Processamento e Recuperação de Informação

Scope of IR topics

The IR Problem

IR Systems

Modeling

Search and The Web

Processamento e Recuperação de Informação

Introduction to Information Retrieval

Departamento de Engenharia Informática
Instituto Superior Técnico

1º Semestre
2018/2019

Outline

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IR Systems

Modeling

Search and The Web

1 Scope of IR topics

2 The IR Problem

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4 Modeling

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Concepts to be Covered

- Basic Concepts of Information Retrieval (IR)
- Classic Information Retrieval Models
- Advanced Information Retrieval Models (BM25, *N*-Gram Language Models, ...)
- Different Types of IR Tasks
- IR Evaluation
- Inverted Indexes and Query Processing
- Web Search and Advanced Search Results Ranking
- Meta-search

Bibliography

Ricardo Baeza-Yates, Berthier Ribeiro-Neto, Modern Information Retrieval, 2nd edtion. Chapter 1, and beginning of Chapter 3.

Bing Liu, Web Data Mining: Exploring Hyperlinks, Contents, and Usage Data, 2nd edition. Chapter 6.

Christopher D. Manning, Prabhakar Raghavan and Hinrich Schütze, Introduction to Information Retrieval. Beginning of Chapters 1, 2, 6 and 19.

Information Retrieval

IR deals with the representation, storage, organization of, and access to information items of various types:

- documents,
- Web pages,
- online catalogs,
- structured records,
- multimedia objects,
- ...

Information Retrieval: Goals

Early goals in IR:

indexing text and searching for useful documents in a collection.

Information Retrieval: Goals

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indexing text and searching for useful documents in a collection.

Current research goals:

- Modeling,
- Web search,
- text classification,
- systems architecture,
- user interfaces, data visualization,
- filtering and
- human language technologies (e.g., in dialogue systems).

IR at the Center of the Stage

- Until recently, IR was an area of interest restricted mainly to librarians and information experts.
- A single fact changed these perceptions:
  - the introduction of the **Web**, the largest repository of knowledge in human history.
- Due to its enormous size, finding useful information on the Web usually requires running a search

Searching on the Web is all about IR and its technologies

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The IR Problem

- Ad-hoc retrieval is perhaps the core problem
- Users of modern IR systems, such as search engine users, have information needs of varying complexity

An example of complex information need

Find all documents that address the problem of global warming, including the currently accepted causes and possible mitigation solutions.

The IR Problem: Relevance

- This full description of the user information need is not necessarily a good query to be submitted to the IR system
- Instead, the user might want to first translate this information need into a **query**
- This translation process yields a set of keywords, or index terms, which summarize the user's information need

Given the user query, the key goal of the IR system is to retrieve information that is useful or relevant to the user

The vague notion of relevance is of central importance in IR

Information vs. Data Retrieval

Data retrieval

Given a specified condition (e.g. $\{\text{global}, \text{warming}\} \in \text{document}$), find all items that satisfy the condition

$$\neq$$

Information retrieval

Given a user query, find all items that contain information relevant to the user's needs

Information vs. Data Retrieval

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Data retrieval

Given a specified condition
(e.g. $\{\text{global}, \text{warming}\} \in \text{document}$), find all items that satisfy the condition

$$\neq$$

Information retrieval

Given a user query, find all items that contain information relevant to the user's needs

However...

... how do you characterize the user's information need?

Translating the user information need

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An example

Find all Web pages containing information on the ethical treatment of animals for medical experiments. The pages should contain references to recent related scientific articles, together with an enumeration of known existing alternatives for different medical fields.

try this on Google

Translating the user information need

An example

Find all Web pages containing information on the ethical treatment of animals for medical experiments. The pages should contain references to recent related scientific articles, together with an enumeration of known existing alternatives for different medical fields.

try this on Google

Usually this is translated to

ethics + animals + medical + experiments

but is this a convenient translation?
how do IR systems deal with this?

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IR Tasks

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Document processing

- Crawling
- Segmenting and annotating
- Indexing
- Query processing
- Distributed IR
- String processing
- ...

Information processing

- *Ad-hoc* retrieval
- Classification
- Clustering
- Filtering
- Summarization
- Question answering
- ...

