Information Retrieval & Data Mining

Winter Semester 2015/16
Saarland University, Saarbrücken

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Information Retrieval & Data Mining: What Is It All About?

**Information Retrieval** is ...
- **finding** relevant contents
- figuring out what users want
- ranking results to satisfy users

... at Web scale

**Data Mining** is ...
- **discovering** insight from data
- mining interesting patterns
- finding clusters and outliers

... from complex data

**Mutual benefits:**

Mining needs to retrieve, filter, rank contents from Internet

Search benefits from analyzing user behavior data

http://tinyurl.com/irdm2015
Organization

• Lectures:
  Tuesday 14-16 in E1.3 Room 001 and Thursday 14-16 in E1.3 Room 002
  Office hours of lecturers: appointment by e-mail

• Assignments / Tutoring Groups:
  Tuesday 16-18    Thursday 16-18    Friday 14-16

Assignments given out in Thursday lecture, to be solved until next Thursday
First assignment given out on Oct 22, solutions turned in on Oct 29
First meetings of tutoring groups: Tue, Nov 3; Thu, Nov 5; Fri, Nov 6

• Requirements for obtaining 9 credit points:
  • pass **2 out of 3 written tests** (ca. 60 min each)
    tentative dates: Thu, Nov 19; Thu, Dec 10; Thu, Feb 4
  • pass **oral exam** (15-20 min), tentative dates: Mon-Tue, Feb 15-16
  • must present **solutions to 3 exercises** (randomly chosen)
  • up to **3 bonus points** possible in tests

Register for course and tutor group at [http://tinyurl.com/irdm2015](http://tinyurl.com/irdm2015)!

http://tinyurl.com/irdm2015
Outline of the IRDM Course

1. Motivation and Overview
2. Data Quality and Data Reduction

4. Patterns: Itemset and Rule Mining
5. Patterns by Clustering
6. Labeling by Supervised Classification
7. Sequences, Time-Series, Streams
8. Graphs: Social Networks, Recommender Systems
9. Anomaly Detection

10. Text Indexing and Similarity Search
11. Probabilistic/Statistical Ranking
12. Topic Models and Graph Models for Ranking
13. Information Extraction
14. Entity Linking and Semantic Search
15. Question Answering

Part I: Introduction & Foundations

Part II: Data Mining

Part III: Information Retrieval
Data Mining:

Information Retrieval:

Foundations from Probability and Statistics:
- Larry Wasserman: „All of Statistics“, Springer, 2004

More books listed on IRDM web page and available in library:
http://www.infomath-bib.de/tmp/vorlesungen/info-core_information-retrieval.html

Each unit of the IRDM lecture states relevant parts of book(s), and gives additional references

Within each unit, core material and advanced material are flagged
important conferences on IR and DM
(see DBLP bibliography for full detail, http://www.informatik.uni-trier.de/~ley/db/)
SIGIR, WSDM, WWW, CIKM, KDD, ICDM, SDM, ICML, ECML

important journals on IR and DM
(see DBLP bibliography for full detail, http://www.informatik.uni-trier.de/~ley/db/)
TOIS, TWeb, InfRetr, JASIST, DAMI, TKDD, TODS, VLDBJ

performance evaluation initiatives / benchmarks:
• Text Retrieval Conference (TREC), http://trec.nist.gov
• Conference and Labs of the Evaluation Forum (CLEF),
  www.clef-initiative.eu
• KDD Cup, http://www.kdnuggets.com/datasets/kddcup.html
  and http://www.sigkdd.org/kddcup/index.php
Chapter 1: Motivation and Overview

1.1 Information Retrieval
1.2 Data Mining

“We are drowning in information, and starved for knowledge.“

-- John Naisbitt
1.1 Information Retrieval (IR) ≈ Search Engine Technology

Core functionality:

• **Match keywords** and multi-word phrases in documents: web pages, news articles, scholarly publications, books, patents, service requests, enterprise dossiers, social media posts, …

• **Rank results** by (estimated) relevance based on: contents, authority, timeliness, localization, personalization, user context, …

• Support interactive **exploration** of document collections

• Generate **recommendations** (implicit search)

…..

