

DD2476: Search Engines and Information Retrieval Systems

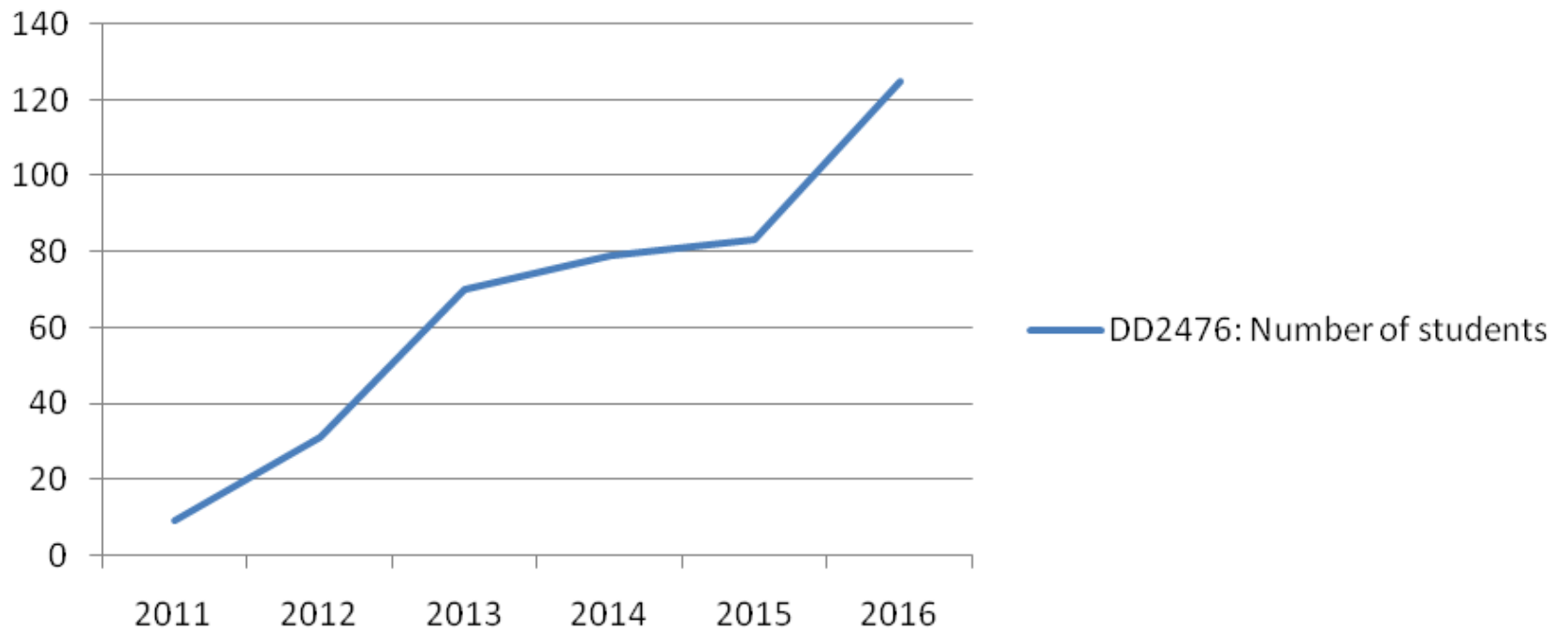
Johan Boye*

KTH

Lecture 1

* Many slides inspired by Manning, Raghavan and Schütze

DD2476: Number of students



Information Retrieval (IR)



- Finding **relevant information**
 - in **unstructured large** sets of material (usually **documents**),
 - satisfying an **information need** of the user.

What IR is not

- An IR system is **not** a database system
- Databases
 - are **structured**
 - allow for **exact** and **deterministic** search
- IR is **inexact** in several regards:
 - information need, search query, relevance

Example IR system

Webb

Bilder

Videoklipp

Kartor

Nyheter

Utforska

403 000 RESULTAT

Datum ▼

Språk ▼

Region ▼

Bilder av **medieval hygiene**

bing.com/images



Se fler bilder på **medieval hygiene**

Middle-Ages: **Middle Ages Hygiene** Översätt den här sidan

www.lordsandladies.org/middle-ages-hygiene.htm ▼

Middle Ages Hygiene. Interesting facts and information about life and the lives of men and women in the **Medieval** period of the Middle Ages

Medieval Hygiene - **Medieval** Life and Times Översätt den här sidan

www.medieval-life-and-times.info/medieval-life/medieval-hygiene.htm ▼

Medieval Hygiene . **Medieval** Monks & Crusaders. Step back into history get **Medieval** facts and information about life for people who lived in **Medieval** Times

History Undressed: History of **Hygiene**: Bathing, Teeth ... Översätt den här sidan

www.historyundressed.com/2008/07/history-of-hygiene-bathing-teeth.html ▼

2008-07-14 · Labels: bathing, cleaning teeth, copper tub, deodorizing, elizabethan, garderobe, history of **hygiene**, **medieval**, nose gay, privy, regency. 48 comments:

Example IR system

WestlawNext™

powered by WestSearch™

WESTLAWNEXT | Folders ▾ | History ▾ | Alerts | Sign Off

Minnesota ▾ SEARCH advanced New Folder (0)

VIEW: <<

Overview 13

Cases 2,583

Statutes 178

Regulations 31

Administrative Decisions & Guidance 49

Trial Court Orders 19

Secondary Sources 10,000

Forms 111

Briefs 433

Trial Court Documents 714

Expert Materials 15

Jury Verdicts & Settlements 4

Proposed & Enacted Legislation 84

Proposed & Adopted Regulations 0

Arbitration Materials 0

All Results 14,221

NARROW:
Select Multiple Filters

Cases (2,583)

1-20 ▶ Sort by: Relevance ▾ 🔍 ⌵ 📄 📧

☐ Select all items | No items selected

☐ 1. State v. Moss
Supreme Court of Minnesota. | July 14, 1978 | 269 N.W.2d 732

Defendant was convicted before the District Court, Hennepin County, William Posten, J., of aggravated robbery, and he appealed. The Supreme Court held that: (1) where defendant under...

...[2][3] Reading s 609.02, subd. 6 in connection with the armed robbery portion of the aggravated robbery statute, s 609.245, we think it is clear that a defendant who has either the first or second type of weapon on his person during the robbery commits armed robbery whether or not he uses the weapon or intends to use it...

...Now, the difference between Simple Robbery and Aggravated Robbery is essentially this: In an Aggravated Robbery, the State must show that a dangerous weapon was used, and in this case it would be a scissors....

☐ 2. State v. Hines
Court of Appeals of Minnesota. | September 04, 1984 | 354 N.W.2d 91

Defendant was convicted in the District Court, Ramsey County, James M. Lynch, J., of simple robbery, burglary, theft, and two counts of receiving stolen property, and he appealed. ...

... The Court of Appeals, Wozniak, J., held that: (1) admission of evidence of three prior burglaries committed by defendant, to show identity and common plan or scheme, was not reversible error; (2) defendant could not be convicted of robbery and also be convicted of theft from the person robbed; (3) defendant could not be convicted of robbery and also be convicted of receiving property stolen in the robbery, where the receiving stolen property count was based on possession of the property one day after the robbery; but (4) defendant could be convicted both of robbery and of receiving property stolen in the robbery...

RELATED DOCUMENTS

Secondary Sources

Admissibility, in robbery prosecution, of evidence of other robberies

42 A.L.R.2d 854 (Originally published in 1955)

The ALR databases are made current by the weekly addition of relevant new cases.

