Document Representation

Jaime Arguello
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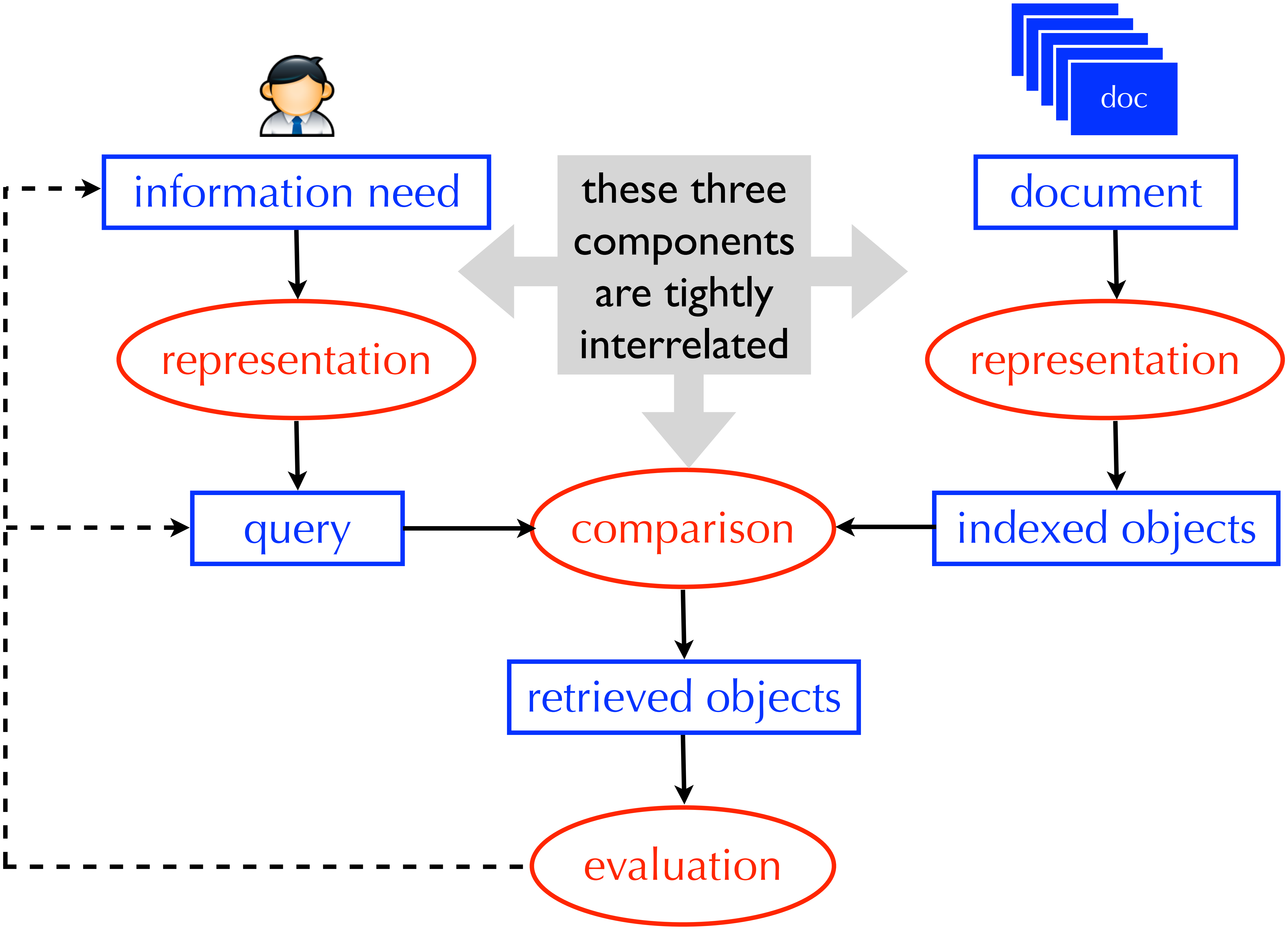
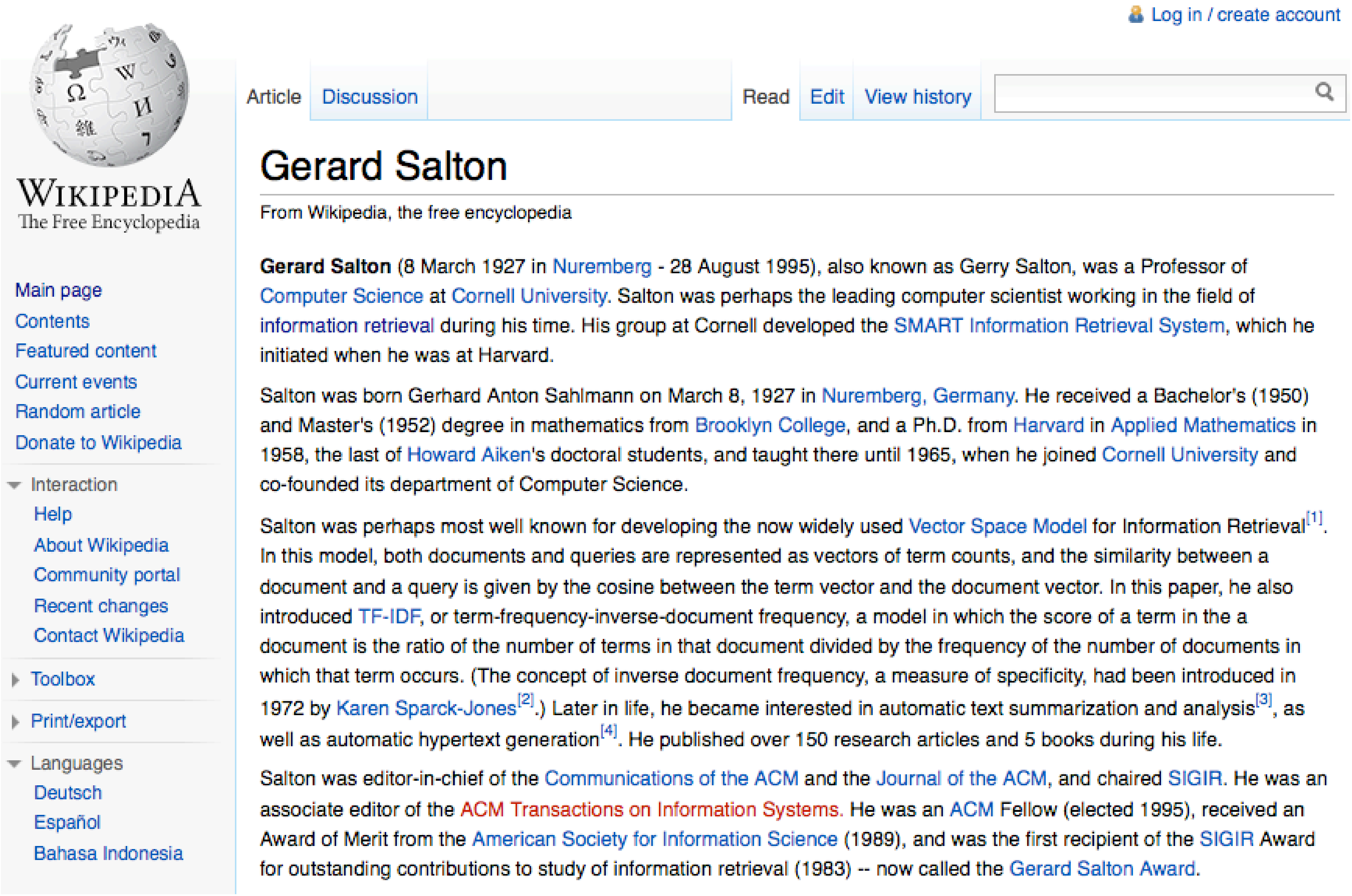
Document Representation



Document Representation

- How should this document be represented?



