Statistical NLP

Spring 2008

Lecture 23: Question Answering

Dan Klein – UC Berkeley

Question Answering

- Following largely from Chris Manning's slides, which includes slides originally borrowed from Sanda Harabagiu, ISI, Nicholas Kushmerick.

Question Answering from Text

- Question Answering:
  - Give the user a (short) answer to their question, perhaps supported by evidence.
  - An idea originating from the IR community
  - With massive collections of full-text documents, simply finding *relevant documents* is of limited use: we want *answers* from textbases
- 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."
    - M. Marshall. *The Straw Men.* HarperCollins Publishers, 2002.

People *want* to ask questions?

Examples from AltaVista query log

who invented surf music?
how to make stink bombs
where are the snowdens of yesteryear?
which english translation of the bible is used in official catholic liturgies?
how to do clayart
how to copy psx
how tall is the sears tower?

Examples from Excite query log (12/1999)

how can i find someone in texas
where can i find information on puritan religion?
what are the 7 wonders of the world
how can i eliminate stress
What vacuum cleaner does Consumers Guide recommend

Around 10–15% of query logs

AskJeeves (Classic)

- Probably the most hyped example of "question answering"
- It largely does pattern matching to match your question to their own knowledge base of questions
- If that works, you get the human-curated answers to that known question
- If that fails, it falls back to regular web search
- A potentially interesting middle ground, but not full QA

A Brief (Academic) History

- Question answering is not a new research area
- Question answering systems can be found in many areas of NLP research, including:
  - Natural language database systems
    - A lot of early NLP work on these
  - Spoken dialog systems
    - Currently very active and commercially relevant
- The focus on open-domain QA is new
  - MURAX (Kupiec 1993): Encyclopedia answers
  - Hirschman: Reading comprehension tests
  - TREC QA competition: 1999–

Question Answering at TREC

- Question answering competition at TREC consists of answering a set of 500 fact-based questions, e.g., *“When was Mozart born*?”.
- For the first three years systems were allowed to return 5 ranked answer snippets (50/250 bytes) to each question.
  - IR think
  - Mean Reciprocal Rank (MRR) scoring:
    - 1, 0.5, 0.33, 0.25, 0.2, 0 for 1, 2, 3, 4, 5, 6+ doc
  - Mainly Named Entity answers (person, place, date, …)
- From 2002 the systems are only allowed to return a single *exact* answer and the notion of confidence has been introduced.

The TREC Document Collection

- One recent round: news articles from:
  - AP newswire, 1998-2000
  - New York Times newswire, 1998-2000
  - Xinhua News Agency newswire, 1996-2000
- In total 1,033,461 documents in the collection.
- 3GB of text
- While small in some sense, still too much text to process entirely using advanced NLP techniques
- Systems usually have initial information retrieval followed by advanced processing.
- Many supplement this text with use of the web, and other knowledge bases

Sample TREC questions

1. Who is the author of the book, "The Iron Lady: A Biography of Margaret Thatcher"?
2. What was the monetary value of the Nobel Peace Prize in 1989?
3. What does the Peugeot company manufacture?
4. How much did Mercury spend on advertising in 1993?
5. What is the name of the managing director of Apricot Computer?
6. Why did David Koresh ask the FBI for a word processor?
7. What debts did Qintex group leave?
8. What is the name of the rare neurological disease with symptoms such as: involuntary movements (tics), swearing, and incoherent vocalizations (grunts, shouts, etc.)?

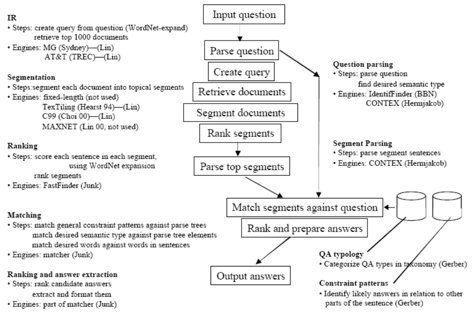
Top Performing Systems

- Currently the best performing systems at TREC can answer approximately 70% of the questions
- Approaches and successes have varied a fair deal
  - Knowledge-rich approaches, using a vast array of NLP techniques stole the show in 2000, 2001
    - Notably Harabagiu, Moldovan et al. – SMU/UTD/LCC
  - AskMSR system stressed how much could be achieved by very simple methods with enough text (and now various copycats)
  - Middle ground is to use large collection of surface matching patterns (ISI)

Online QA System Examples

- Examples
  - **AnswerBus** is an open-domain question answering system: www.answerbus.com
  - **Ionaut:** http://www.ionaut.com:8400/
  - **LCC:** http://www.languagecomputer.com/
  - **EasyAsk, AnswerLogic, AnswerFriend, Start, Quasm, Mulder, Webclopedia, etc.**
  - **ISI TextMap** http://brahms.isi.edu:8080/textmap/

Webclopedia Architecture



IR
• Steps: create query from question (WordNet-expand)
retrieve top 1000 documents
• Engines: MG (Sydney)—(Lin)
AT&T (TREC)—(Lin)

Segmentation
• Steps:segment each document into topical segments
• Engines: fixed-length (not used)
TexTiling (Hearst 94)—(Lin)
C99 (Choi 00)—(Lin)
MAXNET (Lin 00, not used)

Ranking
• Steps: score each sentence in each segment,
using WordNet expansion
rank segments
• Engines: FastFinder (Junk)

Matching
• Steps: match general constraint patterns against parse trees
match desired semantic type against parse tree elements
match desired words against words in sentences
• Engines: matcher (Junk)

Ranking and answer extraction
• Steps: rank candidate answers
extract and format them
• Engines: part of matcher (Junk)

