, in Huntington, Long Island, New York, and began taking voice lessons at age four. At 18 she signed with Columbia...


Mariah Carey is an American singer, songwriter, record producer, and occasional actress. She rose to prominence after releasing her self-titled debut studio album Mariah Carey in 1990; it went multiplatinum ...

Wikipedia

Born: March 27, 1970 (age 45), Huntington, NY
Height: 5' 9" (1.75 m)
Children: Moroccan Scott Cannon, Monroe Cannon
Spouse: Nick Cannon (m. 2008), Tommy Mottola (m. 1993–1998)

Songs
Without You 1993 Music Box
Hero 1993 Music Box
I Want to Know What Love Is 2009 Memoirs of an... I’ll Be There 1990 Mariah Carey
We Belong Together 2005 The Emancipation...

Albums
View 20+ more
50 years
September 18, 1965

Christopher D. Manning / Age

Christopher Manning, Stanford NLP
nip.stanford.edu/manning/  
Mar 1, 2013 - Christopher Manning, Professor of Computer Science and Linguistics, ... is directed at students who have already been admitted to Stanford.

Christopher Manning's ex home page
web.stanford.edu/~manning/  
Sep 6, 2000 - The personal home page of Christopher Manning, Assistant Professor of Computer Science and Linguistics, Stanford University.

Christopher Manning - Stanford University | Coursera
https://www.coursera.org/instructor/~222  
Christopher Manning is an Associate Professor of Computer Science and Linguistics at Stanford University. Chris received a Bachelors degree and University ...
About 207,000 results (0.80 seconds)

_Pandu Nayak_
www.pandunayak.com/ ▼
About me. I am currently at Google, working on various aspects of Search Quality. I am particularly interested in query understanding and helping users ...

_Pandu Nayak | LinkedIn_
https://www.linkedin.com/in/pandu-nayak-4790201 ▼
View Pandu Nayak's professional profile on LinkedIn. ... As a LinkedIn member, you'll join 400 million other professionals who are sharing connections, ideas, ...

_Google Panda - Was it named after Pandu Nayak? - Quora_
https://www.quora.com/Google-Panda-Was-it-named-after-Pandu-Nayak ▼ Quora ▼
Oct 27, 2015 - Pandu Nayak is the guy behind this famed search algo change. ... name of Navneet Panda along with Vladimir Ofitserov, who is the co-inventor ...
Patrick Pantel talk

(Then) Current experience
Desired experience: Towards actions
Politician

Actions easily accessible

Recognize entity in query

Introduction to Information Retrieval
Actions vs. Intents

User Intents and Goals
- plan vacation
- get in shape

Query
- hilton orlando reviews
- sea world location
- how to lose weight

Query Intent
- Informational
- Navigational
- Transactional
  - Advice
  - Locate
  - Download
  - Obtain
  - Interact

Finer-grained Intents
- get address(landmark)
- add to Netflix queue(film)
- read reviews(hotel)
- buy(camera)

[Broder, 2002]
[Rose and Levinson, 2004]
Learning actions from web usage logs

- Three months of us-en web logs
- Annotate with Freebase entities
- Keep queries with an entity in set of 21 types
- Filter out navigational queries
- Filter out clicked hosts that weren’t clicked at least 100 times

- 2,164,579 (query, host) pairs
- 235,385 entities
- 21 types
- 129,088 contexts
- 58,123 hosts

- get reviews
- read biography
- download software
- watch shows online

- Orlando hotel reviews
- Does Hope Solo have a boyfriend?
- Free Winzip download
- watch family guy online
A hodgepodge of related strings
Only actionable through search
Big Wins

- Typed relations
- User Interface accesses structured data
- Click through experience can now leverage strongly-typed identifier
Big Wins

- Typed relations
- User Interface accesses structured data
- Click through experience can now leverage strongly-typed identifier
- Brokered Actions (one click conversions)
Entity disambiguation and linking

- Key requirement is that entities get identified
  - Named entity recognition (e.g., Stanford NER!)
- and disambiguated
  - Entity linking (or sometimes “Wikification”)
    - e.g., Michael Jordan the basketballer or the ML guy
Sergio talked to Ennio about Eli’s role in the Ecstasy scene. This sequence on the graveyard was a highlight in Sergio’s trilogy of western films.
and linked to a canonical reference