American Law Reports ALR2d

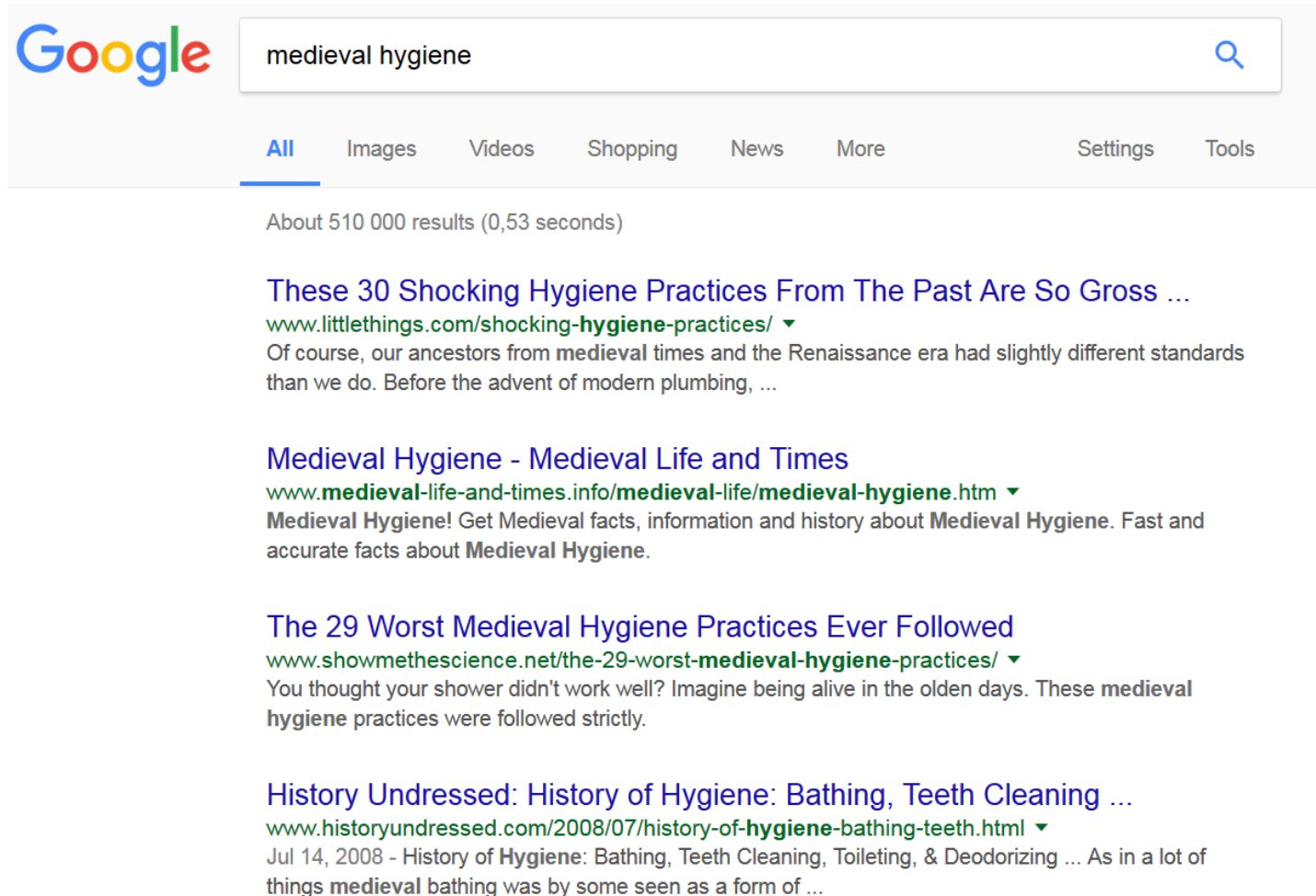
...Defendant's alleged robberies were sufficiently similar to charged robbery to make alleged robberies admissible to show identity; evidence showed that defendant used a paper bag to hide his right hand during alleged robberies and charged robbery, that defendant used his left hand to take money from the registers during alleged robberies and charged robbery, that defendant employed threats or actual violence to force employee compliance during alleged robberies and charged robbery...

Key idea: Inverted index

INDEX

- ABC, 164, 321ⁿ
- academic journals, 262, 280–82
- Adobe eBook Reader, 148–53
- advertising, 36, 45–46, 127, 145–46, 167–68, 321ⁿ
- Africa, medications for HIV patients in, 257–61
- Agee, Michael, 223–24, 225
- agricultural patents, 313ⁿ
- Aibo robotic dog, 153–55, 156, 157, 160
- AIDS medications, 257–60
- air traffic, land ownership vs., 1–3
- Akerlof, George, 232
- Alben, Alex, 100–104, 105, 198–99, 295, 317ⁿ
- alcohol prohibition, 200
- Alice's Adventures in Wonderland* (Carroll), 152–53
- Anello, Douglas, 60
- animated cartoons, 21–24
- antiretroviral drugs, 257–61
- Apple Corporation, 203, 264, 302
- architecture, constraint effected through, 122, 123, 124, 318ⁿ
- archive.org, 112
 - see also* Internet Archive
- archives, digital, 108–15, 173, 222, 226–27
- Aristotle, 150
- Armstrong, Edwin Howard, 3–6, 184, 196
- Arrow, Kenneth, 232
- art, underground, 186
- artists:
 - publicity rights on images of, 317ⁿ
 - recording industry payments to, 52, 58–59, 74, 195, 196–97, 199, 301, 329ⁿ–30ⁿ

Another key idea: Ranking



The image is a screenshot of a Google search interface. At the top left is the Google logo. To its right is a search bar containing the text "medieval hygiene" and a magnifying glass icon. Below the search bar is a horizontal menu with tabs: "All", "Images", "Videos", "Shopping", "News", "More", "Settings", and "Tools". The "All" tab is selected and underlined. Below the menu, the search results are displayed. The first result is titled "These 30 Shocking Hygiene Practices From The Past Are So Gross ..." in blue, with a green URL "www.littlethings.com/shocking-hygiene-practices/" and a green downward arrow. The snippet below the title reads: "Of course, our ancestors from medieval times and the Renaissance era had slightly different standards than we do. Before the advent of modern plumbing, ...". The second result is titled "Medieval Hygiene - Medieval Life and Times" in blue, with a green URL "www.medieval-life-and-times.info/medieval-life/medieval-hygiene.htm" and a green downward arrow. The snippet below the title reads: "Medieval Hygiene! Get Medieval facts, information and history about Medieval Hygiene. Fast and accurate facts about Medieval Hygiene.". The third result is titled "The 29 Worst Medieval Hygiene Practices Ever Followed" in blue, with a green URL "www.showmethescience.net/the-29-worst-medieval-hygiene-practices/" and a green downward arrow. The snippet below the title reads: "You thought your shower didn't work well? Imagine being alive in the olden days. These medieval hygiene practices were followed strictly.". The fourth result is titled "History Undressed: History of Hygiene: Bathing, Teeth Cleaning ..." in blue, with a green URL "www.historyundressed.com/2008/07/history-of-hygiene-bathing-teeth.html" and a green downward arrow. The snippet below the title reads: "Jul 14, 2008 - History of Hygiene: Bathing, Teeth Cleaning, Toileting, & Deodorizing ... As in a lot of things medieval bathing was by some seen as a form of ...".

Google

medieval hygiene

All Images Videos Shopping News More Settings Tools

About 510 000 results (0,53 seconds)