Input question

Parse question

Create query

Retrieve documents

Segment documents

Rank segments

Parse top segments

Match segments against question

Rank and prepare answers

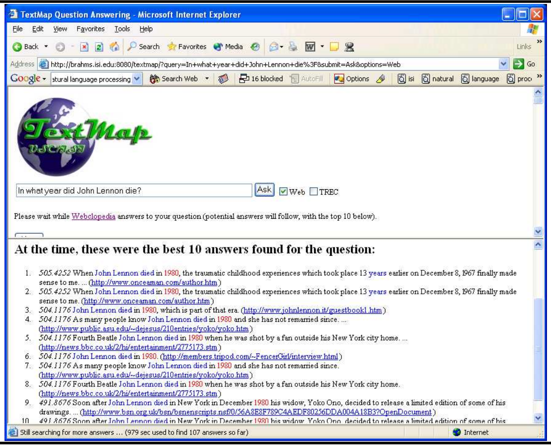
Output answers

Question parsing
• Steps: parse question
find desired semantic type
• Engines: IdentifFinder (BBN)
CONTEX (Hermjakob)

Segment Parsing
• Steps: parse segment sentences
• Engines: CONTEX (Hermjakob)

QA typology
• Categorize QA types in taxonomy (Gerber)

Constraint patterns
• Identify likely answers in relation to other parts of the sentence (Gerber)



TextMap Question Answering - Microsoft Internet Explorer

Address: http://brahms.isi.edu:8080/textmap/?query=In+what+year+did+John+Lennon+die%3F&submit=Ask&options=Web

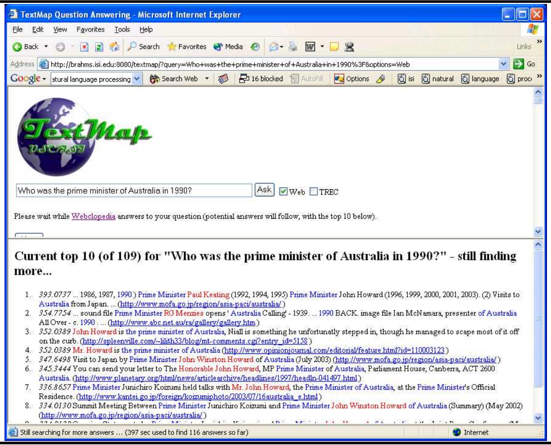
In what year did John Lennon die? Ask ☑ Web □ TREC

Please wait while Webclopedia answers to your question (potential answers will follow, with the top 10 below).

At the time, these were the best 10 answers found for the question:

1. *505.4252* When John Lennon died in 1980, the traumatic childhood experiences which took place 13 years earlier on December 8, 1967 finally made sense to me. ... (http://www.onceaman.com/author.htm)
2. *505.4252* When John Lennon died in 1980, the traumatic childhood experiences which took place 13 years earlier on December 8, 1967 finally made sense to me. (http://www.onceaman.com/author.htm)
3. *504.1176* John Lennon died in 1980, which is part of that era. (http://www.johnlennon.it/guestbook1.htm)
4. *504.1176* As many people know John Lennon died in 1980 and she has not remarried since. ... (http://www.public.asu.edu/~dejesus/210entries/yoko/yoko.htm)
5. *504.1176* Fourth Beatle John Lennon died in 1980 when he was shot by a fan outside his New York city home. ... (http://news.bbc.co.uk/2/hi/entertainment/2775173.stm)
6. *504.1176* John Lennon died in 1980. (http://members.tripod.com/~FencerGirl/interview.html)
7. *504.1176* As many people know John Lennon died in 1980 and she has not remarried since. (http://www.public.asu.edu/~dejesus/210entries/yoko/yoko.htm)
8. *504.1176* Fourth Beatle John Lennon died in 1980 when he was shot by a fan outside his New York city home. (http://news.bbc.co.uk/2/hi/entertainment/2775173.stm)
9. *491.8676* Soon after John Lennon died in New York in December 1980 his widow, Yoko Ono, decided to release a limited edition of some of his drawings. ... (http://www.bsn.org.uk/bsn/bsnenscripts.nsf/0/56A8E8F789C4AEDF80256DDA004A18B3?OpenDocument)
10. *491.8676* Soon after John Lennon died in New York in December 1980 his widow, Yoko Ono, decided to release a limited edition of some of his

Still searching for more answers … (979 sec used to find 107 answers so far)



TextMap Question Answering - Microsoft Internet Explorer

Address: http://brahms.isi.edu:8080/textmap/?query=Who+was+the+prime+minister+of+Australia+in+1990%3F&options=Web

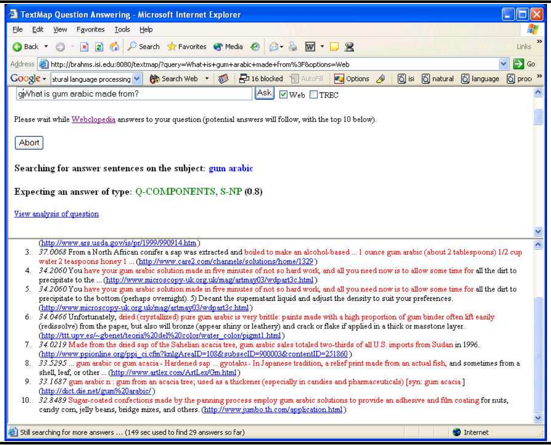
Who was the prime minister of Australia in 1990? Ask ☑ Web □ TREC

Please wait while Webclopedia answers to your question (potential answers will follow, with the top 10 below).

Current top 10 (of 109) for "Who was the prime minister of Australia in 1990?" - still finding more...

