Part III
Semantic Search

Semantic search

- What is "semantic" search?
    - understanding intent, contextual meaning
    - finding actual answers for information needs
    - combining text and structure

- "Entity-centric search"

In this part

- Query understanding

- Semantic search tasks

- Result presentation

- My first semantic search engine

- Open challenges

Query understanding

- First step: recognize, label, and disambiguate entities in queries
    - add: attributes/aspects
    - add: types
    - add: relationships
    - add: actions/verbs
    - etc.

- Then: query understanding
    - what is the intent?
    - currently: mostly template-based **[Agarwal et al. 2010]**

Query understanding

- Adding structure to queries

- Query intents

- Interaction: recommendation, auto-completion

Adding structure to queries

- Phrases, segmentation, weighting
  [Bendersky et al. 2010]

- Keyword queries to structured queries
  [Sarkas et al. 2010; Pound et al. 2012; Mass & Sagiv 2012]

- Query templates
  [Agarwal et al. 2010; Szpektor et al. 2011]

Query intents

- Query intent classification
  - navigational, informational, or transactional
    [Broder 2002]
  - extensions to Broder
    [Rose & Levinson 2004; Jansen et al. 2007]
  - semantic intents
    [Hu et al. 2009]

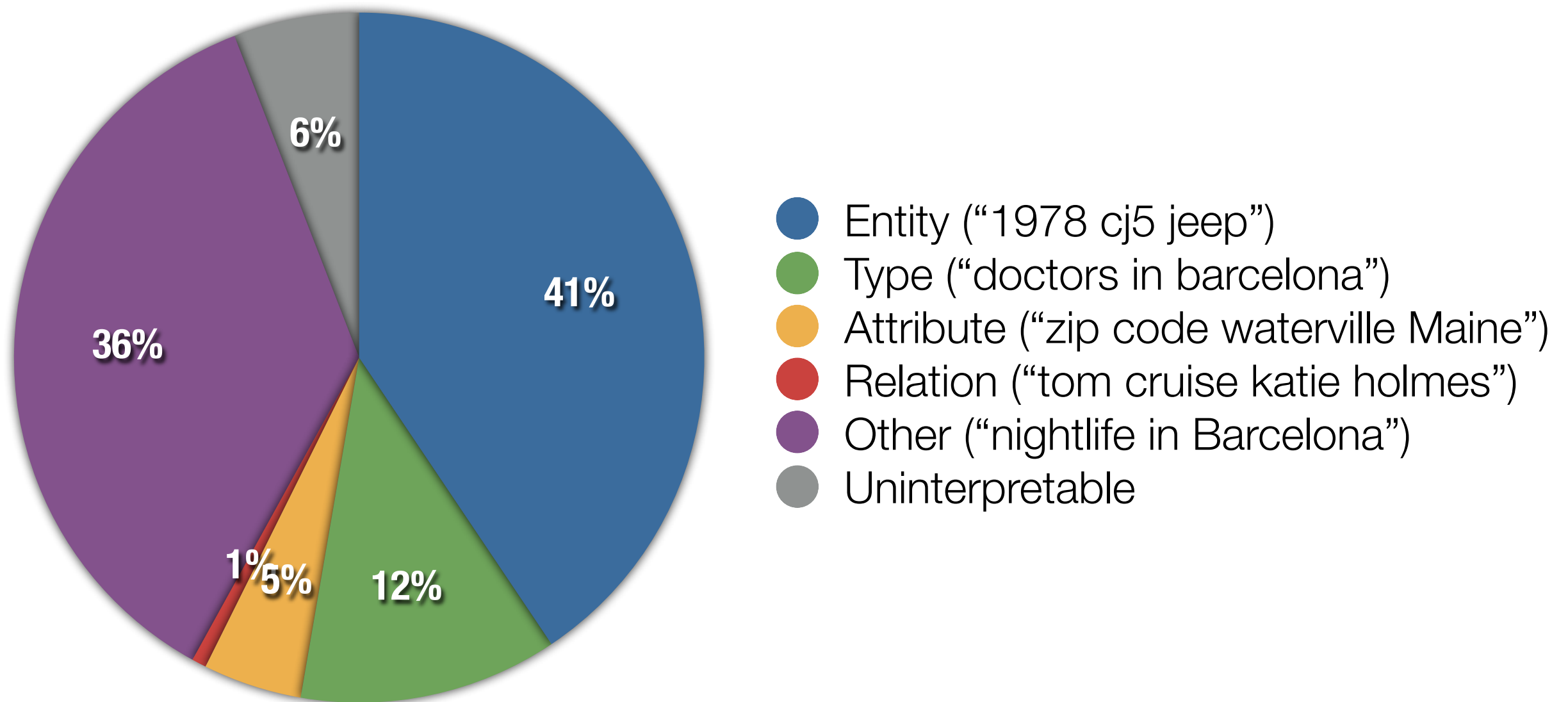- Query context (sessions, users, history, user agents)