**Challenges:**

• *Information Deluge*
• *Needles in Haystack*
• *Understanding the User*
• *Efficiency and Scale*
Search Engine Architecture

- **crawl**: handle dynamic pages, detect duplicates, detect spam
- **extract & clean**: strategies for crawl schedule and priority queue for crawl frontier
- **index**: build and analyze Web graph, index all tokens or word stems
- **search**: fast top-k queries, query logging, auto-completion
- **rank**: scoring function over many data and context criteria
- **present**: GUI, user guidance, personalization

Server farm with 100,000’s of computers, distributed(replicated) data in high-performance file system, massive parallelism for query processing.
Internet crisis: users still love search engines and have trust in the Internet.

Documents

Crawling

Internet crisis
users

Extraction of relevant words

Internet crisis
user

Linguistic methods: stemming

Statistically weighted features (terms)

Internet
Web

Internet Web

Internet crisis

user

love

search

engine

trust

faith

... Indexing

Thesaurus (Ontology)

Synonyms, Sub-/Super-Concepts

Bag-of-Words representations

IRDM 2015
Vector Space Model for Content Relevance Ranking

**Ranking by descending relevance**

**Query** $q \in [0,1]^{\left| F \right|}$ (set of weighted features)

**Documents are feature vectors** (bags of words)

**Search engine**

**Similarity metric:**

$$sim(d_i, q) := \frac{\sum_{j=1}^{\left| F \right|} d_{ij} q_j}{\sqrt{\sum_{j=1}^{\left| F \right|} d_{ij}^2 \sum_{j=1}^{\left| F \right|} q_j^2}}$$

$$d_i \in [0,1]^{\left| F \right|}$$

**Vector Space Model for Content Relevance Ranking**
Vector Space Model for Content Relevance Ranking

**Query** $q \in [0,1]^{|F|}$ (Set of weighted features)

**Documents are feature vectors** $d_i \in [0,1]^{|F|}$ (bags of words)

**Ranking** by descending relevance

**Search engine**

**Similarity metric:**

$$ sim(d_i, q) := \frac{\sum_{j=1}^{|F|} d_{ij} \cdot q_j}{\sqrt{\sum_{j=1}^{|F|} d_{ij}^2 \cdot \sum_{j=1}^{|F|} q_j^2}} $$

**e.g., using:**

$$ d_{ij} := w_{ij} / \sqrt{\sum_k w_{ik}^2} $$

$$ w_{ij} := \log \left( 1 + \frac{\text{freq}(f_j, d_i)}{\max_k \text{freq}(f_k, d_i)} \right) \log \frac{\# \text{docs}}{\# \text{docs with } f_j} $$

**IRDM 2015**
Ranking by descending relevance & authority

Query \( q \in [0,1]^{|F|} \) (Set of weighted features)

+ Consider in-degree and out-degree of Web nodes:
  
  **Authority Rank** \( (d_i) := \) Stationary visit probability \([d_i]\) in random walk on the Web

Reconciliation of relevance and authority (and …) by weighted sum
Google's PageRank [Brin & Page 1998]

Idea: links are endorsements & increase page authority, authority higher if links come from high-authority pages

$$PR(q) = \varepsilon \cdot j(q) + (1 - \varepsilon) \cdot \sum_{p \in IN(q)} PR(p) \cdot t(p,q)$$

with $t(p, q) = 1 / \text{outdegree}(p)$

and $j(q) = 1 / N$

Authority (page q) = stationary prob. of visiting q

random walk: uniformly random choice of links + random jumps

Social Ranking

Extensions with
- weighted links and jumps
- trust/spam scores
- personalized preferences
- graph derived from queries & clicks
Indexing with Inverted Lists

Vector space model suggests **term-document matrix**, but data is sparse and queries are even very sparse → better use **inverted index lists** with terms as keys for B+ tree