1. *393.0737* ... 1986, 1987, 1990) Prime Minister Paul Keating (1992, 1994, 1995) Prime Minister John Howard (1996, 1999, 2000, 2001, 2003). (2) Visits to Australia from Japan. ... (http://www.mofa.go.jp/region/asia-paci/australia/)
2. *354.7754* ... sound file Prime Minister RG Menzies opens ' Australia Calling' - 1939. ... 1990 BACK. image file Ian McNamara, presenter of Australia All Over - c. 1990 . ... (http://www.abc.net.au/ra/gallery/gallery.htm)
3. *352.0389* John Howard is the prime minister of Australia, Niall is something he unfortunatly stepped in, though he managed to scape most of it off on the curb. (http://spleenville.com/~lilith33/blog/mt-comments.cgi?entry_id=5158)
4. *352.0389* Mr. Howard is the prime minister of Australia (http://www.opinionjournal.com/editorial/feature.html?id=110003123)
5. *347.6498* Visit to Japan by Prime Minister John Winston Howard of Australia (July 2003) (http://www.mofa.go.jp/region/asia-paci/australia/)
6. *345.3444* You can send your letter to The Honorable John Howard, MP Prime Minister of Australia, Parliament House, Canberra, ACT 2600 Australia. (http://www.planetary.org/html/news/articlearchive/headlines/1997/headln-041497.html)
7. *336.8657* Prime Minister Junichiro Koizumi held talks with Mr. John Howard, the Prime Minister of Australia, at the Prime Minister's Official Residence. (http://www.kantei.go.jp/foreign/koizumiphoto/2003/07/16australia_e.html)
8. *334.0130* Summit Meeting Between Prime Minister Junichiro Koizumi and Prime Minister John Winston Howard of Australia (Summary) (May 2002) (http://www.mofa.go.jp/region/asia-paci/australia/)

Still searching for more answers … (397 sec used to find 116 answers so far)



TextMap Question Answering - Microsoft Internet Explorer

Address: http://brahms.isi.edu:8080/textmap/?query=What+is+gum+arabic+made+from%3F&options=Web

gWhat is gum arabic made from? Ask ☑ Web □ TREC

Please wait while Webclopedia answers to your question (potential answers will follow, with the top 10 below).

Abort

Searching for answer sentences on the subject: gum arabic

Expecting an answer of type: Q-COMPONENTS, S-NP **(0.8)**

View analysis of question

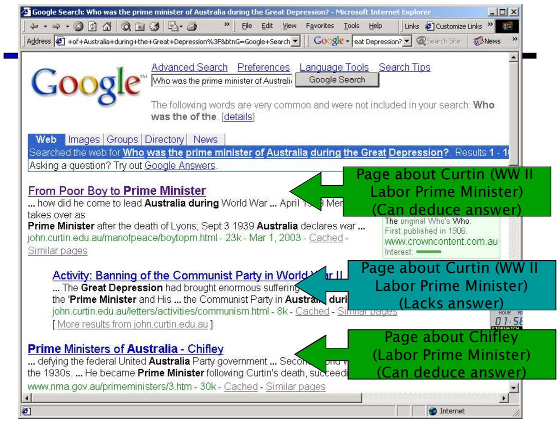
(http://www.ars.usda.gov/is/pr/1999/990914.htm)

3. *37.0068* From a North African conifer a sap was extracted and boiled to make an alcohol-based ... 1 ounce gum arabic (about 2 tablespoons) 1/2 cup water 2 teaspoons honey 1 ... (http://www.care2.com/channels/solutions/home/1329)
4. *34.2060* You have your gum arabic solution made in five minutes of not so hard work, and all you need now is to allow some time for all the dirt to precipitate to the ... (http://www.microscopy-uk.org.uk/mag/artmay03/wdpart3c.html)
5. *34.2060* You have your gum arabic solution made in five minutes of not so hard work, and all you need now is to allow some time for all the dirt to precipitate to the bottom (perhaps overnight). 5) Decant the supernatant liquid and adjust the density to suit your preferences. (http://www.microscopy-uk.org.uk/mag/artmay03/wdpart3c.html)
6. *34.0466* Unfortunately, dried (crystallized) pure gum arabic is very brittle: paints made with a high proportion of gum binder often lift easily (redissolve) from the paper, but also will bronze (appear shiny or leathery) and crack or flake if applied in a thick or masstone layer. (http://ttt.upv.es/~gbenet/teoria%20del%20color/water_color/pigmt1.html)
7. *34.0219* Made from the dried sap of the Sahelian acacia tree, gum arabic sales totaled two-thirds of all U.S. imports from Sudan in 1996. (http://www.ppionline.org/ppi_ci.cfm?knlgAreaID=108&subsecID=900003&contentID=251860)
8. *33.5295* ... gum arabic or gum acacia - Hardened sap ... gyotaku - In Japanese tradition, a relief print made from an actual fish, and sometimes from a shell, leaf, or other ... (http://www.artlex.com/ArtLex/Gm.html)
9. *33.1687* gum arabic n : gum from an acacia tree; used as a thickener (especially in candies and pharmaceuticals) [syn: gum acacia] (http://dict.die.net/gum%20arabic/)
10. *32.8489* Sugar-coated confections made by the panning process employ gum arabic solutions to provide an adhesive and film coating for nuts, candy corn, jelly beans, bridge mixes, and others. (http://www.jumbo.th.com/application.html)

Still searching for more answers … (149 sec used to find 29 answers so far)

The Google Answer #1

- Include question words etc. in your stop-list
- Do standard IR
- Sometimes this (sort of) works:
- Question: *Who was the prime minister of Australia during the Great Depression?*
- Answer: *James Scullin (Labor) 1929–31.*



Google Search: Who was the prime minister of Australia during the Great Depression? - Microsoft Internet Explorer

Address: +of+Australia+during+the+Great+Depression%3F&btnG=Google+Search

Who was the prime minister of Australi Google Search

The following words are very common and were not included in your search: **Who was the of the**. [details]

Searched the web for **Who was the prime minister of Australia during the Great Depression?**. Results **1 - 1**

Asking a question? Try out Google Answers.