Named Entities in Queries
[Guo et al. 2009]

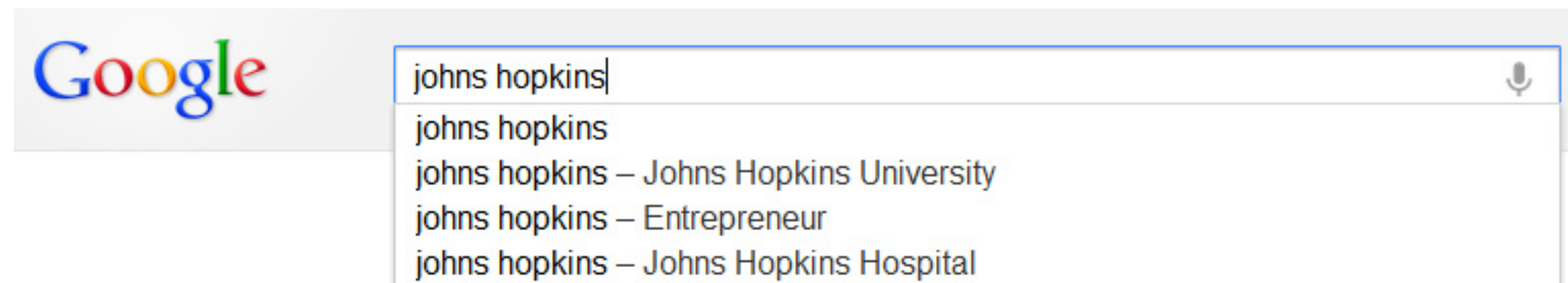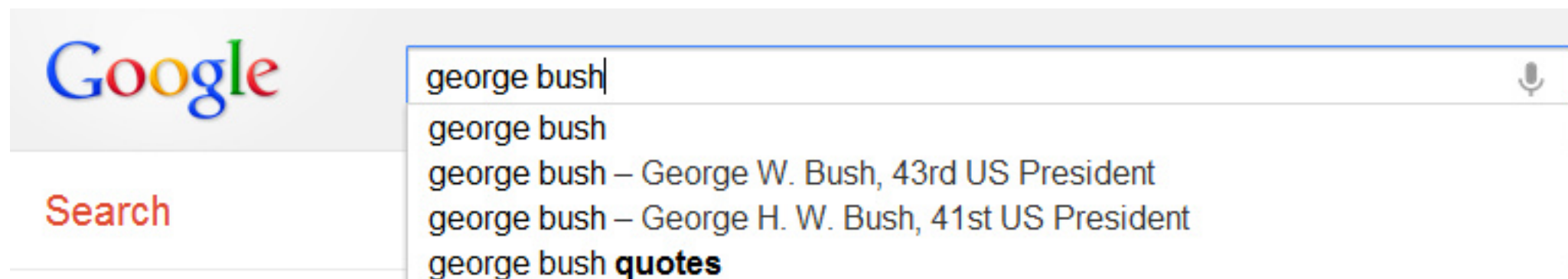- Entities in 71% of queries

- Context per type:

Movie	Game	Book	Music
# movie	# games	# summary	# lyrics
# photos	# cheats	# book	# video
# soundtrack	lego #	# review	# song
# pics	# download	# star	lyrics #
# movies	# wallpaper	# synopsis	lyrics to #

Distribution of web search queries [Pound et al. 2010]

- Entity ("1978 cj5 jeep")
- Type ("doctors in barcelona")
- Attribute ("zip code waterville Maine")
- Relation ("tom cruise katie holmes")
- Other ("nightlife in Barcelona")
- Uninterpretable

41%
12%
5%
1%
36%
6%

Interaction: recommendation, auto-completion

Semantic search tasks/methods

- ~~Ad-hoc~~

- Information filtering

- Finding aggregates

- Profiling and slot filling

- Exploratory search, longitudinal search tasks, and serendipity

Finding aggregates

- Question Answering over Linked Data (QALD)
  - Aggregating information from multiple sources (both unstructured and structured)

🔍 Which German cities have more than 250000 inhabitants?