The Retrieval Process

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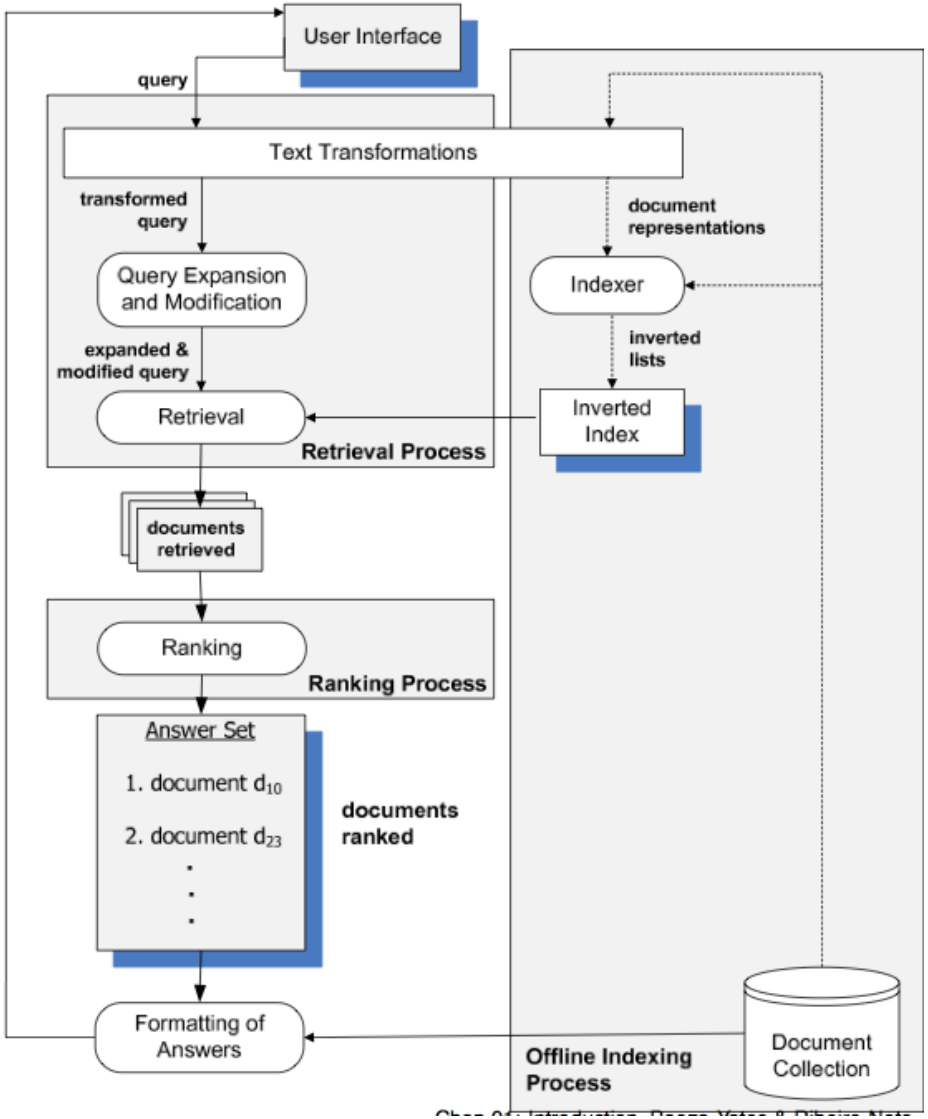