- Freebase, dbPedia, Yago2, (WordNet)
Understanding questions

Google search for: third prime minister of australia

Chris Watson
The 3rd Prime Minister of Australia

Chris Watson
Former Prime Minister of Australia

John Christian Watson, commonly known as Chris Watson, was a Chilean Australian politician who served as the third Prime Minister of Australia. Wikipedia

Born: April 9, 1867, Valparaiso, Chile
Died: November 18, 1941, Sydney, Australia

Party: Australian Labor Party
Previous offices: Member of the Australian Parliament (1906–1910), More

List of Prime Ministers of Australia - Wikipedia, the free ...
Introduction to Information Retrieval

About 2,550,000 results (0.41 seconds)

Chris Watson - Wikipedia, the free encyclopedia
3rd Prime Minister of Australia... He was the first prime minister from the Australian Labour Party, and the first prime minister from the labour movement in the...
Early life - Union activities and colonial... - Federation - Prime Minister in 1904

List of Prime Ministers of Australia by time in office - Wikipedia
This is a list of Prime Ministers of Australia by time in office. The basis of... Rank:
No: Prime Minister: Portrait: Party: District: Assumed Office... 3rd, Chris Watson

List of Prime Ministers of Australia - Wikipedia, the free...
Below is a list of Prime Ministers of the Commonwealth of Australia. The parties shown are those to which... 17 February 1917, 9 February 1923, — 3rd Hughes.
Edmund Barton - Protectionist Party - Longest serving Prime Ministers
Introduction to Information Retrieval
3 approaches to question answering: Knowledge-based approaches (Siri)

- Build a semantic representation of the query
  - Times, dates, locations, entities, numeric quantities
- Map from this semantics to query structured data or resources
  - Geospatial databases
  - Ontologies (Wikipedia infoboxes, dbPedia, WordNet, Yago)
  - Restaurant review sources and reservation services
  - Scientific databases
  - Wolfram Alpha
Text-based (mainly factoid) QA

- **QUESTION PROCESSING**
  - Detect *question type, answer type*, focus, relations
  - Formulate queries to send to a search engine

- **PASSAGE RETRIEVAL**
  - Retrieve ranked documents
  - Break into suitable passages and rerank

- **ANSWER PROCESSING**
  - Extract candidate answers (as named entities)
  - Rank candidates
    - using evidence from relations in the text and external sources
Hybrid approaches (IBM Watson)

- Build a shallow semantic representation of the query
- Generate answer candidates using IR methods
  - Augmented with ontologies and semi-structured data
- Score each candidate using richer knowledge sources
  - Geospatial databases
  - Temporal reasoning
  - Taxonomical classification
Texts are Knowledge
Knowledge: Jeremy Zawodny says ...
Is the goal to go from language to knowledge bases?

- For humans, going from the largely unstructured language on the web to actionable information is effortlessly easy.
- But for computers, it’s rather difficult!
- This has suggested to many that if we’re going to produce the next generation of intelligent agents, which can make decisions on our behalf:
  - Answering our routine email
  - Booking our next trip to Fiji
then we still first need to construct **knowledge bases**
- To go *from languages to information*
- But should we rather just have computers work with language?
Knowledge:
Not just semantics but pragmatics

Pragmatics = taking account of context in determining meaning
A natural part of language understanding and use

Search engines are great because they inherently take into account pragmatics ("associations and contexts")

- [the national] → The National (a band)
- [the national ohio] → The National - Bloodbuzz Ohio – YouTube
- [the national broadband] → www.broadband.gov
Lemmon was awarded the Best Supporting Actor Oscar in 1956 for *Mister Roberts* (1955) and the Best Actor Oscar for *Save the Tiger* (1973), becoming the first actor to achieve this rare double...

*Source: Jack Lemmon -- Wikipedia*
What is the fastest car in the world?

The Jaguar XJ 220 is the dearest, fastest and most sought after car on the planet. [Harabagiu & Moldovan, 2001]

Assume that there is an underlying alignment
- Describes which words in and can be associated

See if the (syntactic/semantic) relations support the answer
Introduction to Information Retrieval

Full NLP QA: LCC (Harabagiu/Moldovan)

[below is the architecture of LCC’s QA system circa 2003]
DrQA: Open-domain Question Answering
Open-domain Question Answering

**SQuAD**
Q: How many of Warsaw's inhabitants spoke Polish in 1933?  
A: 833,500

**TREC**
Q: What U.S. state’s motto is “Live free or Die”?  
A: New Hampshire

**WebQuestions** (Berant et al, 2013)
Q: What part of the atom did Chadwick discover?  
A: neutron

**WikiMovies** (Miller et al, 2016)
Q: Who wrote the film Gigli?  
A: Martin Brest
Q: How many of Warsaw's inhabitants spoke Polish in 1933?