From Poor Boy to **Prime Minister**
... how did he come to lead **Australia during** World War ... April 1939 Men takes over as **Prime Minister** after the death of Lyons; Sept 3 1939 **Australia** declares war ...
john.curtin.edu.au/manofpeace/boytopm.html - 23k - Mar 1, 2003 - Cached - Similar pages

Activity: Banning of the Communist Party in World War II
... The **Great Depression** had brought enormous suffering ... the '**Prime Minister** and His ... the Communist Party in **Austral**... **duri**...
john.curtin.edu.au/letters/activities/communism.html - 8k - Cached - Similar pages
[More results from john.curtin.edu.au]

Prime Ministers of Australia - Chifley
... defying the federal United **Australia** Party government ... Secon... the 1930s. ... He became **Prime Minister** following Curtin's death, succeedi...
www.nma.gov.au/primeministers/3.htm - 30k - Cached - Similar pages

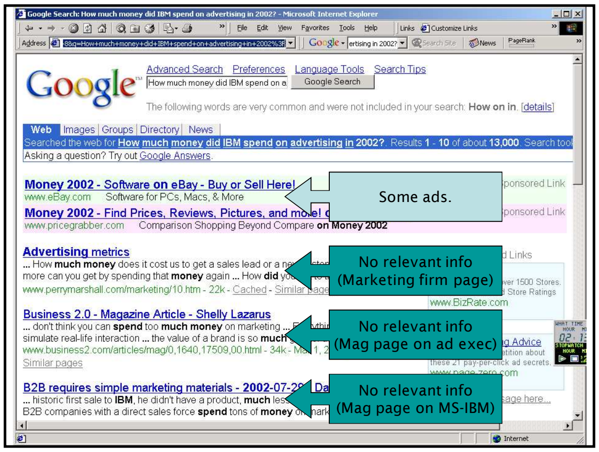
Page about Curtin (WW II Labor Prime Minister) (Can deduce answer)

Page about Curtin (WW II Labor Prime Minister) (Lacks answer)

Page about Chifley (Labor Prime Minister) (Can deduce answer)

But often it doesn't…

- Question: *How much money did IBM spend on advertising in 2002?*
- Answer: *I dunno, but I'd like to …*



Google Search: How much money did IBM spend on advertising in 2002? - Microsoft Internet Explorer

Address: 8&q=How+much+money+did+IBM+spend+on+advertising+in+2002%3F

Advanced Search Preferences Language Tools Search Tips

How much money did IBM spend on a | Google Search

The following words are very common and were not included in your search: **How on in**. [details]

Searched the web for **How much money did IBM spend on advertising in 2002?**. Results **1** - **10** of about **13,000**. Search took

Asking a question? Try out Google Answers.

Money 2002 - Software on eBay - Buy or Sell Here!
www.eBay.com Software for PCs, Macs, & More

Money 2002 - Find Prices, Reviews, Pictures, and more!
www.pricegrabber.com Comparison Shopping Beyond Compare **on Money 2002**

Advertising metrics
... How **much money** does it cost us to get a sales lead or a ne... more can you get by spending that **money** again ... How **did** yo...
www.perrymarshall.com/marketing/10.htm - 22k - Cached - Similar page

Business 2.0 - Magazine Article - Shelly Lazarus
... don't think you can **spend** too **much money** on marketing ... simulate real-life interaction ... the value of a brand is so **much**...
www.business2.com/articles/mag/0,1640,17509,00.html - 34k - Ma... 1, 2...
Similar pages

B2B requires simple marketing materials - 2002-07-2...
... historic first sale to **IBM**, he didn't have a product, **much** les...
B2B companies with a direct sales force **spend** tons of **money** o...

Some ads.

No relevant info (Marketing firm page)

No relevant info (Mag page on ad exec)

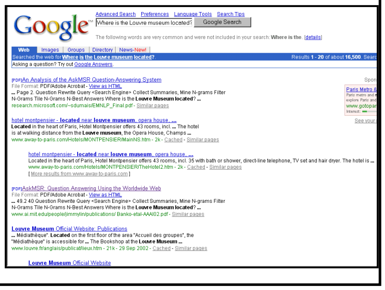
No relevant info (Mag page on MS-IBM)

The Google Answer #2

- Take the question and try to find it as a string on the web
- Return the next sentence on that web page as the answer
- Works brilliantly if this exact question appears as a FAQ question, etc.
- Works lousily most of the time
- Reminiscent of the line about monkeys and typewriters producing Shakespeare
- But a slightly more sophisticated version of this approach has been revived in recent years with considerable success…

AskMSR

- ***Web Question Answering: Is More Always Better?***
  - Dumais, Banko, Brill, Lin, Ng (Microsoft, MIT, Berkeley)
- **Q: "Where is the Louvre located?"**
- Want "Paris" or "France" or "75058 Paris Cedex 01" or a map
- Don't just want URLs



Advanced Search Preferences Language Tools Search Tips

Where is the Louvre museum located? | Google Search

The following words are very common and were not included in your search: **Where is the**. [details]

Searched the web for **Where is the Louvre museum located?**. Results **1** - **20** of about **16,500**.

Asking a question? Try out Google Answers.

[PDF] An Analysis of the AskMSR Question-Answering System
File Format: PDF/Adobe Acrobat - View as HTML
... Page 2. Question Rewrite Query <Search Engine> Collect Summaries, Mine N-grams Filter N-Grams Tile N-Grams N-Best Answers Where is the **Louvre Museum located**? ...
research.microsoft.com/~sdumais/EMNLP_Final.pdf - Similar pages

hotel montpensier - **located** near **louvre museum**, opera house, ...
Located in the heart of Paris, Hotel Montpensier offers 43 rooms, incl. ... The hotel is at walking distance from the **Louvre museum**, the Opera House, Champs ...
www.away-to-paris.com/Hotels/MONTPENSIER/MainNS.htm - 2k - Cached - Similar pages

hotel montpensier - **located** near **louvre museum**, opera house, ...
Located in the heart of Paris, Hotel Montpensier offers 43 rooms, incl. 35 with bath or shower, direct-line telephone, TV set and hair dryer. The hotel is ...
www.away-to-paris.com/Hotels/MONTPENSIER/TheHotel2.htm - 2k - Cached - Similar pages
[More results from www.away-to-paris.com]

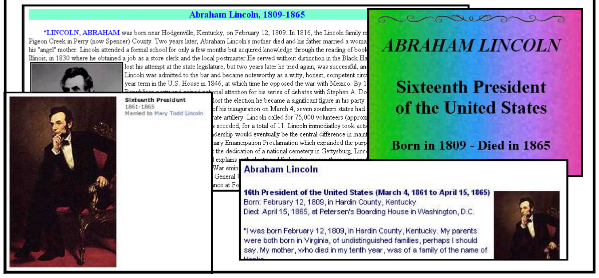
[PDF] AskMSR: Question Answering Using the Worldwide Web
File Format: PDF/Adobe Acrobat - View as HTML
... 49.2 40 Question Rewrite Query <Search Engine> Collect Summaries, Mine N-grams Filter N-Grams Tile N-Grams N-Best Answers Where is the **Louvre Museum located**? ...
www.ai.mit.edu/people/jimmylin/publications/ Banko-etal-AAAI02.pdf - Similar pages