Gerard Salton

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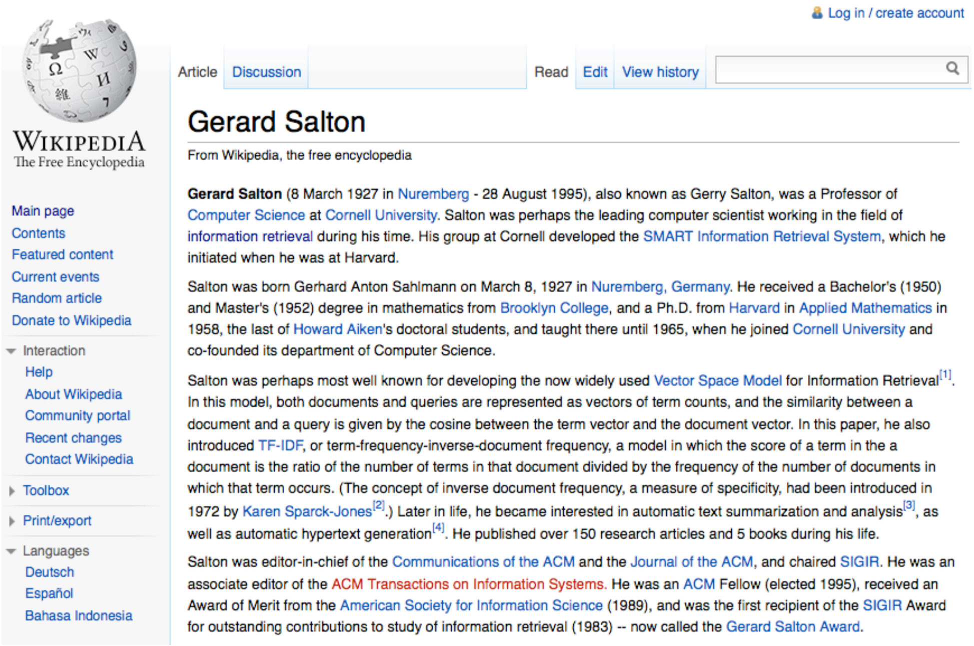
Elements of a Document Representation

- Document attributes (metadata)
  - source, publication date, language, length, etc.
- Controlled vocabulary index terms
- Free-text index terms
  - terms selected from the document text itself
  - may also include text from outside the document (e.g., anchor text)
  - lots of room for creativity!

Elements of a Document Representation



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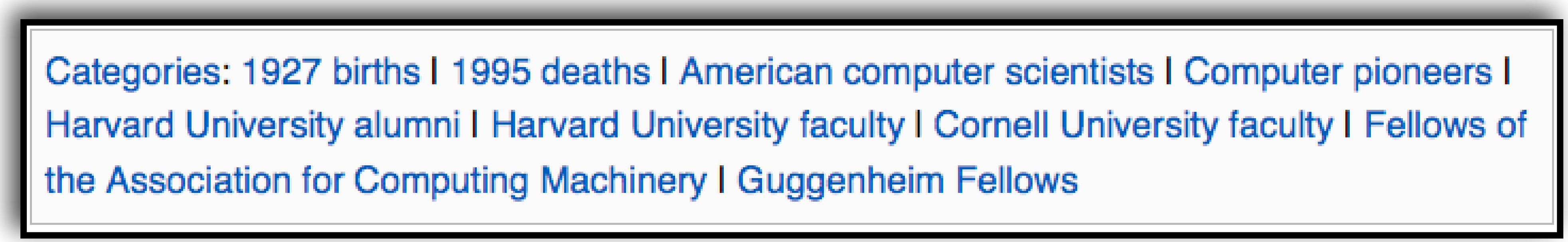
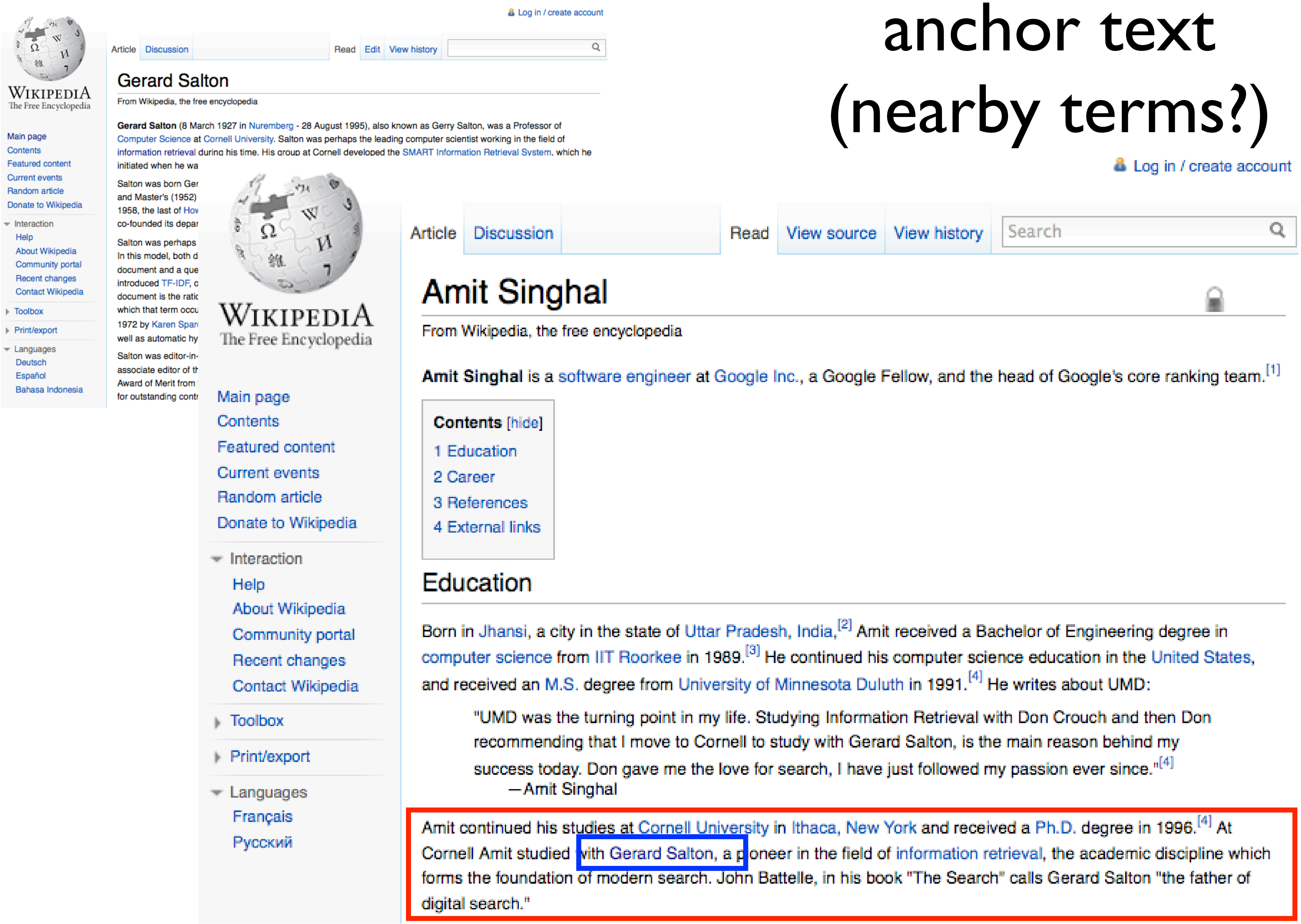
controlled-vocabulary index terms