A: 833,500
## Document Retriever

70-86% of questions we have that the answer segment appears in the top 5 articles

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Wiki Search</th>
<th>Doc. plain</th>
<th>Retriever +bigrams</th>
</tr>
</thead>
<tbody>
<tr>
<td>SQuAD</td>
<td>62.7</td>
<td>76.1</td>
<td>77.8</td>
</tr>
<tr>
<td>CuratedTREC</td>
<td>81.0</td>
<td>85.2</td>
<td>86.0</td>
</tr>
<tr>
<td>WebQuestions</td>
<td>73.7</td>
<td>75.5</td>
<td>74.4</td>
</tr>
<tr>
<td>WikiMovies</td>
<td>61.7</td>
<td>54.4</td>
<td>70.3</td>
</tr>
</tbody>
</table>

Traditional tf.idf inverted index + efficient bigram hash

(Chen et al, 2017)
characters in "@placeholder" movies have gradually become more diverse

Bidirectional LSTMs

Q

q

characters in "@placeholder" movies have gradually become more diverse

more
diverse
Stanford Attentive Reader

Bidirectional LSTMs

\[
\alpha_i = \text{softmax} \left( q^T W_s \tilde{p}_i \right)
\]

\[
o = \sum_i \alpha_i \tilde{p}_i
\]

\[
a = \arg \max_{a \in P \cap E} W_a^T o
\]

characters in "@placeholder" movies have gradually become more diverse

(Chen et al, 2016)
Stanford Attentive Reader++

Who did Genghis Khan unite before he began conquering the rest of Eurasia?

He came to power by uniting many of the nomadic tribes of Northeast Asia. After founding the Mongol Empire and being proclaimed "Genghis Khan", he started the Mongol invasions that resulted in the conquest of most of Eurasia. These included raids or invasions of the Qara Khitai, Caucasus, Khwarezmid Empire, Western Xia and Jin dynasties. These campaigns were often accompanied by wholesale massacres of the civilian populations – especially in the Khwarezmian and Xia controlled lands. By the end of his life, the Mongol Empire occupied a substantial portion of Central Asia and China.
## Results (single model)

<table>
<thead>
<tr>
<th>Method</th>
<th>F1</th>
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<tbody>
<tr>
<td>Logistic regression</td>
<td>51.0</td>
</tr>
<tr>
<td>Fine-Grained Gating (Carnegie Mellon U)</td>
<td>73.3</td>
</tr>
<tr>
<td>Match-LSTM (Singapore Management U)</td>
<td>73.7</td>
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<tr>
<td>DCN (Salesforce)</td>
<td>75.9</td>
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<td>BiDAF (UW &amp; Allen Institute)</td>
<td>77.3</td>
</tr>
<tr>
<td>Multi-Perspective Matching (IBM)</td>
<td>78.7</td>
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<tr>
<td>ReasoNet (MSR Redmond)</td>
<td>79.4</td>
</tr>
<tr>
<td>DrQA (Chen et al. 2017)</td>
<td>79.4</td>
</tr>
<tr>
<td>r-net (MSR Asia)</td>
<td>80.8</td>
</tr>
<tr>
<td>Human performance</td>
<td>91.2</td>
</tr>
</tbody>
</table>

(Chen et al, 2017)
Results

Pre-trained SQuAD
Fine-tuning

SQuAD

WebQuestions

Exact match (top-1 prediction)

(Chen et al, 2017)
Demo

Hello! Please ask a question.

Who invented LSTM?

Hmmm. Tough one. I would say... Sepp Hochreiter

Where is Stanford University located?

I'm quite confident the answer is... California
Demo

What is the highest mountain on Earth?

I'm quite confident the answer is... Mount Everest

What year was the American Declaration of Independence?

I'm quite confident the answer is... 1776
Demo

What is the meaning of life?

I'm quite confident the answer is... What is the meaning in asking?

Who will solve AI?

Hmmm. Tough one. I would say... Computers