Louvre Museum Official Website: Publications
... Médiathèque". **Located** on the first floor of the area "Accueil des groupes", the "Médiathèque" is accessible for ... The Bookshop at the **Louvre Museum** ...
www.louvre.fr/anglais/publicat/lieux.htm - 21k - 29 Sep 2002 - Cached - Similar pages

Louvre Museum Official Website

AskMSR: Shallow approach

- *In what year did Abraham Lincoln die?*
- Ignore hard documents and find easy ones



Abraham Lincoln, 1809-1865

*LINCOLN, ABRAHAM was born near Hodgenville, Kentucky, on February 12, 1809. In 1816, the Lincoln family m... Pigeon Creek in Perry (now Spencer) County. Two years later, Abraham Lincoln's mother died and his father married a woma... his "angel" mother. Lincoln attended a formal school for only a few months but acquired knowledge through the reading of book... Illinois, in 1830 where he obtained a job as a store clerk and the local postmaster. He served without distinction in the Black Ha... lost his attempt at the state legislature, but two years later he tried again, was successful, an... Lincoln was admitted to the bar and became noteworthy as a witty, honest, competent circ... year term in the U.S. House in 1846, at which time he opposed the war with Mexico. By 1... ...onal attention for his series of debates with Stephen A. Do... lost the election he became a significant figure in his party. ...of his inauguration on March 4, seven southern states had ...ate artillery. Lincoln called for 75,000 volunteers (approx... ...s seceded, for a total of 11. Lincoln immediatley took actio... ...dership would eventually be the central difference in maint... ...ary Emancipation Proclamation which expanded the purp... ...the dedication of a national cemetery in Gettysburg, Linc... ...explains... War emin... General U... ...nce at Fo...

Sixteenth President
1861-1865
Married to Mary Todd Lincoln

ABRAHAM LINCOLN

Sixteenth President of the United States

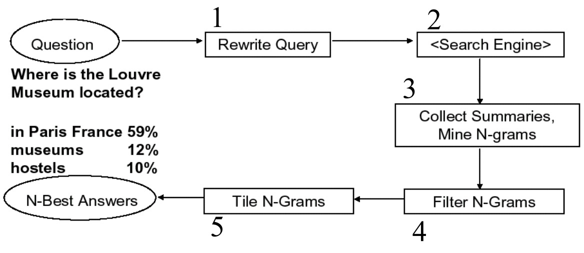
Born in 1809 - Died in 1865

Abraham Lincoln

16th President of the United States (March 4, 1861 to April 15, 1865)
Born: February 12, 1809, in Hardin County, Kentucky
Died: April 15, 1865, at Petersen's Boarding House in Washington, D.C.

"I was born February 12, 1809, in Hardin County, Kentucky. My parents were both born in Virginia, of undistinguished families, perhaps I should say. My mother, who died in my tenth year, was of a family of the name of Hanks...

AskMSR: Details



Where is the Louvre Museum located?

in Paris France	**59%**
museums	**12%**
hostels	**10%**

Step 1: Rewrite queries

- Intuition: The user's question is often syntactically quite close to sentences that contain the answer
  - Where is the Louvre Museum located?
  - The Louvre Museum is located in ***Paris***
  - Who created the character of Scrooge?
  - ***Charles Dickens*** created the character of Scrooge.

Query Rewriting: Variations

- Classify question into seven categories
  - **Who** is/was/are/were…?
  - **When** is/did/will/are/were …?
  - **Where** is/are/were …?

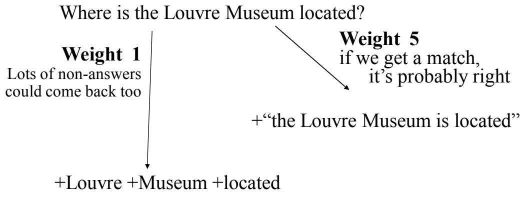
  a. Category-specific transformation rules
  eg "For Where questions, move 'is' to all possible locations"
  "Where is the Louvre Museum located"
  → "is the Louvre Museum located"
  → "the is Louvre Museum located"
  → "the Louvre is Museum located"
  → "the Louvre Museum is located"
  → "the Louvre Museum located is"

  Nonsense, but who cares? It's only a few more queries

  b. Expected answer "Datatype" (eg, Date, Person, Location, …)
  When was the French Revolution? → DATE
- Hand-crafted classification/rewrite/datatype rules
(Could they be automatically learned?)

Query Rewriting: Weights

- One wrinkle: Some query rewrites are more reliable than others


Where is the Louvre Museum located?
Weight 1
Lots of non-answers could come back too
Weight 5
if we get a match, it's probably right
+"the Louvre Museum is located"
+Louvre +Museum +located

Step 2: Query search engine

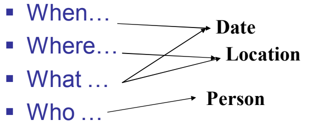
- Send all rewrites to a Web search engine
- Retrieve top N answers (100?)
- For speed, rely just on search engine's "snippets", not the full text of the actual document

Step 3: Mining N-Grams

- Simple: Enumerate all N-grams (N=1,2,3 say) in all retrieved snippets
- Weight of an n-gram: occurrence count, each weighted by "reliability" (weight) of rewrite that fetched the document
- Example: "Who created the character of Scrooge?"
  - Dickens - 117
  - Christmas Carol - 78
  - Charles Dickens - 75
  - Disney - 72
  - Carl Banks - 54
  - A Christmas - 41
  - Christmas Carol - 45
  - Uncle - 31

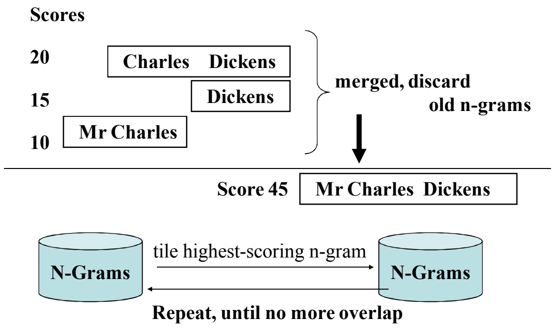
Step 4: Filtering N-Grams

- Each question type is associated with one or more "**data-type filters**" = regular expression



- Boost score of n-grams that do match regexp
- Lower score of n-grams that don't match regexp
- Details omitted from paper….