- **q:** Internet crisis trust

**B+ tree on terms**

<table>
<thead>
<tr>
<th>crisis</th>
<th>...</th>
<th>Internet</th>
<th>...</th>
<th>trust</th>
</tr>
</thead>
<tbody>
<tr>
<td>17: 0.3</td>
<td>12: 0.5</td>
<td>11: 0.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>44: 0.4</td>
<td>14: 0.4</td>
<td>17: 0.1</td>
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<tr>
<td>52: 0.1</td>
<td>28: 0.1</td>
<td>28: 0.7</td>
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<td>53: 0.8</td>
<td>44: 0.2</td>
<td>:</td>
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<tr>
<td>55: 0.6</td>
<td>51: 0.6</td>
<td>:</td>
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</tr>
<tr>
<td>:</td>
<td>52: 0.3</td>
<td>:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Google etc.: > 10 Mio. terms > 100 Bio. docs > 50 TB index

terms can be full words, word stems, word pairs, substrings, N-grams, etc. (whatever „dictionary terms“ we prefer for the application)

- index-list entries in **DocId order** for fast Boolean operations
- many techniques for excellent **compression** of index lists
- additional **position index** needed for phrases, proximity, etc. (or other precomputed data structures)
Search Result Quality: Evaluation Measures

ideal measure is user satisfaction
heuristically approximated by benchmarking measures
(on test corpora with query suite and relevance assessment by experts)

Capability to return **only** relevant documents (no false positives):

\[
Precision (Präzision) = \frac{\# \text{ relevant docs among top } r}{r}
\]

typically for \( r = 10, 100, 1000 \)

Capability to return **all** relevant documents (no false negatives):

\[
Recall (Ausbeute) = \frac{\# \text{ relevant docs among top } r}{\# \text{ relevant docs}}
\]

typically for \( r = \text{corpus size} \)

**Typical quality**

**Ideal quality**
Example: Google

http://www.google.com
Example: Google

http://www.google.com
Example: Google
Example: Google

http://www.google.com

Understand user needs

Bob Dylan | The Official Bob Dylan Site - BobDylan.com
https://www.bobdylan.com/us/songs
View a list of all Bob Dylan songs at the official website. Listen to tracks, view song information, purchase tracks and more.
A Hard Rain's A-Gonna Fall - All Along The Watchtower - Like A Rolling Stone

List of songs written by Bob Dylan - Wikipedia, the free... https://en.wikipedia.org/wiki/List_of_songs_written_by_Bob_Dylan

Bob Dylan: 30 greatest songs - Music - The Telegraph
www.telegraph.co.uk/music/artist/bob-dylan-30-greatest-songs
Jul 24, 2015 - Is this the first hip-hop song? Lyrics cascade in a relentless mosh-pit gush over jet-black blues, with Dylan tearing up social norms in a surreal...

Top 10 Bob Dylan Songs - YouTube
www.youtube.com/watch?v=65-SQgGCDm
Nov 13, 2010 - Uploaded by RetoTay
As with all my videos, this list is based on my opinion and how much I enjoy listening to each song. If you liked...

Songfacts - List of songs by Bob Dylan
www.songfacts.com/artist-bob-dylan.php
List of songs with Songfacts entries for Bob Dylan. ... Bob Dylan, May 24, 1941. List of songs with Songfacts and Lyrics by Bob Dylan. Songs - Artifacts....

The 10 Greatest Bob Dylan Songs | Rolling Stone
www.rollingstone.com/music/artists/bob-dylan-songs-10-greatest-songs-20110...
May 11, 2011 - Dylan later described “Every Grain of Sand” as “an inspired song that just came to me... the best song Dylan ever wrote was “Blind Willie McTell”...

The 10 Best Post-1960s Bob Dylan Songs - Rolling Stone
www.rollingstone.com/music/artists/bob-dylan-songs-10-best-rolling-stone-20150111...
Feb 11, 2015 - Take Dylan's 1963 tune "Blind Willie McTell." He cut it during the
Example: Google with Knowledge Graph
Example: Google with Knowledge Graph

Google search for bob dylan spouses:
- Carolyn Dennis (m. 1960–1992)
- Sara Dylan (m. 1965–1977)

Sara Dylan - Wikipedia, the free encyclopedia
Jump to Marriage to Bob Dylan - [edit]. Lownds and Dylan became romantically involved sometime in late 1964, soon afterwards, they moved into...