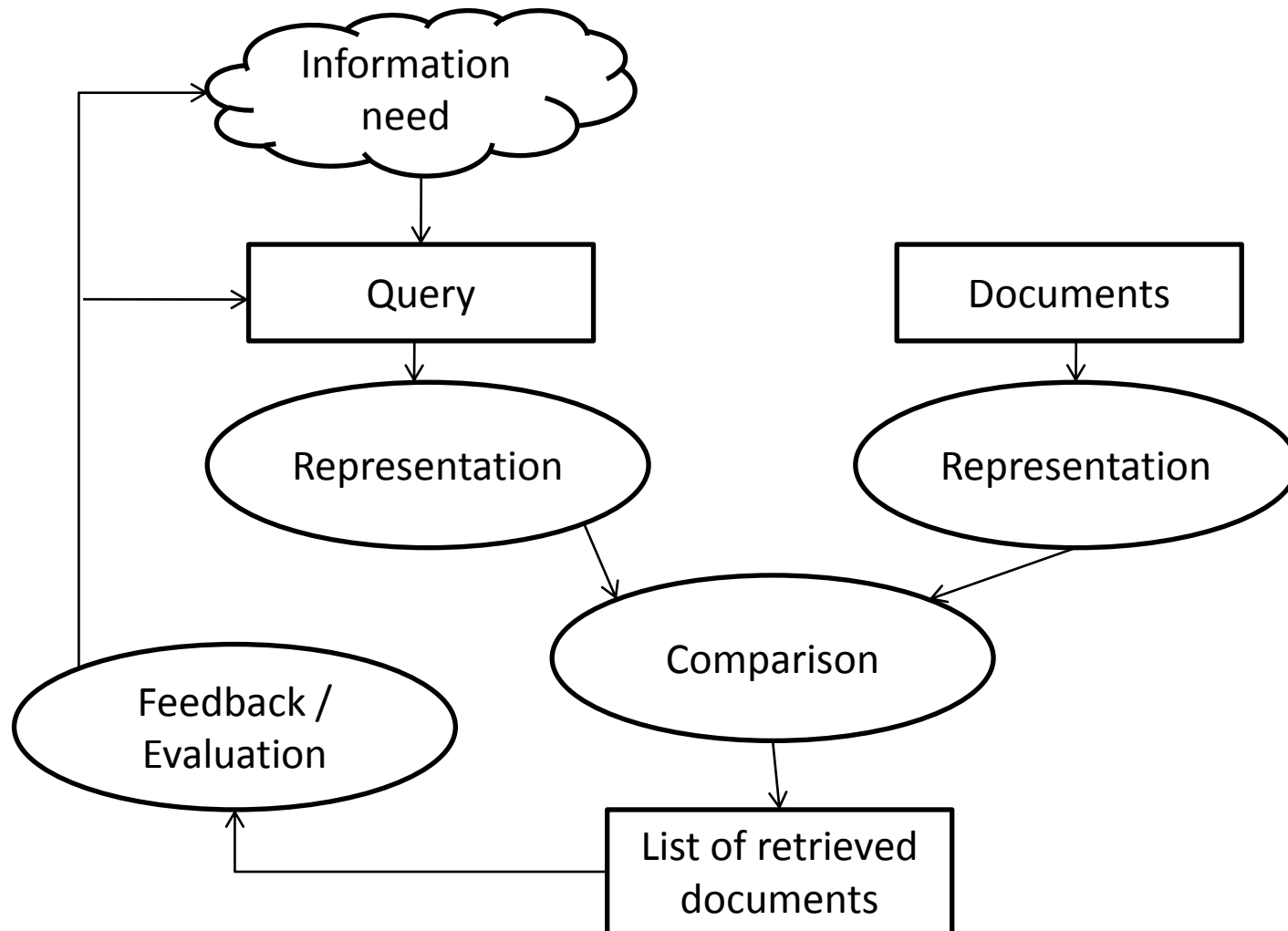
These 30 Shocking Hygiene Practices From The Past Are So Gross ...
www.littlethings.com/shocking-hygiene-practices/ ▼
Of course, our ancestors from medieval times and the Renaissance era had slightly different standards than we do. Before the advent of modern plumbing, ...

Medieval Hygiene - Medieval Life and Times
www.medieval-life-and-times.info/medieval-life/medieval-hygiene.htm ▼
Medieval Hygiene! Get Medieval facts, information and history about Medieval Hygiene. Fast and accurate facts about Medieval Hygiene.

The 29 Worst Medieval Hygiene Practices Ever Followed
www.showmethescience.net/the-29-worst-medieval-hygiene-practices/ ▼
You thought your shower didn't work well? Imagine being alive in the olden days. These medieval hygiene practices were followed strictly.

History Undressed: History of Hygiene: Bathing, Teeth Cleaning ...
www.historyundressed.com/2008/07/history-of-hygiene-bathing-teeth.html ▼
Jul 14, 2008 - History of Hygiene: Bathing, Teeth Cleaning, Toileting, & Deodorizing ... As in a lot of things medieval bathing was by some seen as a form of ...