Categories: 1927 births | 1995 deaths | American computer scientists | Computer pioneers | Harvard University alumni | Harvard University faculty | Cornell University faculty | Fellows of the Association for Computing Machinery | Guggenheim Fellows

Elements of a Document Representation

anchor text
(nearby terms?)



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Amit Singhal

From Wikipedia, the free encyclopedia

Amit Singhal is a software engineer at Google Inc., a Google Fellow, and the head of Google's core ranking team.[1]

Contents [hide]
1 Education
2 Career
3 References
4 External links

Education

Born in Jhansi, a city in the state of Uttar Pradesh, India,[2] Amit received a Bachelor of Engineering degree in computer science from IIT Roorkee in 1989.[3] He continued his computer science education in the United States, and received an M.S. degree from University of Minnesota Duluth in 1991.[4] He writes about UMD:

> "UMD was the turning point in my life. Studying Information Retrieval with Don Crouch and then Don recommending that I move to Cornell to study with Gerard Salton, is the main reason behind my success today. Don gave me the love for search, I have just followed my passion ever since."[4]
> —Amit Singhal

Amit continued his studies at Cornell University in Ithaca, New York and received a Ph.D. degree in 1996.[4] At Cornell Amit studied with Gerard Salton, a pioneer in the field of information retrieval, the academic discipline which forms the foundation of modern search. John Battelle, in his book "The Search" calls Gerard Salton "the father of digital search."

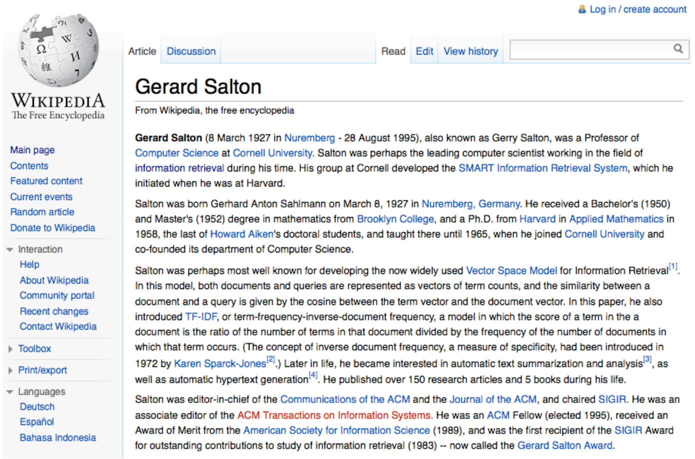
Text Processing

gerard salton 8 march 1978 in nuremberg 28 august 1995 also know as gerry salton was professor of computer science at cornell university salton was perhaps the leading computer scientist working in the field of information retrieval during his time his group at cornell developed the smart information retrieval system which he initiated when he was at harvard

- Our goal is to describe content using content
- After mark-up removal, down-casing, and tokenization, what we have is a sequence of terms
- What are the most descriptive words?

Term-Frequencies

top 20



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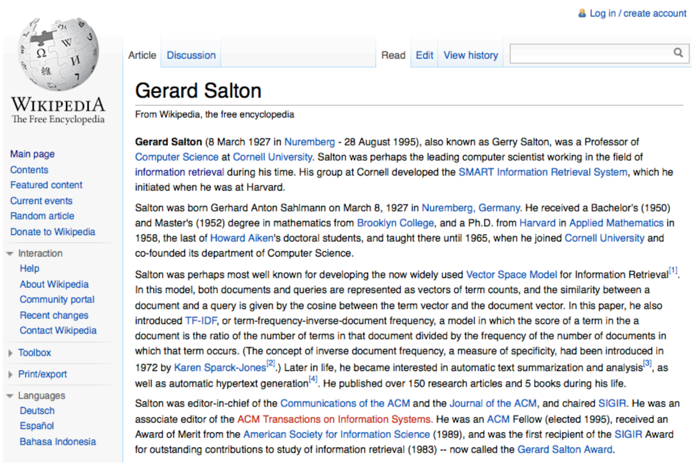
rank	term	freq.	rank	term	freq.
1	the	34	11	as	9
2	of	29	12	he	9
3	a	20	13	vector	8
4	in	20	14	an	8
5	and	19	15	s	7
6	salton	18	16	term	7
7	model	15	17	for	7
8	was	12	18	automatic	7
9	information	11	19	paper	6
10	retrieval	10	20	gerard	6

Term-Frequencies

top 20



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8	was	12	18	automatic	7
9	information	11	19	paper	6
10	retrieval	10	20	gerard	6

Stopwords

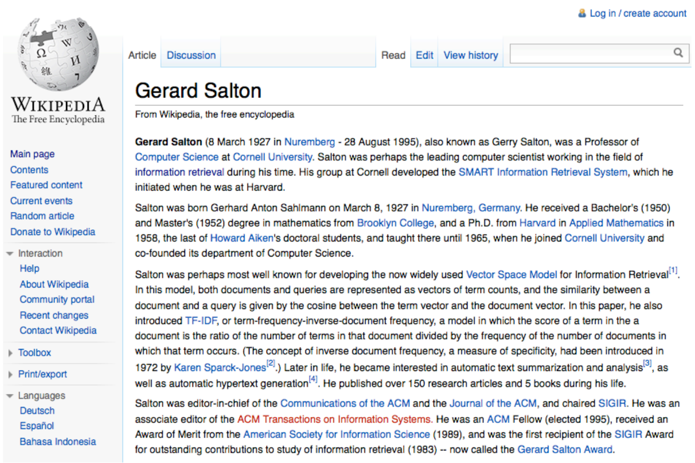
- A stopwords is a term that is discarded from the document representation
- Stopwords are typically function words: determiners (a, the), prepositions (on, above), conjunctions (and, but)
- Assumption: stopwords are unimportant because they are frequent in every document