🔍 How many space missions have there been?

🔍 Who is the youngest player in the Premier League?

Information filtering

- CLEF RepLab
  - Given a stream of items (tweets) identify
    1. which entity this is about
    2. how it impacts the "reputation" of that entity

- Cumulative Citation Recommendation (CCR) @TREC Knowledge Base Acceleration
  - Filter a time-ordered corpus for documents that are highly relevant to a predefined set of entities
  - For each entity, provide a ranked list of documents based on their "citation-worthiness"

CCR @TREC KBA

Update Wikipedia

Entity in Wikipedia

citation worthy?

Yes

Wikipedia editor

Streaming documents
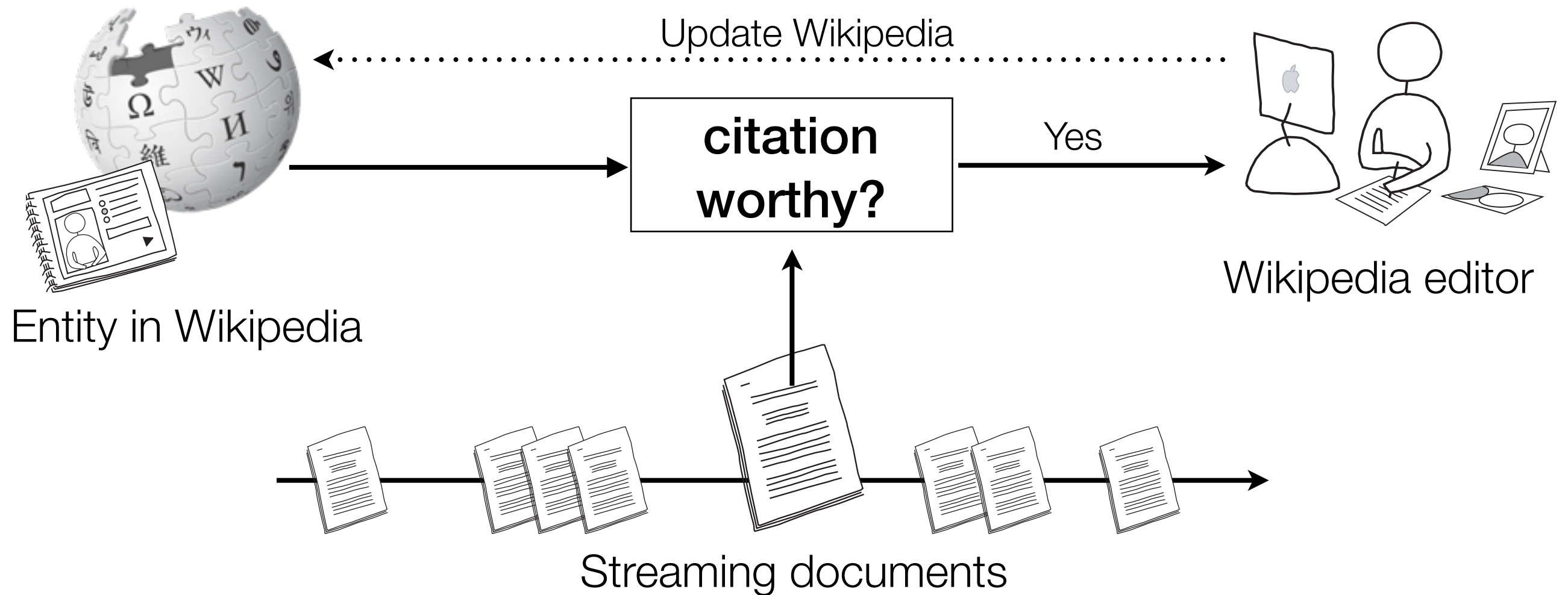
Profiling and slot filling

- Entity profiling
  - generate a *profile* of an entity
    - summary (keywords/full-text)
    - timelines
    - …