The IR process



Evaluation

- IR is an empirical discipline; it is important to **evaluate** the results

- Precision

$$p = \frac{|ret \cap rel|}{|ret|}$$

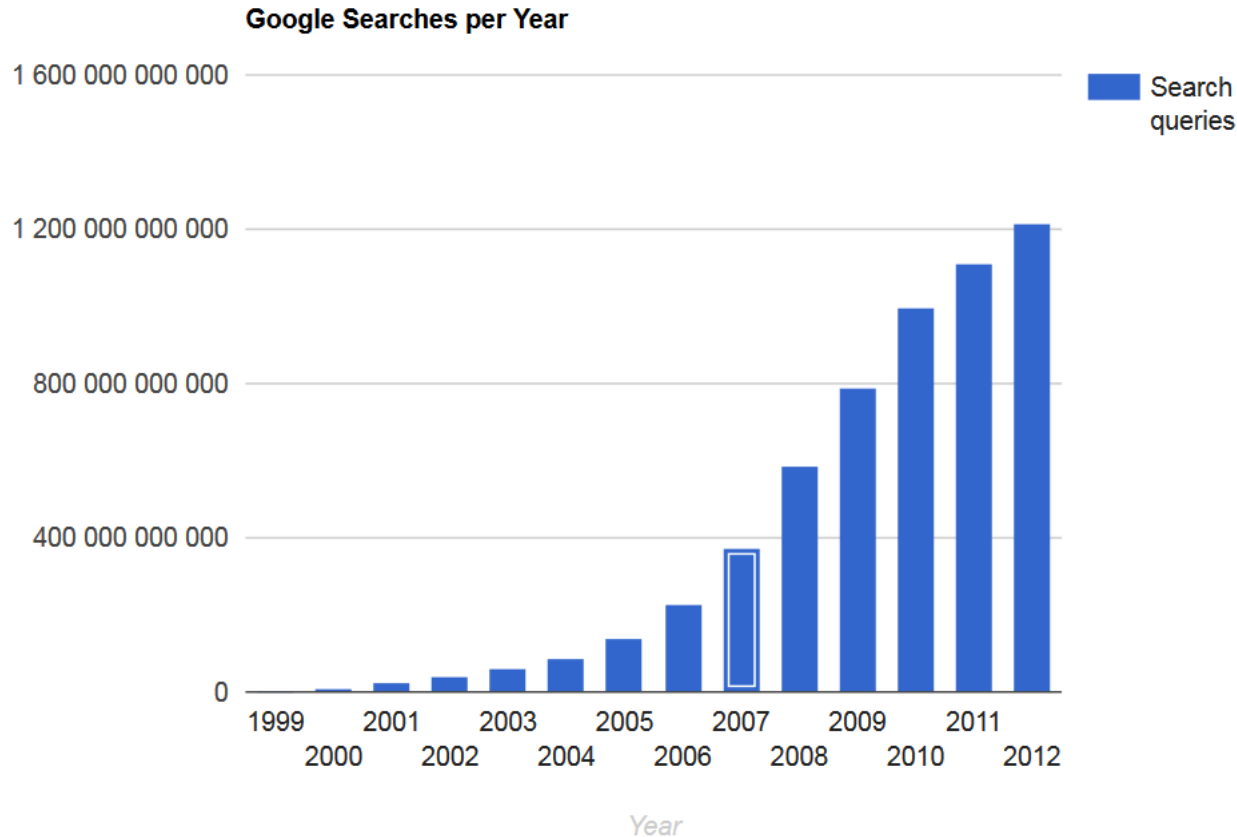
- Recall

$$r = \frac{|ret \cap rel|}{|rel|}$$

where $|rel|$ = number of relevant documents

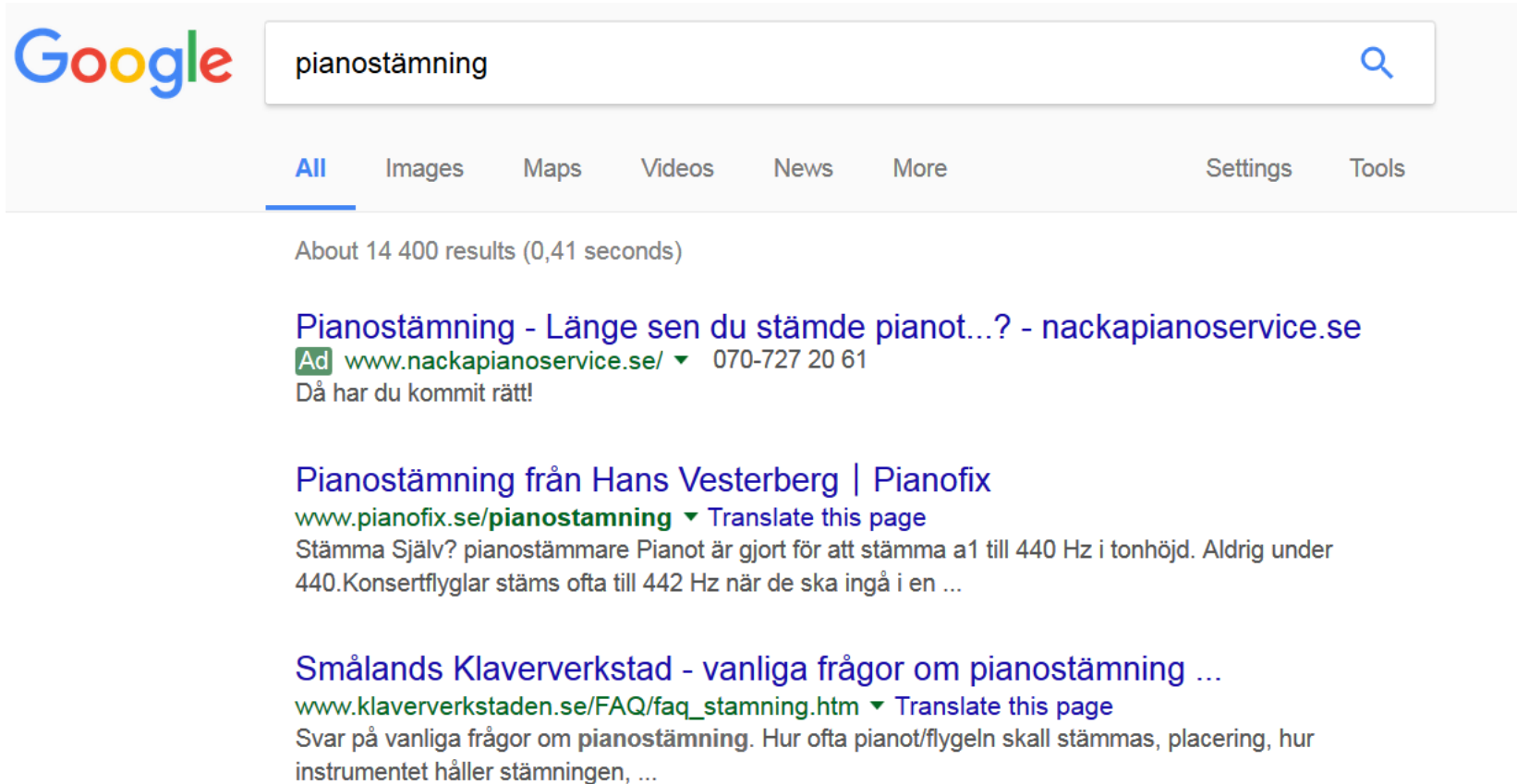
$|ret|$ = number of returned documents

IR is now an indispensable tool...



Source: <http://www.internetlivestats.com/google-search-statistics/>

It can be essential to get a high ranking...



The image is a screenshot of a Google search interface. At the top left is the Google logo. To its right is a search bar containing the text 'pianostämning'. Below the search bar are navigation links: 'All', 'Images', 'Maps', 'Videos', 'News', 'More', 'Settings', and 'Tools'. Below these links, it says 'About 14 400 results (0,41 seconds)'. The first search result is an advertisement for 'Pianostämning - Länge sen du stämde pianot...? - nackapianoservice.se'. It includes a green 'Ad' label, the website URL, a phone number '070-727 20 61', and the text 'Då har du kommit rätt!'. The second search result is for 'Pianostämning från Hans Vesterberg | Pianofix', with the URL 'www.pianofix.se/pianostamning' and a 'Translate this page' link. The third search result is for 'Smålands Klaververkstad - vanliga frågor om pianostämning ...', with the URL 'www.klaververkstaden.se/FAQ/faq_stamning.htm' and a 'Translate this page' link. The text of the third result discusses piano tuning frequency and placement.

Google

pianostämning

All Images Maps Videos News More Settings Tools

About 14 400 results (0,41 seconds)

Pianostämning - Länge sen du stämde pianot...? - nackapianoservice.se
Ad www.nackapianoservice.se/ ▼ 070-727 20 61
Då har du kommit rätt!

Pianostämning från Hans Vesterberg | Pianofix
www.pianofix.se/pianostamning ▼ Translate this page
Stämma Själv? pianostämmare Pianot är gjort för att stämma a1 till 440 Hz i tonhöjd. Aldrig under 440. Konserthflyglar stäms ofta till 442 Hz när de ska ingå i en ...

Smålands Klaververkstad - vanliga frågor om pianostämning ...
www.klaververkstaden.se/FAQ/faq_stamning.htm ▼ Translate this page
Svar på vanliga frågor om pianostämning. Hur ofta pianot/flygeln skall stämmas, placering, hur instrumentet håller stämningen, ...

Some say IR is influencing our thoughts...

politics sport football opinion culture business lifestyle fashion environment
europe US americas asia australia africa middle east cities development

Angela Merkel: internet search engines are 'distorting perception'

A lack of transparency about algorithms is endangering debate, German chancellor tells media conference



Source: The Guardian (US edition), Oct 27, 2016

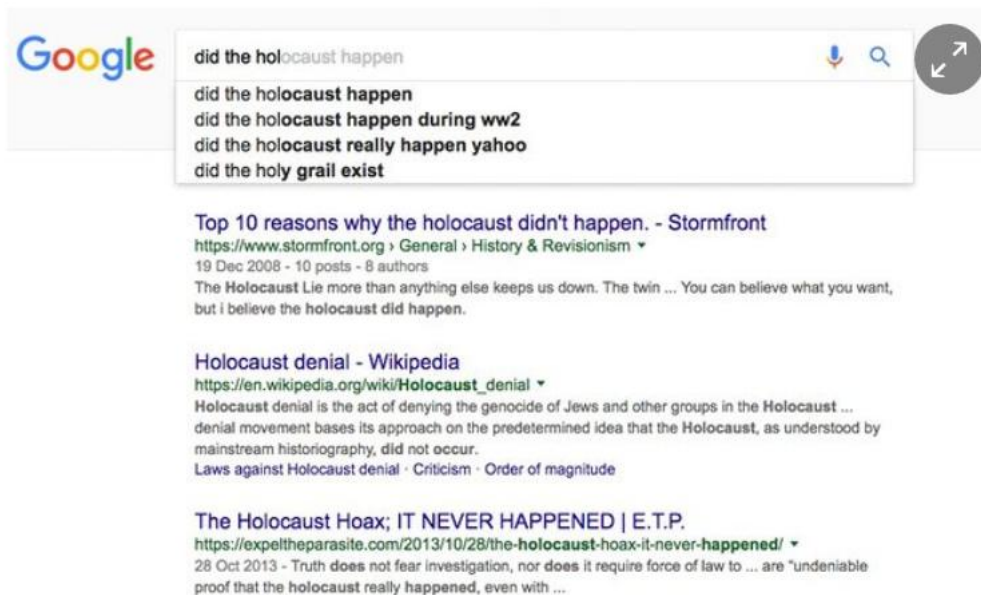
columnists

Google is not 'just' a platform. It frames, shapes and distorts how we see the world

Carole Cadwalladr



Last week, we reported how extremist sites 'game' the search engine, boosting their propaganda. In response, the web giant appears to have modified some results, but would like us not to notice



Did the holocaust happen? Google search for Carole Cadwalladr Photograph: Google

Source: The Guardian (US edition), Dec 11, 2016

Morning Mix

Google faulted for racial bias in image search results for black teenagers

By Ben Guarino June 10



(Google Images)

Most Read

- 1 A treasure hunt of sunken ships can't leave jail where it is
- 2 People were act weird.' Off-duty sensing the rea packed restaur lethal gas
- 3 Video shows off dragging woma flight after boar
- 4 Police: NYC Mus bias report is fa
- 5 A Saudi woman photo of herself hijab. Police ha her.