Lemur Stopword List
first 60 (sorted alphabetically)

a
about
above
according
across
after
afterwards
again
against
albeit
all
almost
alone
along
already
also
although
always
am
among
amongst
an
and
another
any
anybody
anyhow
anyone
anything
anyway
anywhere
apart
are
around
as
at
av
be
became
because
become
becomes
becoming
been
before
beforehand
behind
being
below
beside
besides
between
beyond
both
but
by
can
can
cannot
canst

Term-Frequencies

after stopword removal



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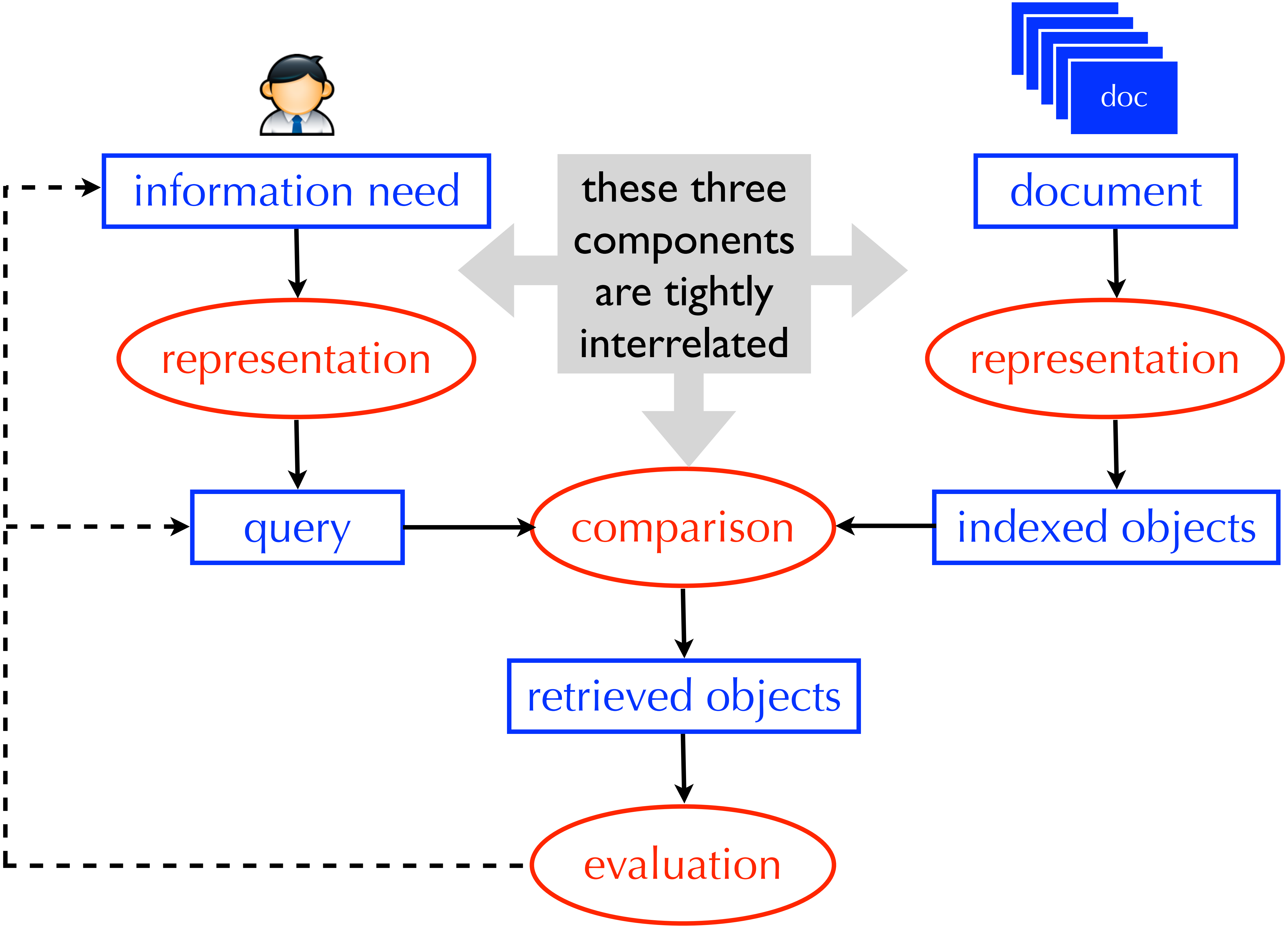
3	information	11	13	acm	6
4	retrieval	10	14	1975	4
5	vector	8	15	frequency	4
6	s	7	16	science	4
7	term	7	17	cornell	4
8	automatic	7	18	award	3
9	gerard	6	19	0	3
10	space	6	20	8	3

Trends in Stopword Removal

- The earliest systems used stopword lists of 200-300 terms
- To improve efficiency and effectiveness
- Very frequent terms were problematic for early retrieval models (e.g, OR operations in ranked boolean)
- Web search engines generally do not remove stopwords
- The latest trend is to index stopwords and (possibly) ignore them at query-time if they seem unimportant
- Newer retrieval models are better at handling very frequent terms (later lecture)

Document Representation



AOL Query-Log Examples

stopword removal

wrong lyrics

- am i wrong lyrics
- i was wrong lyrics
- wrong again lyrics
- where did i go wrong lyrics
- wrong lyrics
- got me wrong lyrics
- what went wrong lyrics

change

- be the change you want in others
- how can i change me
- change
- where is my change
- i want my change
- never change

buy house

- who will buy my house
- buy a house
- buy my house
- buy house
- we buy house
- how to buy a house

calculate bmi

- calculate bmi
- calculate my bmi
- how to calculate your bmi
- how to calculate bmi

Morphological Analysis

Morphology

- the study and description of word formation (as inflection, derivation, and compounding) in language

Merriam-Webster Dictionary

Morphology

- Inflectional morphology: changes to a word that encode its grammatical role (e.g., tense, number, person)
    - say vs. said, cat vs. cats, see vs. sees
- Derivational morphology: changes to a word to make a new word with related meaning
    - organize, organization, organizational
- Compounding: combining words to form new ones
    - shipwreck, outbound, beefsteak
    - more common in other languages (e.g., german)
    - lebensversicherungsgesellschaftangestellter

Morphological Analysis
in information retrieval

- Basic question: words occur in different forms. Do we want to treat different forms as different index terms?
- Conflation: treating different (inflectional and derivational) variants as the same index term