Step 5: Tiling the Answers



Results

- Standard TREC contest test-bed:
  ~1M documents; 900 questions
- Technique doesn't do too well (though would have placed in top 9 of ~30 participants!)
  - MRR = 0.262 (ie, right answered ranked about #4-#5 on average)
  - Why? Because it relies on the enormity of the Web!
- Using the Web as a whole, not just TREC's 1M documents… MRR = 0.42 (ie, on average, right answer is ranked about #2-#3)

Issues

- In many scenarios (e.g., monitoring an individuals email…) we only have a small set of documents
- Works best/only for "Trivial Pursuit"-style fact-based questions
- Limited/brittle repertoire of
  - question categories
  - answer data types/filters
  - query rewriting rules

Ravichandran and Hovy 2002
Learning Surface Patterns

- Use of Characteristic Phrases
- "When was <person> born"
  - Typical answers
    - "Mozart was born in 1756."
    - "Gandhi (1869-1948)..."
  - Suggests phrases like
    - "<NAME> was born in <BIRTHDATE>"
    - "<NAME> (<BIRTHDATE>-"
  - as Regular Expressions can help locate correct answer

Use Pattern Learning

- Example: Start with "Mozart 1756"
  - Results:
    - "The great composer Mozart (1756-1791) achieved fame at a young age"
    - "Mozart (1756-1791) was a genius"
    - "The whole world would always be indebted to the great music of Mozart (1756-1791)"
  - Longest matching substring for all 3 sentences is "Mozart (1756-1791)"
  - Suffix tree would extract "Mozart (1756-1791)" as an output, with score of 3
- Reminiscent of IE pattern learning

Pattern Learning (cont.)

- Repeat with different examples of same question type
  - "Gandhi 1869", "Newton 1642", etc.
- Some patterns learned for BIRTHDATE
  - a. born in <ANSWER>, <NAME>
  - b. <NAME> was born on <ANSWER> ,
  - c. <NAME> (<ANSWER> -
  - d. <NAME> (<ANSWER> -)

Experiments: (R+H, 2002)

- 6 different Question types
  - from Webclopedia QA Typology (Hovy et al., 2002a)
    - BIRTHDATE
    - LOCATION
    - INVENTOR
    - DISCOVERER
    - DEFINITION
    - WHY-FAMOUS

Experiments: pattern precision

- BIRTHDATE table:
  - 1.0 <NAME> (<ANSWER> -)
  - 0.85 <NAME> was born on <ANSWER>,
  - 0.6 <NAME> was born in <ANSWER>
  - 0.59 <NAME> was born <ANSWER>
  - 0.53 <ANSWER> <NAME> was born
  - 0.50 - <NAME> (<ANSWER>
  - 0.36 <NAME> (<ANSWER> -
- INVENTOR
  - 1.0 <ANSWER> invents <NAME>
  - 1.0 the <NAME> was invented by <ANSWER>
  - 1.0 <ANSWER> invented the <NAME> in

Experiments (cont.)

- WHY-FAMOUS
  - 1.0 <ANSWER> <NAME> called
  - 1.0 laureate <ANSWER> <NAME>
  - 0.71 <NAME> is the <ANSWER> of
- LOCATION
  - 1.0 <ANSWER>'s <NAME>
  - 1.0 regional : <ANSWER> : <NAME>
  - 0.92 near <NAME> in <ANSWER>
- Depending on question type, get high MRR (0.6–0.9), with higher results from use of Web than TREC QA collection

Shortcomings & Extensions

- Need for POS &/or semantic types
  - "Where are the Rocky Mountains?"
  - "Denver's new airport, topped with white fiberglass cones in imitation of the Rocky Mountains in the background , continues to lie empty"
  - <NAME> in <ANSWER>
- NE tagger &/or ontology could enable system to determine "background" is not a location

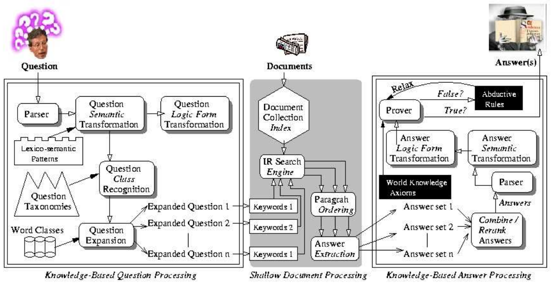
Shortcomings... (cont.)

- Long distance dependencies
  - "Where is London?"
  - "London, which has one of the most busiest airports in the world, lies on the banks of the river Thames"
  - would require pattern like:
    <QUESTION>, (<any_word>)*, lies on <ANSWER>
- But: abundance & variety of Web data helps system to find an instance of patterns w/o losing answers to long distance dependencies

Shortcomings... (cont.)

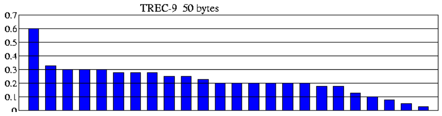
- Their system uses only one anchor word
  - Doesn't work for Q types requiring multiple words from question to be in answer
    - "In which county does the city of Long Beach lie?"
    - "Long Beach is situated in Los Angeles County"
    - required pattern:
      <Q_TERM_1> is situated in <ANSWER> <Q_TERM_2>
- Does not use case
  - "What is a micron?"
  - "...a spokesman for Micron, a maker of semiconductors, said SIMMs are..."