Our Online Games

Play right from this pag



Source: Washington Post, Jun 10, 2016

Facebook fires trending team, and algorithm without humans goes crazy

Module pushes out false story about Fox's Megyn Kelly, offensive Ann Coulter headline and a story link about a man masturbating with a McDonald's sandwich

● [I worked on Facebook's Trending team - the most toxic work experience of my life](#)



Source: The Guardian (US edition), Aug 29, 2016

Business

Why Facebook and Google are struggling to purge fake news



Mark Zuckerberg, chief executive and founder of Facebook, speaks at the Techonomy conference in Half Moon Bay, Calif., on Nov. 10. (David Paul Morris/Bloomberg News)

By **Elizabeth Dwoskin, Caitlin Dewey and Craig Timberg** November 15

Most Read

- 1 A Trump team member just compared climate science to the flat-Earth theory 
- 2 Federal Reserve raises interest rates for second time in a decade 
- 3 Scientists are frantically copying U.S. climate data, fearing it might vanish under Trump 
- 4 A year after food safety scares, Chipotle has a new set of problems 
- 5 Trump transition says request for names of climate scientists was 'not authorized' 

Market Watch

DJIA **-0.6%** NASDAQ **-0.5%**

Co. name or symbol

Get qu

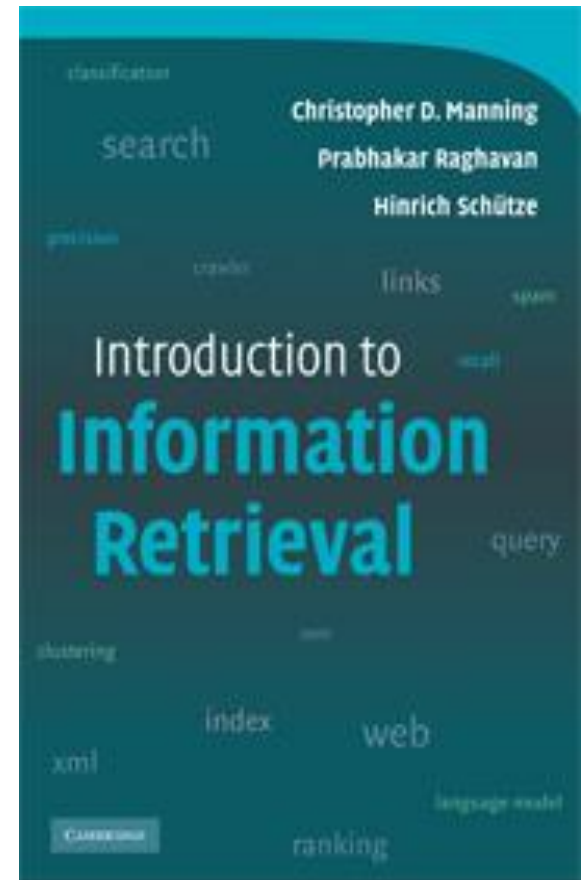
Source: Washington Post, Nov 15, 2016

IR: A hot topic

- Competence in IR + Natural Language Processing + Machine Learning is in high demand
 - nice career opportunities
- IR influences the lives of many people
 - information acquisition
 - decision making
 - info wars

Literature

- C. D. Manning, P. Raghavan and H. Schütze, *Introduction to Information Retrieval*, Cambridge University Press, 2008
 - available as free pdf
 - see course page



Contents

- First part of the course (period 3):
 - we will cover Chapters 1-4, 6-9 and 21.
 - 3 individual implementation assignments
 - allows you to learn IR basics
- Second part of the course (period 4):
 - group project (~4 persons/group)
 - you will be placed into a group
 - allows you to go more into depth in some topic(s)

Examination

- Three individual assignments (ECTS 6, A-F)
- Reviewed in three sessions:
 - Tuesday 7 Feb, 13-18 in Grön (*Assignment 1, ch 1-4*)
 - Monday 6 Mar, 10-15 in Grön (*Assignment 2, ch 6-8, 21*)
 - Tuesday 28 Mar, 13-18 in Grön (*Assignment 3, ch 9*)
- Poster presentation of final project (ECTS 3, A-F):
 - Friday 19 May 9-12

Grading

- Grades on the individual assignments are cumulative
 - implement this much for an D, implement some more for a C, etc.
- Missed deadlines → deduction in grade

Grading

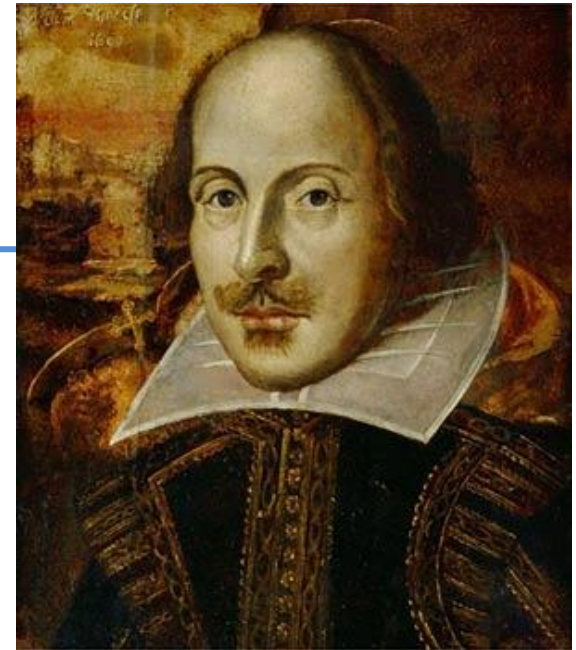
Computer Assignments	Project					
		A	B	C	D	E
	A	A	A	B	B	B
	B	B	B	B	C	C
	C	B	C	C	C	D
	D	C	C	D	D	D
	E	D	D	D	E	E

Honor code

- The individual assignments are individual:
 - Don't look at somebody else's code
 - Don't show your code to anyone
 - Don't post your code online
- Final project:
 - You are welcome to use software libraries etc., but cite it in your report

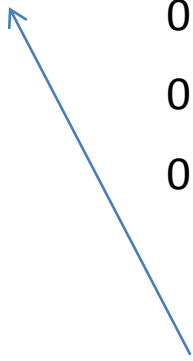
A first IR example

- Which plays by Shakespeare contain the words "**Brutus**" AND "**Caesar**" but NOT "**Calpurnia**"?
- Suggestion:
 - Search for "**Brutus**" in all plays → resulting set R1
 - Search for "**Caesar**" i R1 → resulting set R2
 - Search for R2 and return plays that do **not** contain "**Calpurnia**"
- Is there something wrong with this solution?



Term-document matrix

	Antony and Cleopatra	Julius Caesar	Tempest	Hamlet	Othello	Macbeth
Antony	1	1	0	0	0	1
Brutus	1	1	0	1	0	0
Caesar	1	1	0	1	1	1
Calpurnia	0	1	0	0	0	0
Cleopatra	1	0	0	0	0	0
mercy	1	0	0	1	1	1
citizen	1	1	0	0	1	0