- Slot filling
  - automatically fill attribute fields

Vincent van Gogh

Vincent Willem van Gogh was a post-Impressionist painter of Dutch origin whose work, notable for its rough beauty, emotional honesty and bold color, had a far-reaching influence on 20th-century art. After years of painful anxiety and frequent bou… +

en.wikipedia.org

en.wikipedia.org

Lived: Mar 30, 1853 - Jul 29, 1890 (age 37)

Height: 5' 7" (1.70 m)

Periods: Divisionism

Siblings: Theo van Gogh · Wil van Gogh · Cornelis Vincent van Gogh · Vincent Van Gogh · Elisabeth Huberta Du Quesne-van Gogh +

Written works: The Letters of Vincent Van Gogh · Dear Theo: The Autobiography of Vincent Van Gogh +

Education: Royal Academy of Fine Arts · Académie Royale des Beaux-Arts · Willem II College

Timeline

1886: Despite his rejection of academic teaching, he took the higher-level admission exams at the Academy of Fine Arts in Antwerp, and in January 1886, matriculated in painting and drawing.

1886: Van Gogh traveled to Paris in March 1886, where he shared Theo's Rue Laval apartment on Montmartre, to study at Fernand Cormon's studio.

1887: In November 1887, Theo and Vincent met and befriended Paul Gauguin who had just arrived in Paris.

1888: Finally in February 1888, feeling worn out from life in Paris, he left, having painted over 200 paintings during his two years in the city.
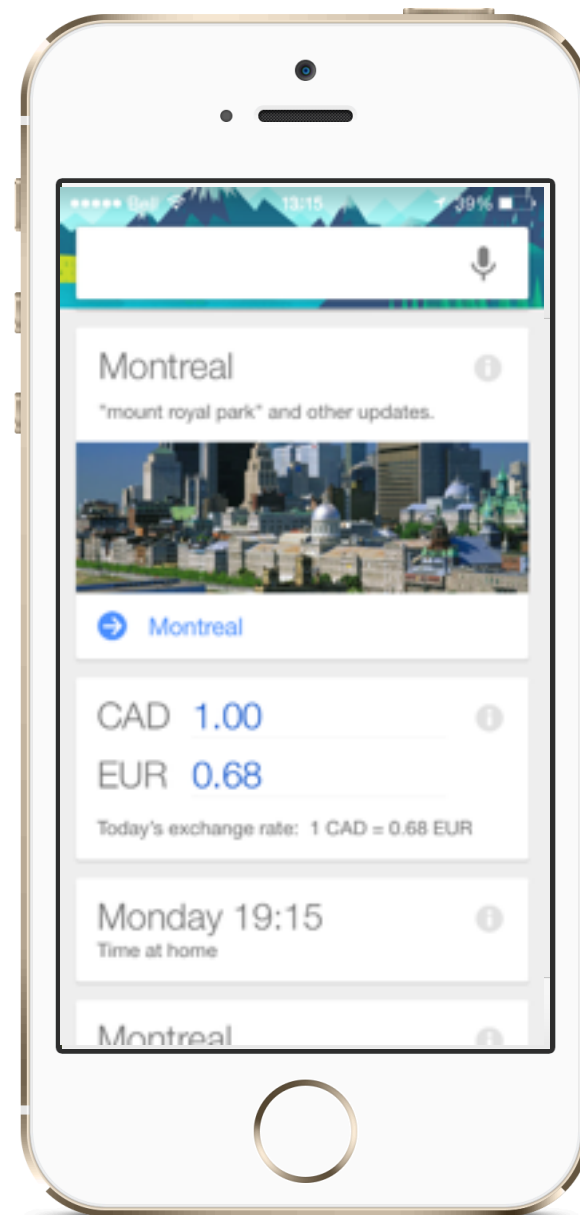
+ See more

Artwork

# Exploratory search, longitudinal search tasks, and serendipity

- Entity-driven serendipitous search system [Bordino et al. 2013]
  - Lazy random walk on entity networks extracted from Wikipedia and Yahoo! Answers
  - The entity networks are similar, but Yahoo! Answers contributes more to serendipitous browsing experience

Exploratory search, longitudinal search tasks, and serendipity

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Miranda Kerr denies Brad Pitt romance rumours
Telegraph.co.uk - 5 hours ago
Are we the only ones who missed the rumour mill circulating tales of Miranda Kerr's alleged romance with Brad Pitt? According to the Australian ...