Morphological Analysis

in information retrieval

- Conflation: treating different (inflectional and derivational) variants as the same index term

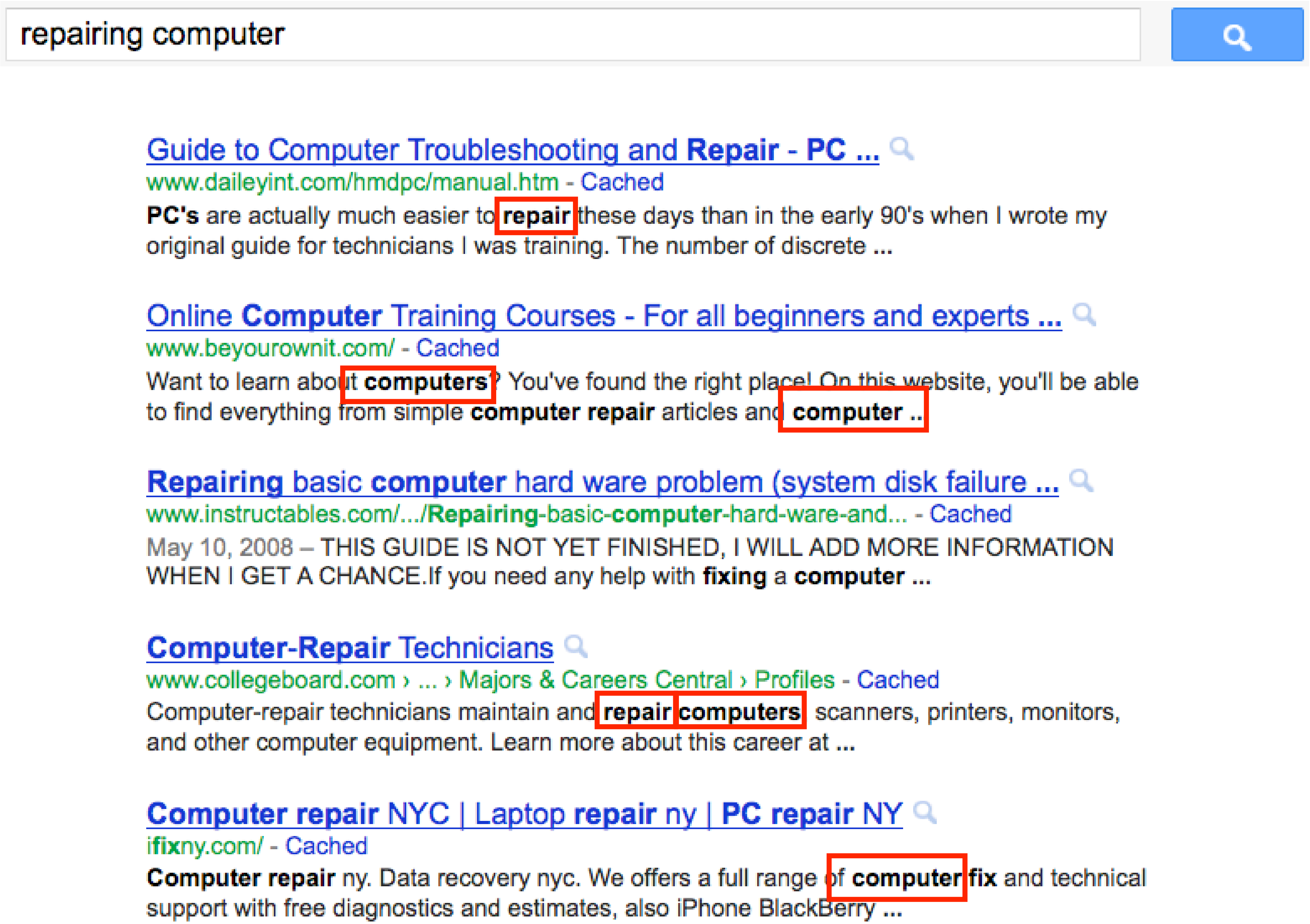
image	*images*	*imaging*
df=6	*df=4*	*df=3*
1, 4	1, 4	1, 4
10, 1	10, 5	10, 5
15, 2	16, 1	16, 1
16, 1	68, 1	
33, 5		
68, 7		

imag (root form)*
df=6
1, 12
10, 11
15, 2
16, 3
33, 5
68, 8

docid , term frequency

Google

Morphological Analysis
in information retrieval



repairing computer

Guide to Computer Troubleshooting and **Repair** - **PC** ...
www.daileyint.com/hmdpc/manual.htm - Cached
PC's are actually much easier to **repair** these days than in the early 90's when I wrote my original guide for technicians I was training. The number of discrete ...

Online **Computer** Training Courses - For all beginners and experts ...
www.beyourownit.com/ - Cached
Want to learn about **computers**? You've found the right place! On this website, you'll be able to find everything from simple **computer repair** articles and **computer** ...

Repairing basic **computer** hard ware problem (system disk failure ...
www.instructables.com/.../**Repairing**-basic-**computer**-hard-ware-and... - Cached
May 10, 2008 – THIS GUIDE IS NOT YET FINISHED, I WILL ADD MORE INFORMATION WHEN I GET A CHANCE.If you need any help with **fixing** a **computer** ...

Computer-Repair Technicians
www.collegeboard.com › ... › Majors & Careers Central › Profiles - Cached
Computer-repair technicians maintain and **repair computers**, scanners, printers, monitors, and other computer equipment. Learn more about this career at ...

Computer repair NYC | Laptop **repair** ny | **PC repair** NY
i**fix**ny.com/ - Cached
Computer repair ny. Data recovery nyc. We offers a full range of **computer fix** and technical support with free diagnostics and estimates, also iPhone BlackBerry ...

Morphological Analysis

in information retrieval

- The query “computer repairs“ will match all combinations of:

computer
computers
computing
computation
computational
::

and

repair
repairs
repaired
repairing
repairable
::

Morphological Analysis
in information retrieval

- In English, conflating morphological variants is usually done using a stemmer
- Stemming: automatic suffix-stripping
- English word variations occur at the end of a word
- root/stem + suffix
    - **repair** + **s/ed/ing/able**
- A stemmer conflates different variations by reducing them to a common root/stem