Bob Dylan - Wikipedia, the free encyclopedia
Spouse(s), Sara Lownds (m ... Bob Dylan ("Dylan", born Robert Allen Zimmerman, May 24, 1941) is an ... The album was dedicated to "Godby Goo Goo", a nickname for the daughter of Dylan and Carolyn Dennis, Dasiene Gabriella ... Discography - Jakob Dylan - Jesse Dylan - Bob Dylan (album)

Bob Dylan hid one marriage - and a daughter - for 15 years ...
www.dailymail.co.uk/.../Bob-Dylan-hid-marriage-daughter-15-years-C...
May 3, 2011 - Bob Dylan today: 'The singer reportedly has a large number of secret' ... and the marriage to Carolyn Dennis is the only other marriage for him.

DYLAN'S GIRLFRIENDS | Bob Dylan-Visions of Dylan
https://visionsbobdylan.wordpress.com/dylans-girlfriends/
Fix of Dylan's Girlfriends, wives and other romances. All pix copyright of the ... Sara Dylan. BobSara ... Carolyn Dennis. Bob's second wife. Ruth Tyrangiel.

Bob Dylan - Rolling Stone
www.rollingstone.com/.../6-things-we-learned-from-the-new-bob-dylan...
Sep 9, 2014 - A new tell-all book by Bob Dylan's former road manager reveals the truth ... been faithful and that it was a constant challenge in the marriage.

Bob Dylan Secretly Marries & Breaks Up With Third Wife ...
radaronline.com/.../bob-dylan-darlene-springs-secret-wedding-wife-split...
Nov 6, 2014 - Bob Dylan has pulled off what few in Hollywood have been able to accomplish ... Springs allegedly spent her husband's $130 million fortune on ...

Accelerated Decrepitude: The 10 Sins of Bob Dylan
accelerateddecrepitude.blogspot.com/2005/12/10-sins-of-bob-dylan.html
Dec 5, 2005 - Dylan's diatribe against the Rotolo sisters, ex-girlfriend Suze and ... Hearing that Bob had taken ill in Italy, she went to his hotel room ... Joan always wanted more of Bob than he could or would give - she proposed marriage ...
Example: Google

Bob Dylan
Singer-songwriter

Bob Dylan is an American singer-songwriter, artist and writer. He has been influential in popular music and culture for more than five decades. Wikipedia

Born: May 24, 1941 [age 74], Duluth, Minnesota, United States

Albums: The Times They Are A-Changin', more

Upcoming events

Regensburg
Donau Arena
Wed Nov 11

Paris, France
Le Dôme de Paris - Palais Des Sports
Mon Oct 19

London, United Kingdom
Royal Albert Hall
Wed Oct 21

Profiles

Facebook
Twitter
YouTube
MySpace

Quotes

People seldom do what they believe in. They do what is convenient, then repent.

All I can do is be me, whoever that is.

Take care of all your memories. For you cannot relive them.

People also search for

The 20 Best Uses of Bob Dylan Songs in Film :: Movies :: Lists


Google
Example: Google

http://www.google.com

About 1,300,000 results (0.35 seconds)

The 20 Best Uses of Bob Dylan Songs In Film :: Movies :: Lists
Feb 27, 2012 · Bob Dylan has had his music used in so many movies, it's almost become a cliché. But that pairing of song and film has also created some of...

Bob Dylan at the Movies - Searching For A Gem
www.searchingforagem.com/Soundtracks.htm
Aug 27, 2016 · There are many more films that contain cover versions of Dylan songs, but they are outside the scope of this site. For these, see David Plante's...

Bob Dylan songs in movies and TV series list
Jul 15, 2010 · Beyond Here Lies Nashville, Forgetful Heart, I Believe In You perform by Don Sparks, I Feel A Change Coming On, It's All Good, Life Is Hard...

Bob Dylan - IMDb
www.imdb.com/name/nm0001168/
Bob Dylan and David Letterman at event of Late Show with David Letterman (1993) ... of Song (Still of Bob Dylan, Neil Diamond, Robbie Robertson, Rick Danko, Dr. ... 2014 Rímes del cor (TV Movie documentary) (editor: "Par sempre jove").