William Hague defends summit with Brad Pitt and Angelina ...
Daily Mail - 8 hours ago

Angelina Jolie makes a stylish arrival at Heathrow airport ...
Daily Mail - 2 days ago

More news for brad pitt

Brad Pitt - IMDb
www.imdb.com/name/nm0000093/ ▾ Internet Movie Database ▾
An actor and producer known as much for his versatility as he is for his handsome face, Golden Globe-winning actor Brad Pitt's most widely recognized role may ...
Latest Titles With Brad Pitt - IMDb - Biography - Rated - Show all

Brad Pitt - Wikipedia, the free encyclopedia
en.wikipedia.org/wiki/Brad_Pitt ▾ Wikipedia ▾
William Bradley "Brad" Pitt (born December 18, 1963) is an American actor and film producer. He has received a Golden Globe Award, a Screen Actors Guild ...
Filmography - List of awards and ... - List of most expensive - Jill Schoelen

Brad Pitt News, Photos, and Videos | Just Jared
www.justjared.com/tags/brad-pitt/ ▾ Just Jared ▾
2 days ago - Angelina Jolie and Brad Pitt make their way through Heathrow Airport to catch a flight out of town on Saturday (June 14) in London, England.

Brad Pitt : People.com
www.people.com/people/brad_pitt/ ▾ People ▾
Get everything Brad Pitt straight from America's #1 celebrity brand, PEOPLE. The latest Brad Pitt news, a full collection of photos, fun facts and his complete bio ...

Brad Pitt Biography - Facts, Birthday, Life Story - Biography ...
www.biography.com/people/brad-pitt-9441989 ▾ The Biography Channel ▾
Explore the life, career and romances—including his relationship with Angelina Jolie—of Academy Award- and Golden Globe-winning actor Brad Pitt, ...

More images

Brad Pitt

Actor

William Bradley "Brad" Pitt is an American actor and film producer. He has received a Golden Globe Award, a Screen Actors Guild Award, and three Academy Award nominations in acting categories, and ... Wikipedia

Born: December 18, 1963 (age 50), Shawnee, OK

Partner: Angelina Jolie (2005–)

Spouse: Jennifer Aniston (m. 2000–2005)

Awards: Academy Award for Best Picture, More

Children: Shiloh Nouvel Jolie-Pitt, Vivienne Marcheline Jolie-Pitt, More

Movies — View 45+ more

| The Curious Case of B... 2008 | Fight Club 1999 | Moneyball 2011 | World War Z 2013 | Ocean's Eleven 2001 |

People also search for — View 15+ more

| Angelina Jolie Partner | Jennifer Aniston Former | Tom Cruise | George Clooney | Leonardo DiCaprio |

Result presentation

- Rich result pages (SERPs)

- Directly displaying answers and relevant information or context

Rich result pages

Rich result pages

Rich result pages

Henry Ford

Henry Ford was an American industrialist, the founder of the Ford Motor Company, and sponsor of the development of the assembly line technique of mass production. Although Ford did not invent the automobile or the assembly line, he devel... **+**

en.wikipedia.org

www.biography.com

Lived: Jul 30, 1863 - Apr 7, 1947 (age 83)

Height: 5' 10" (1.78 m)

Spouse: Clara Ala Bryant (1888 - 1947)

Children: Edsel Ford

Founded: Ford Motor Company · The Henry Ford · Ford Foundation · Henry Ford Company · Kingsford · Detroit Automobile Company **+**

Parents: William Ford · Mary Litogot Ford

Timeline ⌃

1888: Ford married Clara Ala Bryant (1866–1950) in 1888 and supported himself by farming and running a sawmill.

1903: Ford & Malcomson was reincorporated as the Ford Motor Company on June 16, 1903, with $28,000 capital.

1913: In 1913, Ford attempted to enter a reworked Model T in the Indianapolis 500 but was told rules required the addition of another 1,000 pounds (450 kg) to the car before it could qualify.

1918: Henry Ford turned the presidency of Ford Motor Company over to his son Edsel Ford in December 1918.

+ See more

People also search for

Vincent van Gogh

Vincent Willem van Gogh was a post-Impressionist painter of Dutch origin whose work, notable for its rough beauty, emotional honesty and bold color, had a far-reaching influence on 20th-century art. After years of painful anxiety and frequent bou... **+**

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1888: Finally in February 1888, feeling worn out from life in Paris, he left, having painted over 200 paintings during his two years in the city.