1 if the play contains
the term, 0 otherwise

Boolean search

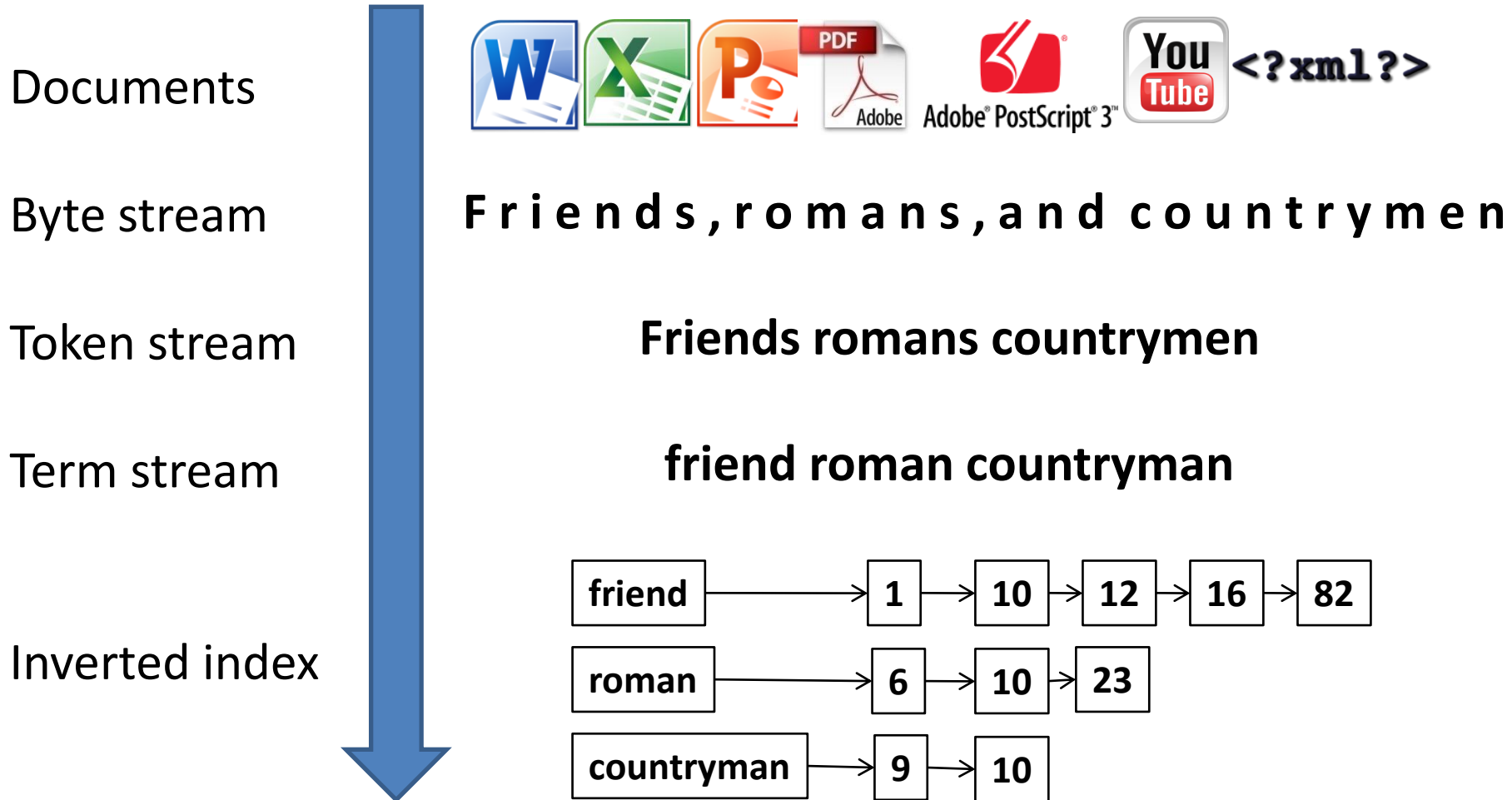
- The terms can be represented by **bit vectors**:
 - Brutus: 110100, Caesar: 110111, Calpurnia: 010000, NOT Calpurnia 101111
 - Bitwise AND: $110100 \& 110111 \& 101111 = 100100$
 - The answer is the first and fourth column of the matrix:
Antony and Cleopatra and **Hamlet**



Boolean search: Advantages

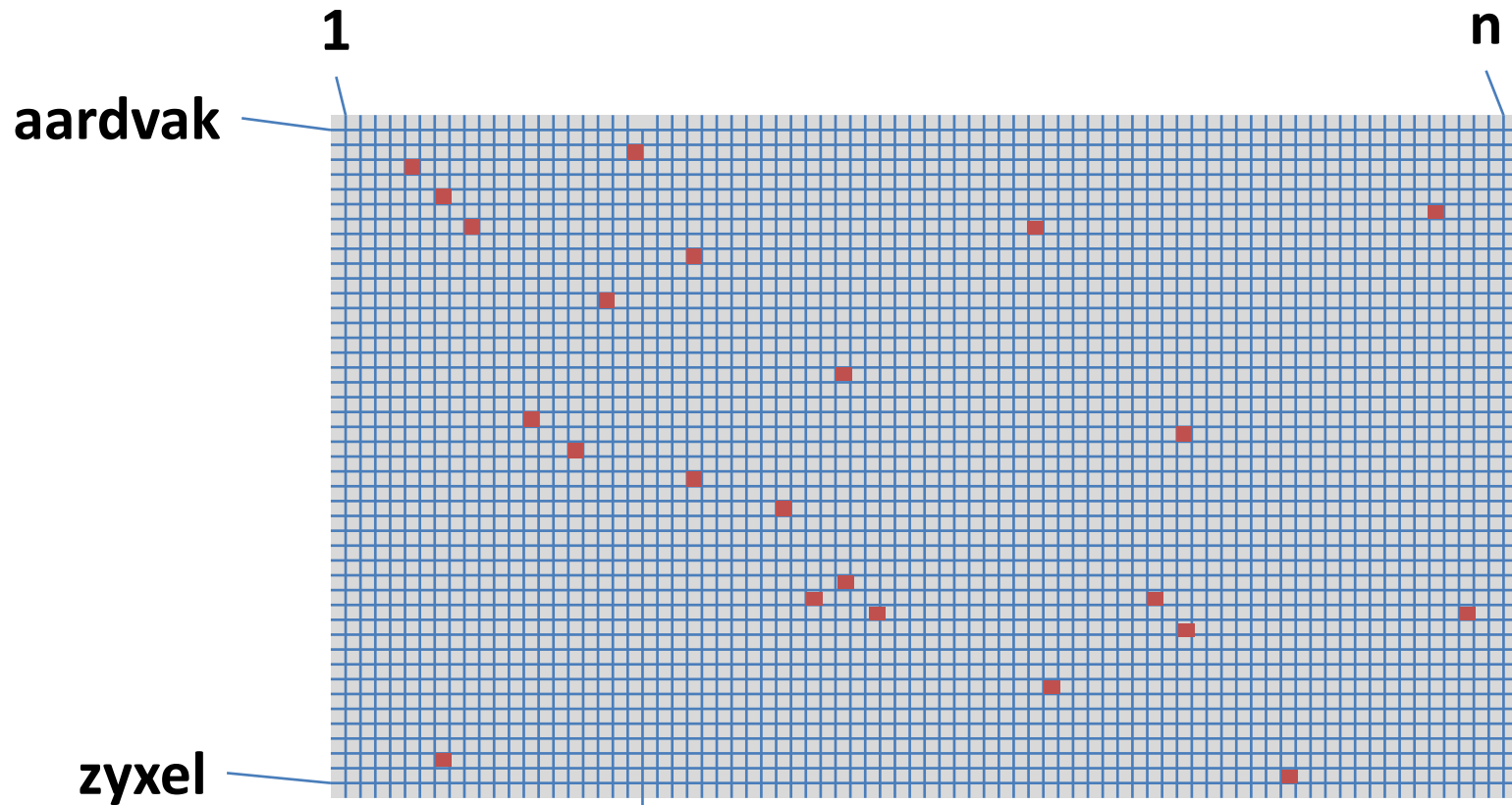
- Simple model to understand and implement
- A Boolean query has a (a mathematically) precise meaning
- Works well for **expert users** working with a **well-defined** document collection (e.g. librarians)

Indexing pipeline



The index

- Conceptually: the **term-document matrix**



Practical indexing

- We need a **sparse matrix representation**.
- In the computer assignments we use:
 - a **hashtable** for the dictionary
 - **sorted linked lists** for the rows
- Rows are called **postings lists**.

One-word queries

denmark

- Return all the documents in which '**denmark**' appears.