This Clip of Bill Murray Singing Along to Bob Dylan Will Get ...
time.com/6476217/bill-murray-singing-vincent-bob-dylan-singer/
Oct 6, 2014 · The film is called St. Vincent and it's in theaters Oct. 10... hybrid as he harmonizes with the song blaring through his headphones. He does all...

The Best Dylan Cues In Movie History | Flavorwire
flavorwire.com/323619/the-best-dylan-cues-in-movie-history
Sep 11, 2012 · He’s also an ever-present force in film and television, with his songs (as ... In honor of Dylan’s new record (always a cause for celebration), we ...

The 10 Best Post-1960s Bob Dylan Songs - Rolling Stone
www.rollingstone.com/.../a35506/bob-dylan-songs-20150211
Feb 11, 2015 · The simple song worked perfectly in the film and gave Dylan a much-needed hit, setting the stage for his huge comeback tour the following year...

List of songs written by Bob Dylan - Wikipedia, the free ...
This list contains songs written by American singer-songwriter Bob Dylan, including....

BOB DYLAN’S SOUNDTRACK SONGS Part One: Things...www.chrisgregory.org/...Imole��.../...Beneath the Blue...
Example: Google

http://www.google.com

Top 10 Bob Dylan Protest Songs - Ultimate Classic Rock
http://ultimatemetalrock.com/bob-dylan-protest-songs/
Nov 3, 2012 - It's time to discuss hurricanes, wind and rain (and social injustice, naturally), while we talk about our list of Bob Dylan's Top 10 Protest Songs!

5 Bob Dylan Songs That Actually Changed the Course of...
http://www.rollingstone.com/music/artists/bob-dylan/bob-dylan-masters-of-war-2014-
Mar 20, 2015 - Bob Dylan twisted timeless songs and hooked them to the most pressing modern issues. His songs inspired new political and artistic ...

Bob Dylan Protest Songs and the Civil Rights Movement
http://www.rollingstone.com/music/artists/bob-dylan/masters-of-war-2014-
Dec 3, 2014 - The very week that Bob Dylan arrived in New York City, outgoing president Dwight ... Readers' Poll: The 10 Best Protest Songs of All Time.

Bob Dylan, 'Masters of War' - Rolling Stone
http://www.rollingstone.com/music/artists/bob-dylan/masters-of-war-2014-
May 24, 2011 - Journalists and historians often treat Dylan's songs as emblematic of the era and Dylan himself as the quintessential "protest" singer. An image ...

The Politics of Bob Dylan | Red Pepper
http://redpepper.org.uk/the-politics-of-bob-dylan/

The protest songs for which Bob Dylan is most famous were written in a 20-month burst in the early 1960s. Within a year Dylan had turned his back on them - set ...

The Political Bob Dylan | Dissent Magazine
https://www.dissentmagazine.org/online_articles/the-political-bob-dylan-
May 24, 2011 - Journalists and historians often treat Dylan's songs as emblematic of the era and Dylan himself as the quintessential "protest" singer. An image ...

List of anti-war songs - Wikipedia, the free encyclopedia

Many of these songs are considered protest songs, and some have been embraced. Some popular anti-war songs include: ... 1962, "John Brown", Bob Dylan.

Protest and Rock n Roll During the Vietnam War - Student ...
http://www.studentpulse.com/feature/11078/protest-and-rock-n-roll-during-the-vietnam-war-
May 25, 2015 - With that caveat out of the way, here are my twenty picks for best protest songs in order of the year they were released: Bob Dylan, "Blowin' in ...
Example: Google

http://www.google.com

Find needles in haystacks
Example: Google

Bob Dylan covered by black african musicians

List of artists who have covered Bob Dylan songs - Wikipedia
https://en.wikipedia.org/wiki/List_of_artists_who_have_covered_Bob_Dylan

Many major recording artists have covered Dylan's material, some even increasing its... The Black Crowes, When the Night Comes Falling from the Sky.

Bob Dylan - Wikipedia, the free encyclopedia

Bob Dylan (1941) is an American singer-songwriter, author, poet and painter who has been a major influence on popular music for... The Byrds' cover version of 'Mr. Tambourine Man'.