Morphological Analysis

in information retrieval

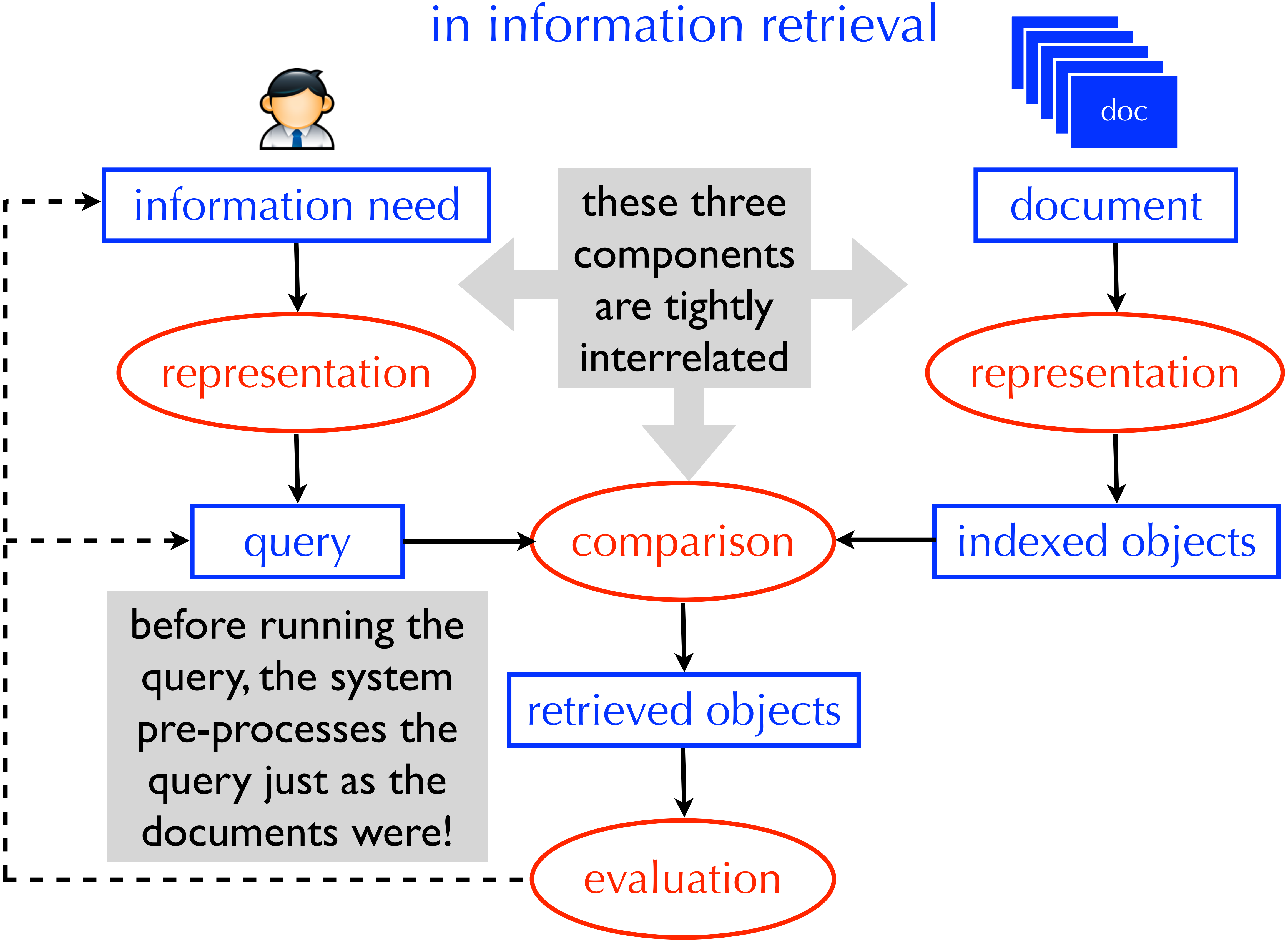
- In some cases, whatever is left after suffix-stripping is not even a word (e.g., comput)
- Is this a problem?

computer
computers
computing
computation
computational
::

repair
repairs
repaired
repairing
repairable
::

Morphological Analysis

in information retrieval



doc

information need

representation

query

document

representation

indexed objects

comparison

retrieved objects

evaluation

these three components are tightly interrelated

before running the query, the system pre-processes the query just as the documents were!

Morphological Analysis

the porter stemmer **(porter '80)**

- A long list of rules that are applied in sequence
  - apply the rule that removes the longest suffix
  - check to see that the stem is likely to be a root (replac+ement vs. c+ement)
- Fast, effective, and, therefore, very popular

Martin Porter's Home Page

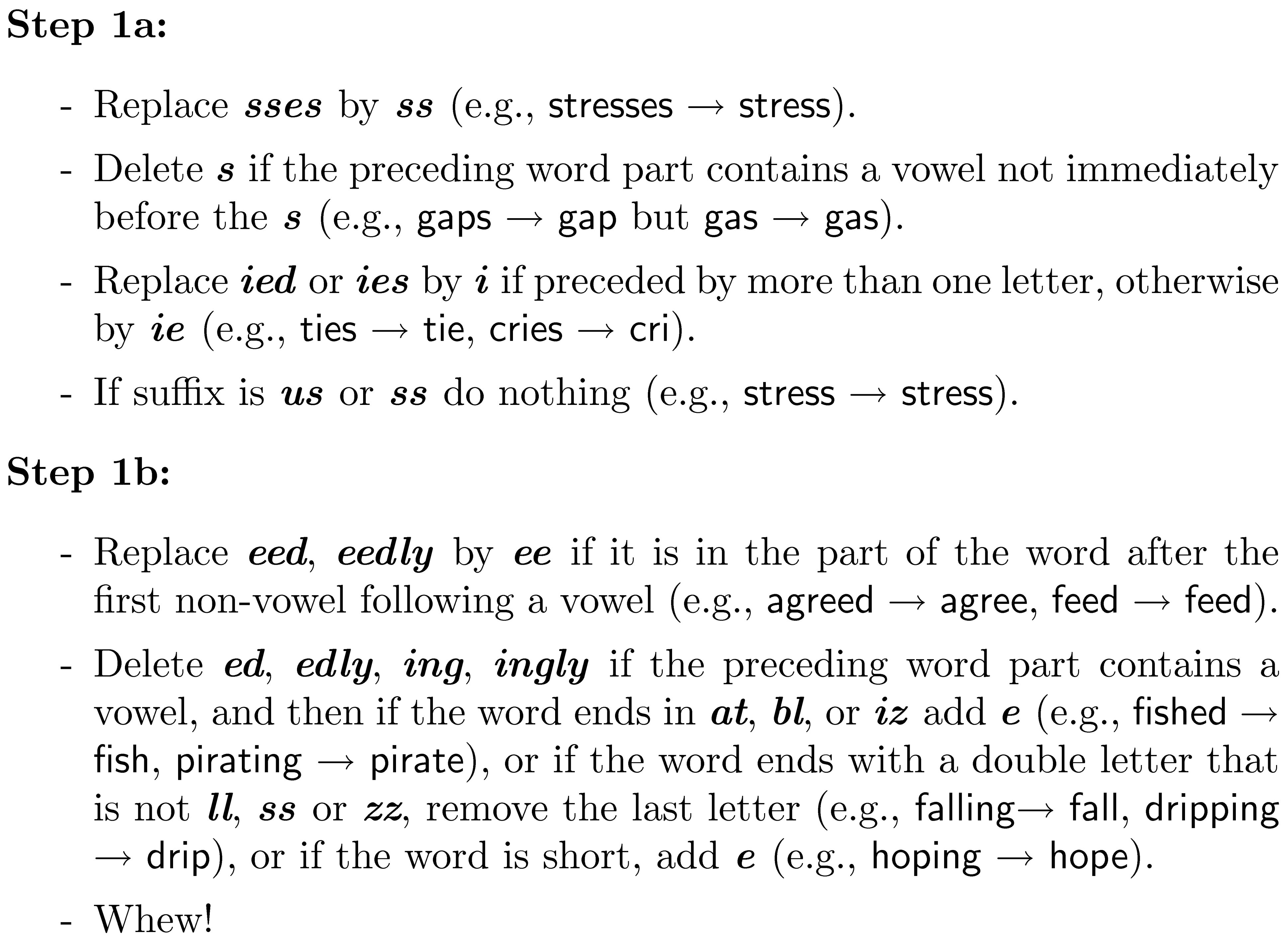
No doubt you came here out of idle curiosity from the Porter Stemming Algorithm page. Before you hastily return, you are welcome to look at the following.