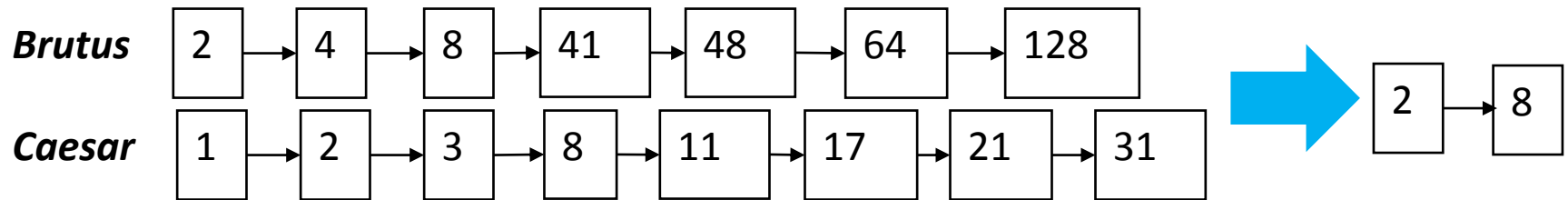
Multi-word queries

copenhagen denmark

- **Intersection** query
- **Phrase** query
- **Union** query

Intersection

- Walk through two postings lists simultaneously



- Runs in $O(n+m)$, where n, m are the lengths of the lists

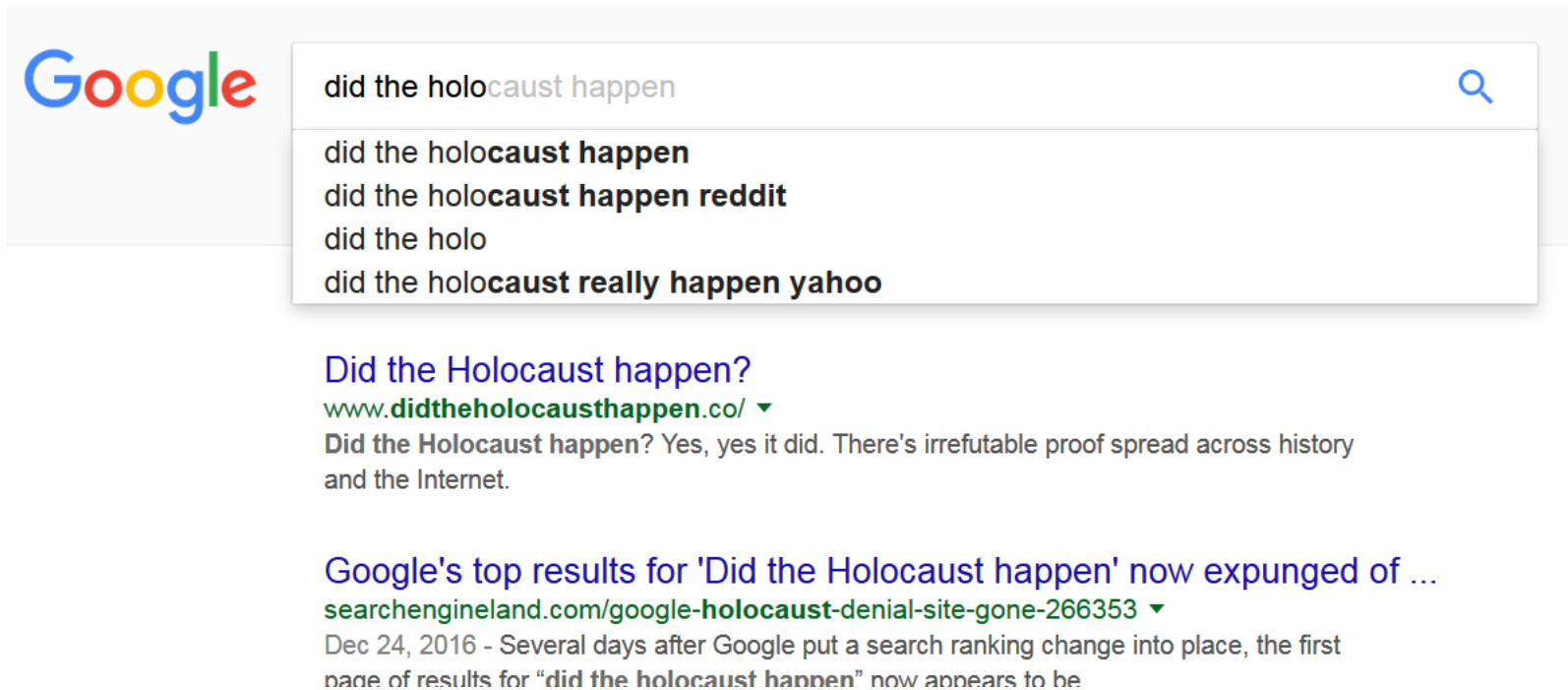
Boolean search: Problems

- Many users have difficulties formulating search queries
- Often returns **too many** or **too few** results
 - "zyxel P-660h" → 192 000 results
 - "zyxel P-660h" "no card found" → 0 results
- Requires skill to formulate a search query returning a manageable number of results
- **No ranking** of results
- All terms equally important

Extensions

- A search engine needs some extensions to be truly useful:
 - query completion
 - spell checking
 - NLP: treating synonyms, inflections, derivations, compound words, etc.
 - clustering

Query completion



The image is a screenshot of a Google search interface. On the left is the Google logo. To its right is a search bar containing the text "did the holocaust happen". A magnifying glass icon is at the end of the search bar. Below the search bar is a dropdown menu with four suggestions: "did the holocaust happen", "did the holocaust happen reddit", "did the holo", and "did the holocaust really happen yahoo". Below the suggestions, the first search result is displayed. It has a title "Did the Holocaust happen?" in blue, a green URL "www.didtheholocausthappen.co/" with a downward arrow, and a snippet of text: "Did the Holocaust happen? Yes, yes it did. There's irrefutable proof spread across history and the Internet." The second search result is also displayed. It has a title "Google's top results for 'Did the Holocaust happen' now expunged of ..." in blue, a green URL "searchengineland.com/google-holocaust-denial-site-gone-266353" with a downward arrow, and a snippet of text: "Dec 24, 2016 - Several days after Google put a search ranking change into place, the first page of results for 'did the holocaust happen' now appears to be".

Google

did the holocaust happen

did the holocaust happen

did the holocaust happen reddit



did the holo

did the holocaust really happen yahoo

Did the Holocaust happen?
www.didtheholocausthappen.co/ ▼
Did the Holocaust happen? Yes, yes it did. There's irrefutable proof spread across history and the Internet.

Google's top results for 'Did the Holocaust happen' now expunged of ...
searchengineland.com/google-holocaust-denial-site-gone-266353 ▼
Dec 24, 2016 - Several days after Google put a search ranking change into place, the first page of results for "did the holocaust happen" now appears to be

Spell checking




[All](#) [Images](#) [Videos](#) [News](#) [Books](#) [More](#) [Settings](#) [Tools](#)

About 12 700 000 results (0.28 seconds)

Showing results for **information retrieval**
Search instead for **information retrieval**

Information retrieval (IR) is the activity of obtaining **information** resources relevant to an **information** need from a collection of **information** resources. Searches can be based on full-text or other content-based indexing.