The Freewheelin' Bob Dylan - Wikipedia, the free encyclopedia
https://en.wikipedia.org/wiki/The_Freewheelin%27_Bob_Dylan

The Freewheelin' Bob Dylan album cover... The speed and facility with which Dylan wrote topical songs attracted the attention of other musicians in the... Columbia paired Dylan with a young, African-American jazz producer, Tom Wilson.

Intellectual Property and Information Wealth: Copyright

Perry K. Yu - 2007 - Copyright: musical works. Other musical traditions reflect the influence of jazz and blues... collaboration that incorporates musical styles from three Black South African genres. 'Jimi Hendrix's cover recording of the Bob Dylan song 'All Along the...

How Many Roads: Black America Sings Bob Dylan - Various artists
www.allmusic.com/.../how-many-roads-black-america-sings-bob-dylan

Bob Dylan is not a black artist, not thought of as an R&B/Decca/blues artist, and not even especially thought of as a songwriter often covered by African Americans... compositions have garnered their share of interpretations by black musicians, ...

Olatunji, Babatun - Bob Dylan Who's Who
www.expectingrain.com/docs/whoswho/olatunji.html

What Bob Dylan song references the African musician who sold the most... Some people would also know Olatunji by Santana's booming cover of his song 'Jingo'.... Black people cannot create the slick hair that was so popular at the time if... 10 musicians influenced by Bob Dylan who are better than...

http://www.google.com

List of artists who have covered Bob Dylan songs
From Wikipedia, the free encyclopedia
Bob Dylan (born Robert Allen Zimmerman, May 24, 1941) is an American singer-songwriter, author, poet and painter who has been a major influence on popular music for... The Byrds' cover version of 'Mr. Tambourine Man'.

This article is a list of musicians who have recorded and released their own version of a song written by Dylan.

<table>
<thead>
<tr>
<th>Artist</th>
<th>Song Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>13th Floor Elevators</td>
<td>It's All Over Now, Baby Blue</td>
</tr>
<tr>
<td>54-40</td>
<td>Walkin' Down the Line</td>
</tr>
<tr>
<td>Lee Abramson</td>
<td>Masters of War</td>
</tr>
<tr>
<td>Adele</td>
<td>Make You Feel My Love</td>
</tr>
<tr>
<td>The Atmosphere</td>
<td>Roots of Spanish Leather</td>
</tr>
</tbody>
</table>

Miriam Makeba

Miriam Makeba (4 March 1932 – 9 November 2000), nicknamed Mama Africa, was a South African singer and civil rights activist. In the 1960s, she was the first artist from Africa to popularise African music around the world. She is best known for the song “Fela Pata” first recorded in 1957 and released in the U.S. in 1961. She recorded and branched with many popular artists, such as Harry Belafonte, Paul Simon, and her former husband Hugh Masekela. Makeba campaigned against the South African system of apartheid. The South African government responded by revoking her passport in 1960 and denying her citizenship and right of return in 1963. As the apartheid system crumbled she returned home for the first time in 1990. Makeba died of a heart attack on 9 November 2000 after performing in a concert in Italy organised to support万里キチ替り in its 1987 agreement against the Corridors, a multimedia arts project.
Example: Google

List of artists who have covered Bob Dylan songs - Wikipedia
https://en.wikipedia.org/wiki/List_of_artists_who_have_covered_Bob_Dylan...
Many major recording artists have covered Dylan's material, some even increasing its...who have recorded and released their own version of a song written by Dylan. ... The Black Crowes, When the Night Comes Falling from the Sky.

Cover version - Wikipedia, the free encyclopedia
https://en.wikipedia.org/wiki/Cover_version
The Hendrix version, released six months after Dylan's original, became a Top 10...Musicians now play what they call "cover versions" (the reworking, updating or...The Black Crowes formed in 1990, initially dedicated to reviving 1970s style...

50 Best Bob Dylan Covers of All Time :: Music :: Lists :: Paste
Apr 20, 2009 - I've listened to literally hundreds of Dylan covers over the course of the past week...We chose only one song from each of the artists, though some are mentioned...Joan Osborne - "Man in the Long Black Coat" / Relish

How Many Roads: Black America Sings Bob Dylan - Various...
www.allmusic.com/.../how-many-roads-black-america-sings-bob-dylan....
Find album reviews, stream songs, credits and award information for How Many...Bob Dylan is not a black artist, not thought of as an R&B/soul/blues artist, and...of interpretations by black musicians, and 20 such covers from 1964-1990 were...