+ See more

Artwork

Direct displays

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1 Euro equals
1.37 US Dollar

| 1 | Euro ⇕ |
| 1.37 | US Dollar ⇕ |

1.6
1.4
1.2
1.0
2010 2011 2012 2013 2014
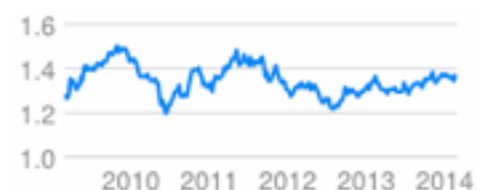
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This Free Currency Exchange Rates Calculator helps you convert any amount from one currency to another.
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coinmill.com/EUR_USD.html ▾
Use "Swap currencies" to make United States Dollar the default currency. Click on United States Dollars or Euros to convert between that currency and all other ...

XE Currency Converter - Live Rates
www.xe.com/currencyconverter/ ▾ XE.com ▾
AUD - Australian Dollar, CAD - Canadian Dollar, CHF - Swiss Franc, CNY ... EUR - Euro, GBP - British Pound, HKD - Hong Kong Dollar, HUF - Hungarian Forint ...

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Google How tall was Abraham Lincoln 🔍

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About 3,150,000 results (0.36 seconds)

6' 4" (1.93 m)

Abraham Lincoln, Height

George Washington
6' 3"

Daniel Day-Lewis
6' 2"

Barack Obama
6' 1"

Feedback

Abraham Lincoln - Wikipedia, the free encyclopedia
en.wikipedia.org/wiki/Abraham_Lincoln ▾ Wikipedia ▾
For other uses, see **Abraham Lincoln** (disambiguation). Page semi- ..... At 6 feet 4
inches (193 cm), he was **tall** and "strong enough to intimidate any rival". At his ...
Sexuality - William Wallace Lincoln - Assassination of Abraham - Daguerreotype

Sexuality of Abraham Lincoln - Wikipedia, the free encyclopedia
en.wikipedia.org/wiki/Sexuality_of_Abraham_Lincoln ▾ Wikipedia ▾
The sexuality of **Abraham Lincoln** (1809–1865), the 16th President of the United ...
The "**Tall** Sucker" was a very strange man, one of the strangest in American ...
Historical scholarship and debate - Co-sleeping - Relationship with Joshua Speed

Heights of presidents and presidential candidates of the United States

https://www.google.com/search?q=How+tall+was+Abraham+Lincoln&oq=How+tall+...

Google   How tall is Abraham Lincoln   🎤   🔍   +Edgar   ⊞   🔔   Share

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About 7,280,000 results (0.60 seconds)

6' 4" (1.93 m)

Abraham Lincoln, Height

George Washington
6' 3"

Daniel Day-Lewis
6' 2"

Barack Obama
6' 1"

Feedback

Abraham Lincoln - Wikipedia, the free encyclopedia
en.wikipedia.org/wiki/**Abraham_Lincoln** ▾   Wikipedia ▾
Abraham Lincoln was **born** February 12, 1809, the second child of Thomas Lincoln
and Nancy Lincoln (née Hanks), in a one-room log cabin on the Sinking ...
Sexuality - William Wallace Lincoln - Assassination of Abraham - Daguerreotype

Heights of presidents and presidential candidates of the United States
en.wikipedia.org/.../**Heights**_of_presidents_and_presidential_c... ▾   Wikipedia ▾
Presidents, like the U.S. population, have grown **taller** over time. A record ... **Abraham
Lincoln** tied Lyndon B. Johnson as the tallest president at 6 ft 4 in (193 cm).
US Presidents by height order - Electoral success as a ...

Sexuality of Abraham Lincoln - Wikipedia, the free encyclopedia

https://www.google.com/search?q=How+many+seats+at+Yankee+stadium&oq=How+m...

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98,787

Camp Nou, Capacity

Santiago Bernabéu Stadium
85,454

Old Trafford
75,811

Wembley Stadium
90,000

Feedback

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4.6 ★★★★☆ 487 Google reviews · Write a review

Carrer d'Arístides Maillol, 12, 08028 Barcelona, Spain
+34 902 18 99 00

Camp Nou - Wikipedia, the free encyclopedia
en.wikipedia.org/wiki/Camp_Nou ▾ Wikipedia ▾
The **Camp Nou seats** 99,786, reduced to 96,336 in matches organized by UEFA, making it the largest stadium in Europe and the 11th largest in the world in ...
History - Future - Other uses - Transport connections

https://www.google.com/search?q=How+much+does+Beckham+make&oq=How+much...