LCC: Harabagiu, Moldovan et al.

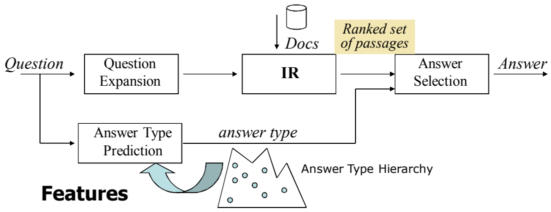


Value from Sophisticated NLP Pasca and Harabagiu (2001)

- Good IR is needed: SMART paragraph retrieval
- Large taxonomy of question types and expected answer types is crucial
- Statistical parser used to parse questions and relevant text for answers, and to build KB
- Query expansion loops (morphological, lexical synonyms, and semantic relations) important
- Answer ranking by simple ML method



Answer types in SOA QA systems

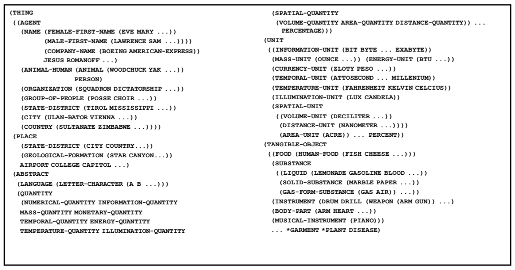


Features

- Answer type
  - Labels questions with answer type based on a taxonomy
  - Classifies questions (e.g. by using a maximum entropy model)

QA Typology (from ISI USC)

- Typology of typical Q forms—94 nodes (47 leaf nodes)
- Analyzed 17,384 questions (from answers.com)



```
(THING
 ((AGENT
   (NAME (FEMALE-FIRST-NAME (EVE MARY ...))
         (MALE-FIRST-NAME (LAWRENCE SAM ...))))
         (COMPANY-NAME (BOEING AMERICAN-EXPRESS))
         JESUS ROMANOFF ...)
   (ANIMAL-HUMAN (ANIMAL (WOODCHUCK YAK ...))
                 PERSON)
   (ORGANIZATION (SQUADRON DICTATORSHIP ...))
   (GROUP-OF-PEOPLE (POSSE CHOIR ...))
   (STATE-DISTRICT (TIROL MISSISSIPPI ...))
   (CITY (ULAN-BATOR VIENNA ...))
   (COUNTRY (SULTANATE ZIMBABWE ...))))
 (PLACE
   (STATE-DISTRICT (CITY COUNTRY...))
   (GEOLOGICAL-FORMATION (STAR CANYON...))
   AIRPORT COLLEGE CAPITOL ...)
 (ABSTRACT
  (LANGUAGE (LETTER-CHARACTER (A B ...)))
  (QUANTITY
   (NUMERICAL-QUANTITY INFORMATION-QUANTITY
   MASS-QUANTITY MONETARY-QUANTITY
   TEMPORAL-QUANTITY ENERGY-QUANTITY
   TEMPERATURE-QUANTITY ILLUMINATION-QUANTITY
```

```
   (SPATIAL-QUANTITY
    (VOLUME-QUANTITY AREA-QUANTITY DISTANCE-QUANTITY)) ...
     PERCENTAGE)))
 (UNIT
  ((INFORMATION-UNIT (BIT BYTE ... EXABYTE))
   (MASS-UNIT (OUNCE ...)) (ENERGY-UNIT (BTU ...))
   (CURRENCY-UNIT (ZLOTY PESO ...))
   (TEMPORAL-UNIT (ATTOSECOND ... MILLENIUM))
   (TEMPERATURE-UNIT (FAHRENHEIT KELVIN CELCIUS))
   (ILLUMINATION-UNIT (LUX CANDELA))
   (SPATIAL-UNIT
    ((VOLUME-UNIT (DECILITER ...))
     (DISTANCE-UNIT (NANOMETER ...))))
     (AREA-UNIT (ACRE)) ... PERCENT))
 (TANGIBLE-OBJECT
  ((FOOD (HUMAN-FOOD (FISH CHEESE ...)))
   (SUBSTANCE
    ((LIQUID (LEMONADE GASOLINE BLOOD ...))
     (SOLID-SUBSTANCE (MARBLE PAPER ...))
     (GAS-FORM-SUBSTANCE (GAS AIR)) ...))
   (INSTRUMENT (DRUM DRILL (WEAPON (ARM GUN)) ...)
   (BODY-PART (ARM HEART ...))
   (MUSICAL-INSTRUMENT (PIANO)))
   ... *GARMENT *PLANT DISEASE)
```

Extracting Answers for Factoids

- In TREC 2003 the LCC QA system extracted 289 correct answers for factoid questions
- The Name Entity Recognizer was responsible for 234 of them

QUANTITY	55	ORGANIZATION	15	PRICE	3
NUMBER	45	AUTHORED WORK	11	SCIENCE NAME	2
DATE	35	PRODUCT	11	ACRONYM	1
PERSON	31	CONTINENT	5	ADDRESS	1
COUNTRY	21	PROVINCE	5	ALPHABET	1
OTHER LOCATIONS	19	QUOTE	5	URI	1
CITY	19	UNIVERSITY	3		

Special Case of Names

Questions asking for names of authored works

1934: What is the play "West Side Story" based on? Answer: Romeo and Juliet
1976: What is the motto for the Boy Scouts? Answer: Be Prepared
1982: What movie won the Academy Award for best picture in 1989? Answer: Driving Miss Daisy
2080: What peace treaty ended WWI? Answer: Versailles
2102: What American landmark stands on Liberty Island? Answer: Statue of Liberty