These 13 Singers Are the Definitive Cover Artists of Our...
mic.com/13-singers-are-the-definitive-cover-artists-of-our-generation...
Nov 12, 2014 - One of Eric Clapton's most recognizable songs is a Bob Marley cover...Jimi Hendrix played the definitive version of Bob Dylan's "All Along the...

9 Songs that Prove Miley Cyrus Is the Best Cover Artist of...
mic.com/9-songs-that-prove-miley-cyrus-is-the-best-cover-artist-of-ou...
Feb 28, 2014 - Seriously, the Outkast cover is bonkers...Her versions of classic...artists like Dolly Parton, Bob Dylan and others prove not only that Cyrus can...

Strange Brew: Metaphors of Magic and Science in Rock Music
https://books.google.de/books?id=1443650772
Victor Kennedy - 2013 - Social Science
White musicians covered music originally played by black musicians, such as Eric...Clapton's...there are plenty of songs written by white songwriters and re-recorded by black musicians, such as Bob Dylan's "All Along the Watchtower" (1967),...
Example: Google

Main Title Theme (Billy) - Bob Dylan - YouTube
www.youtube.com/watch?v=Za6CYNQYmnl
May 25, 2013 - Uploaded by Random Acts
From the movie and the soundtrack "Pat Garrett & Billy the Kid".
My wife walked down the aisle to this song.

Bob Dylan - Girl from the North Country (Silver Linings ...
www.youtube.com/watch?v=mMgg4-ya3gFw
Feb 6, 2013 - Uploaded by cartronet1
Bob Dylan - Girl from the North Country (Silver Linings Playlist)
... There was a movie with a song by my ...

St. Vincent - Bill Murray Sings Bob Dylan - The Weinstein ...
www.youtube.com/watch?v=OGdZg8yETRM
Oct 3, 2014 - Uploaded by The Weinstein Company
St. Vincent - Bill Murray Sings Bob Dylan - The Weinstein Company ... a truly great film and a great song ...

Bob Dylan: Don't Look Back - Clip - YouTube
www.youtube.com/watch?v=VY4f9Q-KjDE
Oct 21, 2009 - Uploaded by Cinedigm
Wanting more than just a concert film, Pennabaker decided to seek out both the ... YouTube is the ...

Top 10 Bob Dylan Songs - YouTube
www.youtube.com/watch?v=65_uocuGODM
Nov 13, 2010 - Uploaded by RetroTop10
Also check out my Top 10 Bob Dylan Albums video, ... MEMBER
AND CURATOR OF INTERNATIONAL FILM ...

Bob Dylan - Knocking on Heavens door (Movie version ...
www.youtube.com/watch?v=LAoP2Q-Egc8
Jan 11, 2014 - Uploaded by Boby Max
Bob Dylan knocking on heavens door original version 1973 Pat Garrett and Billy the Kid Full song Movie ...

Bob Dylan - The Man in Me (The Big Lebowski version ...
www.youtube.com/watch?v=ss110lORHSw
Dec 18, 2008 - Uploaded by MUre114
Bob Dylan - The man in me (The Big Lebowski version) opening credits ... movie intro extended to be a ...
Example: Google

Implicit search: automatically generated recommendations

Bob Dylan - Knocking on Heavens door (Movie version 1973 - Pat Garrett and Billy the Kid)
Beyond (Standard) Google: From Information to Knowledge

Answer „knowledge queries“ (by researchers, journalists, market & media analysts, etc.) such as:

- Politicians who are also scientists?
- European composers who have won film music awards?
- African singers who covered Dylan songs?
- Relationships between John Lennon, Billie Holiday, Heath Ledger, King Kong?
- Enzymes that inhibit HIV? Influenza drugs for teens with high blood pressure?
- Photos of Buddhist temples at lakes with snow-covered mountains

.....
Information Retrieval (IR) ≈ Search Engine Technology

Advanced functionality:

Different ways of asking
natural-language questions (QA):
• factual
• opinions
• how-to

Different ways of answering
find entities in contents: people, places, products, ...