Google

How much does Messi make

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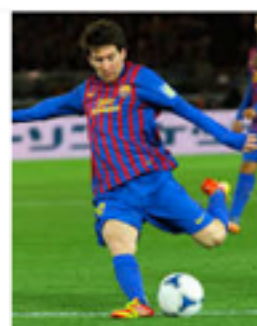Web   Shopping   News   Images   Videos   More ▾   Search tools

About 5,170,000 results (0.49 seconds)

16 million EUR (2013)

Lionel Messi, Salary

Cristiano
Ronaldo
21M EUR

Neymar
7M EUR

Gareth Bale
15.6M GBP

Feedback

Lionel Messi - Forbes
www.forbes.com/profile/lionel-messi/ ▾ Forbes ▾
Lionel Messi on Forbes - #39 Celebrity 100, #10 The World's Highest-Paid Athletes. ...
How many millionaire earners does your state have? [...] more>>.
David Letterman - Adam Sandler - Back

Lionel Messi Net Worth | Celebrity Net Worth
www.celebritynetworth.com › Richest Athletes › Footballers ▾
How much is Lionel Messi worth? $115 Million ... Messi makes additional millions
every year from endorsements. ... How much money does Lionel Messi have?

Lionel Messi tops the football rich list | Mail Online - Daily Mail
www.dailymail.co.uk/.../Lionel-Messi-tops-football-rich-list.ht... ▾ Daily Mail ▾
Mar 20, 2012 - Lionel Messi can add the accolade of the world's best paid footballer

Spoiler alert

- If you plan on watching Germany – Portugal, close your eyes for a bit…

www.google.com/#q=ger+por

Google

ger por

Web   Videos   Images   News   Shopping   More ▾   Search tools

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2014 FIFA World Cup™

FIFA WORLD CUP Brasil

Full-time • Arena Fonte Nova, Salvador • Group G

Germany   **4 - 0**   Portugal

Timeline   Match stats   Lineups

FULL-TIME

Video on ESPN FC

FULL-TIME

Lukas Podolski (#10)   ⬆

                              82'

Thomas Müller (#13)   ⬇

Template-based query understanding

- Rule-based approaches (editorial)
  - high precision
  - difficult to generalize
  - costly to create/maintain

- Research into more generic approaches is ongoing

Evaluation

Evaluation

- Do traditional metrics cover semantic search?
  - do we know the user's intent from a keyword query?
  - haven't users grown accustomed to not getting actual answers?
  - no interaction when the correct answer is shown

- Other "dimensions" of relevance
  - recency
  - interestingness
  - popularity
  - social

So, we have some tools now: How to go about QU?

- Entity linking
  - assume some knowledge base/structure/graph
  - link to the entity that is mentioned in the input
    - "recognize, label, and disambiguate"
  - leverage various signals
    - titles, redirects, anchor text, ...
    - graph information
    - machine learning: clicks/editorial data

So, we have some tools now: How to go about QU?

- Entity retrieval
  - retrieve the actual answer
    - single entity
    - set/list of entities
    - attribute value(s)
    - snippet
  - from the KB, the web, a vertical, ...

- In some cases, EL/ER can be one and the same...

Let's take a step back

- Assume you want to build a "semantic" search engine
  - What would you need?
  - What would you do?
  - Which of the building blocks we have seen do we need and how do they fit together?

The life of a query

The life of a query

- "How tall is the eiffel tower"
  - "eiffel tower height"

The life of a query

- "Which airlines fly the Airbus A380?"
  - "airbus a380 airlines"

The life of a query

- "yul arrivals"

The life of a query

- "woody allen movies"

The life of a query

- "Who was the oldest person in outer space?"
  - "oldest person outer space"

Open challenges

- Tail entities

- (Hyper)local

- Social

- Aggregation/Summarization

- "Provenance" ~ result explanation

- (Online) evaluation

- Freshness

Wrap-up

- Introduction

- Part 1 – Entity Linking

- Part 2 – Entity Retrieval

- Part 3 – Semantic Search

Questions?

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Krisztian Balog – @krisztianbalog
Daan Odijk – @dodijk