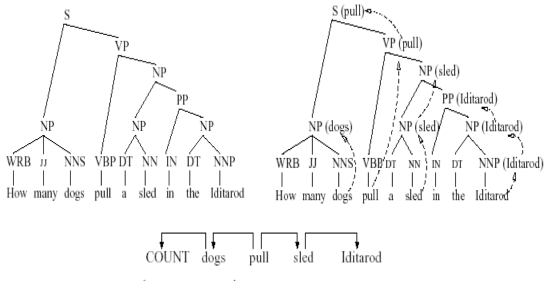
Named Entity Recognition for QA

- The results of the past 5 TREC evaluations of QA systems indicate that current state-of-the-art QA is determined by the recognition of Named Entities:
  - *Precision of recognition*
  - *Coverage of name classes*
  - *Mapping into concept hierarchies*
  - *Participation into semantic relations (e.g. predicate-argument structures or frame semantics)*

Concept Taxonomies

- For 29% of questions the QA system relied on an off-line taxonomy with semantic classes such as:
  - Disease
  - Drugs
  - Colors
  - Insects
  - Games
- *The majority of these semantic classes are also associated with patterns that enable their identification*

Syntax to Logical Forms


S
VP
NP
PP
NP
NP
NP
WRB JJ NNS VBP DT NN IN DT NNP
How many dogs pull a sled in the Iditarod
S (pull)
VP (pull)
NP (sled)
PP (Iditarod)
NP (dogs)
NP (sled)
NP (Iditarod)
WRB JJ NNS VBP DT NN IN DT NNP (Iditarod)
How many dogs pull a sled in the Iditarod
COUNT dogs pull sled Iditarod

•Syntactic analysis plus semantic => logical form
•Mapping of question and potential answer LFs to find the best match

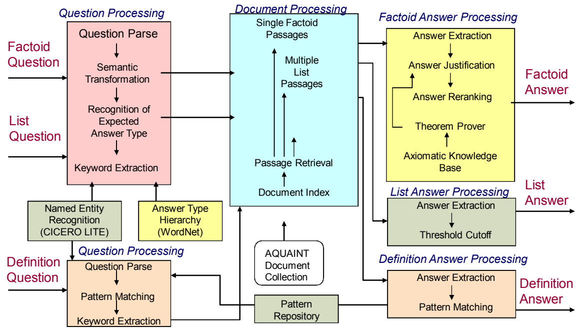
Abductive inference

- System attempts inference to justify an answer (often following lexical chains)
- Their inference is a kind of funny middle ground between logic and pattern matching
- But quite effective: 30% improvement
- *Q: When was the internal combustion engine invented?*
- *A: The first internal-combustion engine was built in 1867.*
- invent -> create_mentally -> create -> build

Question Answering Example

- How hot does the inside of an active volcano get?
- get(TEMPERATURE, inside(volcano(active)))
- “lava fragments belched out of the mountain were as hot as 300 degrees Fahrenheit”
- fragments(lava, TEMPERATURE(degrees(300)), belched(out, mountain))
  - volcano ISA mountain
  - lava ISPARTOF volcano
  - lava inside volcano
  - fragments of lava HAVEPROPERTIESOF lava
- The needed semantic information is in WordNet definitions, and was successfully translated into a form that was used for rough ‘proofs’

The Architecture of LCC’s QA System around 2003



Definition Questions

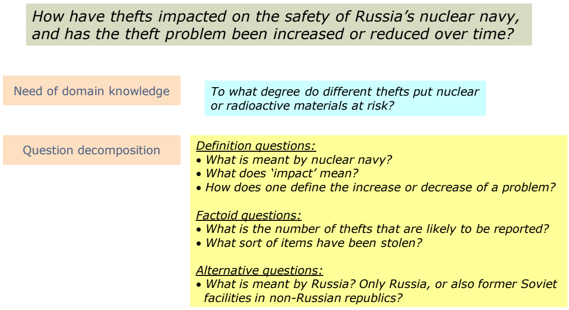
- They asked about:
  - PEOPLE (most of them starting with “Who”)
  - other types of NAMES
  - general concepts
- People questions
  - Many use the PERSON name in the format [First name, Last name]
    - examples: Aaron Copland, Allen Iverson, Albert Ghiorso
  - Some names had the PERSON name in format [First name, Last name1, Last name2]
    - example: Antonia Coello Novello
  - Other names had the name as a single word → very well known person
    - examples: Nostradamus, Absalom, Abraham
  - Some questions referred to names of kings or princes:
    - examples: Vlad the Impaler, Akbar the Great

Answering definition questions

- Most QA systems use between 30-60 patterns
- The most popular patterns:

Id	Pattern	Freq.	Usage	Question
25	person-hyponym QP	0.43%	The doctors also consult with former Italian Olympic skier Alberto Tomba, along with other Italian athletes	1907: Who is Alberto Tomba?
9	QP, the AP	0.28%	Bausch Lomb, the company that sells contact lenses, among hundreds of other optical products, has come up with a new twist on the computer screen magnifier	1917: What is Bausch & Lomb?
11	QP, a AP	0.11%	ETA, a Basque language acronym for Basque Homeland and Freedom _ has killed nearly 800 people since taking up arms in 1968	1987: What is ETA in Spain?
13	QA, an AP	0.02%	The kidnappers claimed they are members of the Abu Sayaf, an extremist Muslim group, but a leader of the group denied that	2042: Who is Abu Sayaf?
21	AP such as QP	0.02%	For the hundreds of Albanian refugees undergoing medical tests and treatments at Fort Dix, the news is mostly good: Most are in reasonable good health, with little evidence of infectious diseases such as TB	2095: What is TB?

Example of Complex Question



How have thefts impacted on the safety of Russia's nuclear navy, and has the theft problem been increased or reduced over time?

Need of domain knowledge

To what degree do different thefts put nuclear or radioactive materials at risk?

Question decomposition

Definition questions:
- *What is meant by nuclear navy?*
- *What does 'impact' mean?*
- *How does one define the increase or decrease of a problem?*

Factoid questions:
- *What is the number of thefts that are likely to be reported?*
- *What sort of items have been stolen?*

Alternative questions:
- *What is meant by Russia? Only Russia, or also former Soviet facilities in non-Russian republics?*

Complex questions

- Characterized by the need of domain knowledge
- There is no single answer type that can be identified, but rather an answer structure needs to be recognized
- Answer selection becomes more complicated, since inference based on the semantics of the answer type needs to be activated
- Complex questions need to be decomposed into a set of simpler questions