This (jerkily) spinning can is the work of Philip Holmes Esquire, ingenious graphic designer and inventor of visual puns. I could never have thought up anything so clever. (Apologies to the Dr Pepper people!)

Morphological Analysis

the porter stemmer **(porter '80)**

- Example step (1 of 5)



Step 1a:

- Replace ***sses*** by ***ss*** (e.g., stresses → stress).
- Delete ***s*** if the preceding word part contains a vowel not immediately before the ***s*** (e.g., gaps → gap but gas → gas).
- Replace ***ied*** or ***ies*** by ***i*** if preceded by more than one letter, otherwise by ***ie*** (e.g., ties → tie, cries → cri).
- If suffix is ***us*** or ***ss*** do nothing (e.g., stress → stress).

Step 1b:

- Replace ***eed***, ***eedly*** by ***ee*** if it is in the part of the word after the first non-vowel following a vowel (e.g., agreed → agree, feed → feed).
- Delete ***ed***, ***edly***, ***ing***, ***ingly*** if the preceding word part contains a vowel, and then if the word ends in ***at***, ***bl***, or ***iz*** add ***e*** (e.g., fished → fish, pirating → pirate), or if the word ends with a double letter that is not ***ll***, ***ss*** or ***zz***, remove the last letter (e.g., falling→ fall, dripping → drip), or if the word is short, add ***e*** (e.g., hoping → hope).
- Whew!

Morphological Analysis

the porter stemmer **(porter '80)**

- Original Text

gerard salton 8 march 1978 in nuremberg 28 august 1995 also know as gerry salton was professor of computer science at cornell university salton was perhaps the leading computer scientist working in the field of information retrieval during his time his group at cornell developed the smart information retrieval system which he initiated when he was at harvard

- Stemmed Text

gerard salton 8 march 1978 in nuremberg 28 august 1995 also know as gerri salton wa professor of comput scienc at cornel univers salton wa perhap the lead comput scientist work in the field of inform retriev dure hi time hi group at cornel develop the smart inform retriev system which he initi when he wa at harvard

Morphological Analysis

the porter stemmer **(porter '80)**

- false positives: two words conflated to the same root when they shouldn't have been

organization/organ
generalization/generic
numerical/numerous
policy/police
university/universe
addition/additive
negligible/negligent
execute/executive
past/paste
ignore/ignorant
special/specialized
head/heading

Morphological Analysis

the porter stemmer **(porter ‘80)**

- false negatives: two words not conflated to the same root word when they should have been

european/europe
cylinder/cylindrical
matrices/matrix
urgency/urgent
create/creation
analysis/analyses
useful/usefully
noise/noisy
decompose/decomposition
sparse/sparsity
resolve/resolution
triangle/triangular

AOL Query-log Examples

stemmed queries

- russian translat
    - russian translations
    - russian translator
    - russian translation
    - russian translate
- secret
    - secret
    - secretions
    - secrets
    - secretion
- stock for sale
    - stockings for sale
    - stocking for sale
    - stocks for sale
- smokei mountain nation park
    - smokey mountains national park
    - smokey mountain national park
    - smokey mountains national parks
- cat fenc
    - cat fencing
    - cat fences
    - cat fence
- strawberri plant
    - strawberry planting
    - strawberry plants
    - strawberries planting

AOL Query-log Examples

stopped + stemmed queries

bui comput

- buy a computer
- buying a computer
- we buy computers
- how to buy a computer
- buying computers

rid raccoon

- get rid of raccoons
- how to get rid of raccoons
- how to get rid of a raccoon
- what to use to get rid of raccoons
- how do i get rid of a raccoon

auto repair

- auto repairables
- how to auto repairs
- auto repair do it yourself
- do it yourself auto repair
- auto repair .com
- do it yourself auto repairs
- auto repair

water diet

- the water diet
- the all water diet
- water and diet
- water diet
- water diets

AOL Query-log Examples

stopped + stemmed queries

planet orbit sun

- why is there only one planet in each orbit around the sun
- why do the planets orbit the sun
- planets that orbit the sun

plant shade

- plant shade
- plants for shade
- plants that do well in shade
- plants that like shade
- plants shade
- planting in the shade

univers

- universalism
- universism
- other universe
- university
- our universe
- across the universe
- the universe within
- universities

Morphological Analysis

evaluation results

- Stemming
  - English: 0-5% improvements
  - Finnish: 30% improvement
  - Spanish: 10% improvement
- Compound Splitting
  - German: 15% improvements
  - Swedish: 25% improvement

(Hollink *et al.*, 2004)

Morphology Across Languages

European Parliament Corpus

- Number of unique terms (remember, these are translations of the same text):
    - English: 150,725
    - Spanish: 213,486
    - Portuguese: 219,121
    - Danish: 367,282
    - Finnish: 709,049
    - German: 401,929

To Stem or Not To Stem

users care more about recall	?
users care more about precision	?

To Stem or Not To Stem

users care more about recall	Yes
users care more about precision	Maybe

What about homonyms?

(words that are spelled the same, but have different meaning)

Words often have multiple senses

- *bank* (noun)

1. the rising ground bordering a lake, river, or sea
2. a mound, pile, or ridge above the surrounding level
3. a steep slope (as in "bank of a hill")
4. an establishment for the custody, loan, exchange, and issue of money
5. a supply of something held in reserve
6. the lateral inward tilt of a vehicle (as an airplane) when turning

(Merriam-Webster Dictionary)

Word Sense Disambiguation

- Given a word in a particular context, automatically predict its correct sense from a finite set (bank 1-6)?

"I stopped by the bank to deposit some cash."

↓

An establishment for the custody, loan, and exchange of money

"I stopped by the food bank to donate some food."

↓

A supply of something held in reserve

- An active area of research since the 1950's
- How would you do this?