Different kinds of digital contents
• semi-structured or streaming data
• multimodal contents (images, videos, ...)
This town is known as "Sin City" & its downtown is "Glitter Gulch"

This American city has two airports named after a war hero and a WW II battle

Q: Sin City?
   → movie, graphical novel, nickname for city, ...

A: Vegas? Strip?
   → Vega (star), Suzanne Vega, Vincent Vega, Las Vegas, ...
   → comic strip, striptease, Las Vegas Strip, ...

IBM Journal of R&D 56(3/4), 2012: This is Watson.
Demos

Question Answering (natural questions)

• http://www.wolframalpha.com

Semantic Search (crisper answers)

• http://broccoli.cs.uni-freiburg.de/
• http://stics.mpi-inf.mpg.de

Image Search and Image-Text Tasks (more data)

• http://www.bing.com/images/
• http://www.robots.ox.ac.uk/~vgg/research/on-the-fly/
• http://cs.stanford.edu/people/karpathy/deepimagesent/generationdemo/
• http://wang.ist.psu.edu/IMAGE/
When and where was Bob Dylan born?

Input interpretation:

Bob Dylan basic information

Result:

<table>
<thead>
<tr>
<th>full name</th>
<th>Robert Allen Zimmerman</th>
</tr>
</thead>
<tbody>
<tr>
<td>date of birth</td>
<td>Saturday, May 24, 1941 (age: 74 years)</td>
</tr>
<tr>
<td>place of birth</td>
<td>Duluth, Minnesota, United States</td>
</tr>
</tbody>
</table>
Who was US president when Bob Dylan was born?

Franklin D. Roosevelt

<table>
<thead>
<tr>
<th>official position</th>
<th>President (32nd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>country</td>
<td>United States</td>
</tr>
<tr>
<td>political affiliation</td>
<td>Democratic</td>
</tr>
<tr>
<td>start date</td>
<td>04. March 1933</td>
</tr>
<tr>
<td>end date</td>
<td>12. April 1945</td>
</tr>
<tr>
<td>duration of leadership</td>
<td>12 years 1 month 8 days</td>
</tr>
</tbody>
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Who was US president in Bob Dylan’s birth year?

Result:

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<tr>
<td>political affiliation</td>
<td>Democratic</td>
</tr>
<tr>
<td>start date</td>
<td>04. March 1933 (82 years 7 months 16 days ago)</td>
</tr>
<tr>
<td>end date</td>
<td>12. April 1945 (70 years 6 months 8 days ago)</td>
</tr>
<tr>
<td>duration of leadership</td>
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</table>
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</table>
Who was chancellor of Germany when Angela Merkel was born?

Konrad Adenauer

<table>
<thead>
<tr>
<th>official position</th>
<th>Chancellor</th>
</tr>
</thead>
<tbody>
<tr>
<td>start date</td>
<td>16. September 1949 (60 years 26 days ago)</td>
</tr>
<tr>
<td>end date</td>
<td>16. October 1963 (45 years 11 months 27 days ago)</td>
</tr>
<tr>
<td>duration</td>
<td>14 years 30 days</td>
</tr>
</tbody>
</table>
Who was the spouse of the chancellor of Germany when Angela Merkel was born?
Which Bob Dylan songs are featured in films?

Using closest Wolfram|Alpha interpretation: bob dylan songs

More interpretations: featured

Assuming "bob dylan" is a person | Use as a music act or a music album instead

Input interpretation:

music works with composer Bob Dylan (musician)
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Internet Image Search

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Buddhist temple
Internet Image Search

Buddhist temple

http://www.bing.com/images/
Internet Image Search

Buddhist temple at lake

http://www.bing.com/images/
Internet Image Search

http://www.bing.com/images/

Buddhist temple at lake in front of snow mountain
Internet Image Search

http://www.bing.com/images/?view=gallery&q=buddhist+temple+at+lake+in+front+of+snow+mountain
Internet Image Search

http://www.google.com