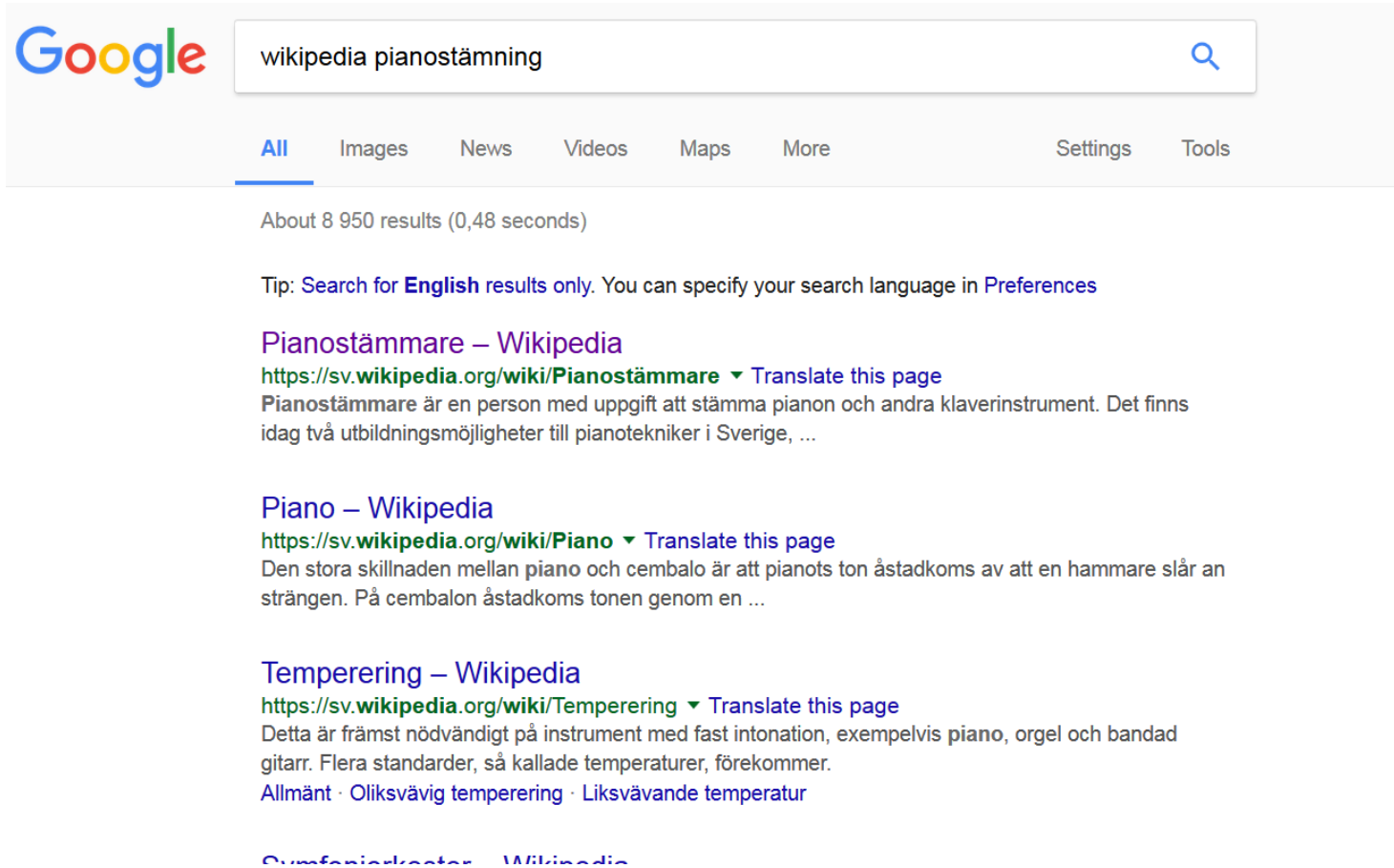
[Information retrieval - Wikipedia](https://en.wikipedia.org/wiki/Information_retrieval)
https://en.wikipedia.org/wiki/Information_retrieval



The diagram illustrates the Information Retrieval (IR) process, divided into two main phases: 'Preparation of the Search' and 'With Search the User's Request'. The 'Preparation' phase includes 'Indexing' (which involves 'Document Analysis' and 'Indexing') and 'Retrieval' (which involves 'Query Formulation' and 'Query Execution'). The 'With Search' phase includes 'Query Formulation' (which involves 'Query Formulation' and 'Query Execution') and 'Query Execution' (which involves 'Query Execution' and 'Query Execution').

About this result • Feedback

Natural Language Processing



The image shows a Google search interface. The search bar contains the text "wikipedia pianostämning". Below the search bar, there are tabs for "All", "Images", "News", "Videos", "Maps", and "More". The "All" tab is selected. To the right of the tabs are links for "Settings" and "Tools". Below the tabs, it says "About 8 950 results (0,48 seconds)". A tip is displayed: "Tip: Search for **English** results only. You can specify your search language in [Preferences](#)". The first search result is titled "Pianostämmare – Wikipedia" with a URL "https://sv.wikipedia.org/wiki/Pianostämmare" and a link to "Translate this page". The snippet for this result reads: "Pianostämmare är en person med uppgift att stämma pianon och andra klaverinstrument. Det finns idag två utbildningsmöjligheter till pianotekniker i Sverige, ...". The second result is titled "Piano – Wikipedia" with a URL "https://sv.wikipedia.org/wiki/Piano" and a link to "Translate this page". The snippet reads: "Den stora skillnaden mellan piano och cembalo är att pianots ton åstadkoms av att en hammare slår an strängerna. På cembalon åstadkoms tonen genom en ...". The third result is titled "Temperering – Wikipedia" with a URL "https://sv.wikipedia.org/wiki/Temperering" and a link to "Translate this page". The snippet reads: "Detta är främst nödvändigt på instrument med fast intonation, exempelvis piano, orgel och bandad gitarr. Flera standarder, så kallade temperaturer, förekommer. Allmänt · Oliksvävig temperering · Liksvävande temperatur". The fourth result is partially visible, titled "Symfoniorkester – Wikipedia".

Google

wikipedia pianostämning

All Images News Videos Maps More Settings Tools

About 8 950 results (0,48 seconds)

Tip: Search for **English** results only. You can specify your search language in [Preferences](#)

Pianostämmare – Wikipedia
<https://sv.wikipedia.org/wiki/Pianostämmare> ▾ [Translate this page](#)
Pianostämmare är en person med uppgift att stämma pianon och andra klaverinstrument. Det finns idag två utbildningsmöjligheter till pianotekniker i Sverige, ...

Piano – Wikipedia
<https://sv.wikipedia.org/wiki/Piano> ▾ [Translate this page](#)
Den stora skillnaden mellan piano och cembalo är att pianots ton åstadkoms av att en hammare slår an strängerna. På cembalon åstadkoms tonen genom en ...

Temperering – Wikipedia
<https://sv.wikipedia.org/wiki/Temperering> ▾ [Translate this page](#)
Detta är främst nödvändigt på instrument med fast intonation, exempelvis piano, orgel och bandad gitarr. Flera standarder, så kallade temperaturer, förekommer.
[Allmänt](#) · [Oliksvävig temperering](#) · [Liksvävande temperatur](#)

Symfoniorkester – Wikipedia

Natural Language Processing

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Sök på Wikipedia

Pianostämmare [\[redigera\]](#) [\[redigera wikitext\]](#)

Pianostämmare är en person med uppgift att stämma [pianon](#) och andra [klaverinstrument](#).

Det finns idag två utbildningsmöjligheter till pianotekniker i Sverige, [Oskarshamns folkhögskola](#)^[1] och [Kungliga Musikhögskolan](#).

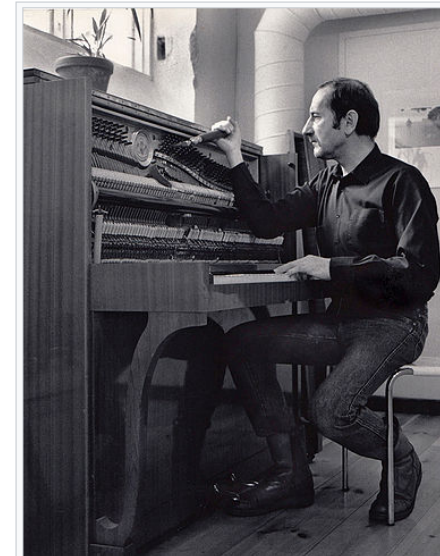
Pianostämmarutbildning förekom förr som en utbildning för blinda personer, bland annat vid [Tomtebodaskolan](#).^{[1][2]}


Referenser [\[redigera\]](#) [\[redigera wikitext\]](#)

- ¹ Blindundervisning^[1] i *Nordisk familjebok* (andra upplagan, 1905)
- ² ”Tomtebodaskolan”^[2]. Solna Stad. Läst 18 mars 2012.

Externa länkar [\[redigera\]](#) [\[redigera wikitext\]](#)

- [Sveriges pianostämmare och teknikerförening](#)^[3]



André Studencki stämmer ett piano på en kulturförening i Malmö 1987. 

Clustering

In order to show you the most relevant results, we have omitted some entries very similar to the 60 already displayed.

If you like, you can [repeat the search with the omitted results included](#).



Next time

- Chapter 2
 - tokens, terms and postings lists
 - phrase retrieval
- Chapter 3
 - tolerant retrieval: spell checking and wildcards
- Chapter 4
 - storing the index on disk