Word Sense Disambiguation

- Predict the sense whose definition contains terms that co-occur often with those in the surrounding context

"I stopped by the bank to deposit some cash."

An establishment for the custody, loan, and exchange of money

mutual information from IMDB corpus

money	raise	2.686
debt	money	2.578
dollars	money	2.567
money	cash	2.546
buy	money	2.471
money	gambling	2.436
money	pay	2.427
money	bank	2.387
insurance	money	2.117
money	paid	2.018

Word Sense Disambiguation

in information retrieval

1. Expand the indexed vocabulary so that each sense of a word is a different index term
2. Automatically predict the correct sense for each word in the collection (e.g, bank^{1}, bank^{2} , ... , bank^{6})
   - lots of context (i.e., surrounding text)
3. Index the collection as usual
4. At query-time, predict the correct word sense in the query (e.g., “drive-through bank^{4} carrboro”)
   - more difficult, not much context
5. Retrieve documents as usual

Word Sense Disambiguation

in information retrieval

- Does it improve (average) retrieval effectiveness?

Word Sense Disambiguation
in information retrieval

- Not much. Why not?

(Sanderson, 1996)

Word Sense Disambiguation

in information retrieval

- Not really a problem for long-queries (other query terms disambiguate the ambiguous ones)
- In theory, could improve performance for short queries
- However, these are precisely the queries for which disambiguation is the most difficult (not much context)

(Sanderson, 1996)

Word Sense Disambiguation

in information retrieval

- There is another reason. What is it?

Word Sense Disambiguation

in information retrieval

united bank
union bank california
union bank
tyra banks show
star bank
republic bank
pnc bank
people bank
outer banks north carolina
outer banks nc
online banking bank america
national bank texas
commerce bank

national bank south carolina
national bank oneida
national bank omaha
national bank marin
national bank alaska
national bank
merchants bank
loans bank account
hotels outer banks nc
hotels outer banks
guaranty bank
freedom bank
farmers merchants bank

Word Sense Disambiguation

in information retrieval

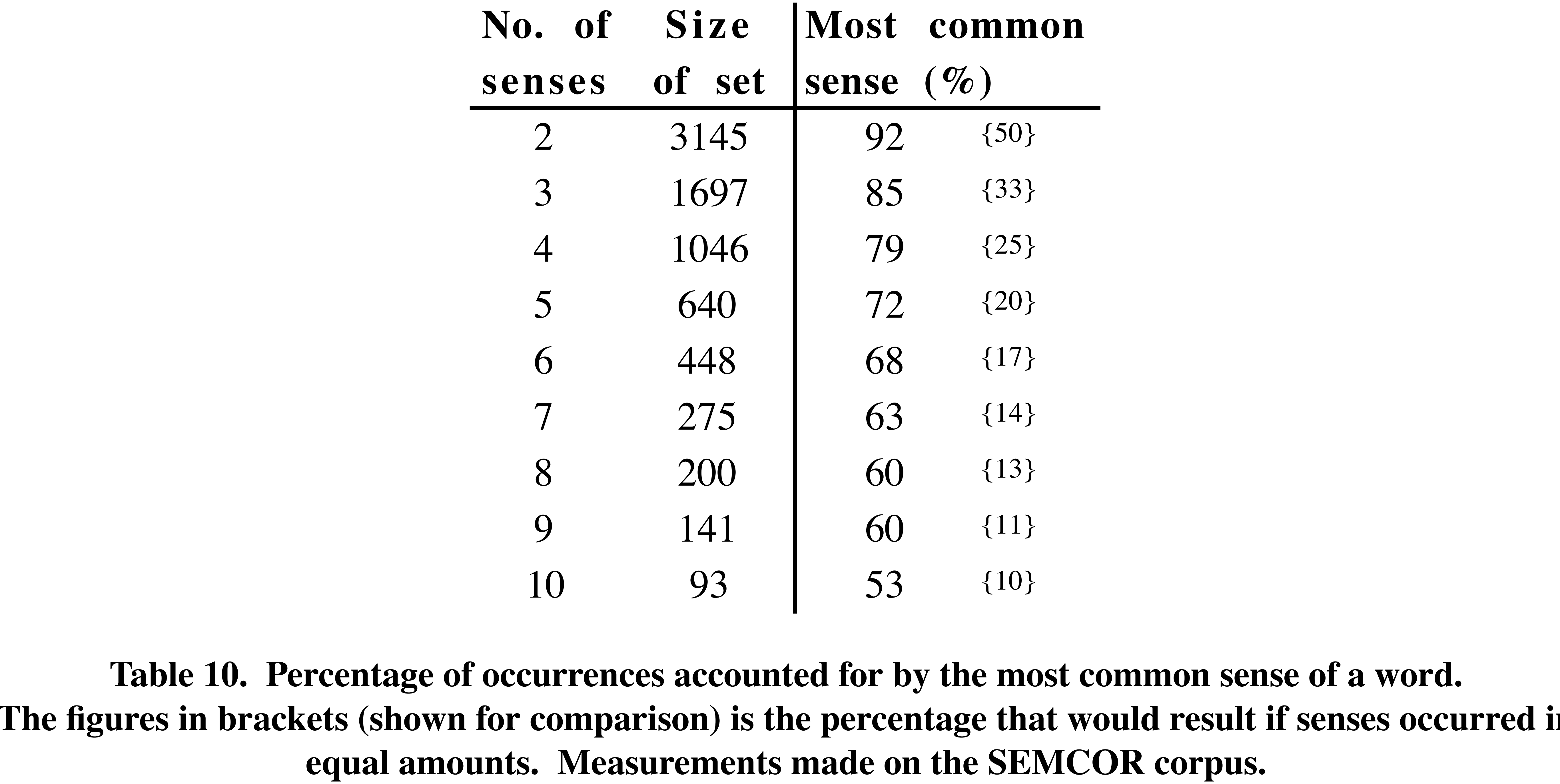
- Word senses also (more or less) follow Zipf's law: a few are very frequent and most a rare

united bank
union bank california
union bank
tyra banks show
star bank
republic bank
pnc bank
people bank
outer banks north carolina
outer banks nc
online banking bank america
national bank texas
commerce bank

national bank south carolina
national bank oneida
national bank omaha
national bank marin
national bank alaska
national bank
merchants bank
loans bank account
hotels outer banks nc
hotels outer banks
guaranty bank
freedom bank
farmers merchants bank

Word Sense Disambiguation

in information retrieval



No. of senses	Size of set	Most common sense (%)	
2	3145	92	{50}
3	1697	85	{33}
4	1046	79	{25}
5	640	72	{20}
6	448	68	{17}
7	275	63	{14}
8	200	60	{13}
9	141	60	{11}
10	93	53	{10}

Table 10. Percentage of occurrences accounted for by the most common sense of a word. The figures in brackets (shown for comparison) is the percentage that would result if senses occurred i equal amounts. Measurements made on the SEMCOR corpus.

(Sanderson, 1996)