A First Proposal: Memex

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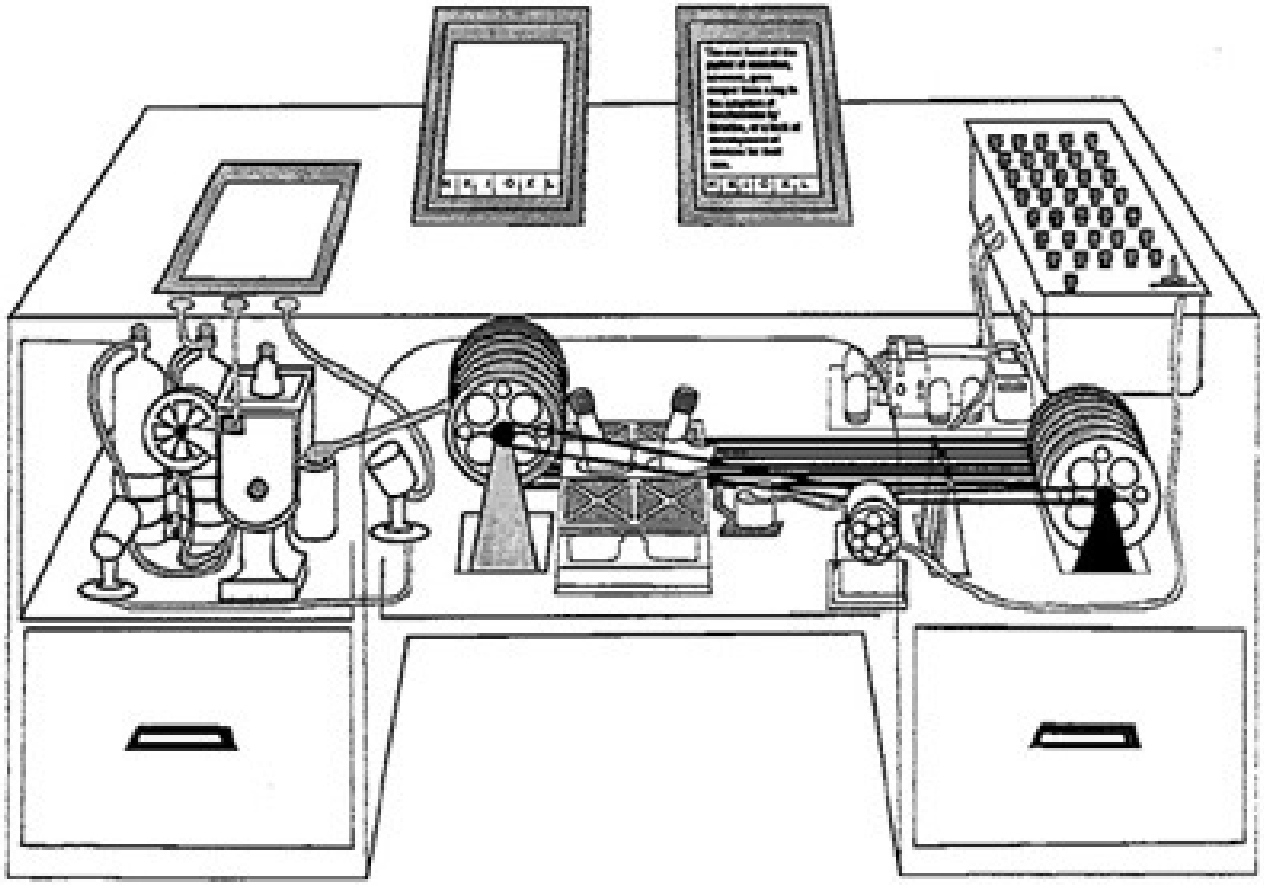

Bush, V. As We May Think, 1945

A First Solution: Universal Card Scanner

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Luhn, H. P. 1950(–1958)

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An Example

Example document

A spider conducts operations that resemble those of a weaver, and a bee puts to shame many an architect in the construction of her cells. But what distinguishes the worst architect from the best of bees is this, that the architect raises his structure in imagination before he erects it in reality.

An Example

Index terms

a	but	and	architect	bee	before
best	cell	conduct	construction	distinguish	erect
from	he	her	his	imagination	in
is	it	many	of	operation	put
raise		reality	resemble	shame	spider
structure	that	the	this	those	to
weaver	what	worst			

An Example

Index terms

a 4	but 1	and 2	architect 3	bee 2	before 1
best 1	cell 1	conduct 1	construction 1	distinguish 1	erect 1
from 1	he 1	her 1	his 1	imagination 1	in 3
is 1	it 1	many 1	of 3	operation 1	put 1
raise 1		reality 1	resemble 1	shame 1	spider 1
structure 1	that 2	the 4	this 1	those 1	to 1
weaver 1	what 1	worst 1			

An Example

Index terms

			architect 3	bee 2	before 1
best 1	cell 1	conduct 1	construction 1	distinguish 1	erect 1
	he 1	her 1	his 1	imagination 1	
is 1	it 1	many 1		operation 1	put 1
raise 1		reality 1	resemble 1	shame 1	spider 1
structure 1					
weaver 1		worst 1			

An Example

Logical view of the documents

	architect	bee	before	...	weaver	worst	...
d_1	3	2	1	...	1	1	...
d_2	0	1	0	...	2	2	...
d_3	0	2	0	...	1	0	...
d_4	2	0	2	...	2	1	...

...

Bag-of-Words Models

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Art installation of a bag of words @ CMU

Term Vectors

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In general, documents can be represented as vectors, or sets, of term weights

$$\vec{d_1} = (0, 1, 2, 3, 0, 1, \ldots)$$
$$\vec{d_2} = (3, 0, 1, 1, 0, 2, \ldots)$$
$$\ldots$$

Operations on the documents are operations on the vectors

Other, more complex, models are also possible:

- e.g., probabilistic language models, with like:

$$P(t_1 t_2 t_3) = P(t_1)P(t_2 \mid t_1)P(t_3 \mid t_1 t_2)$$

Building the Logical View of the Documents

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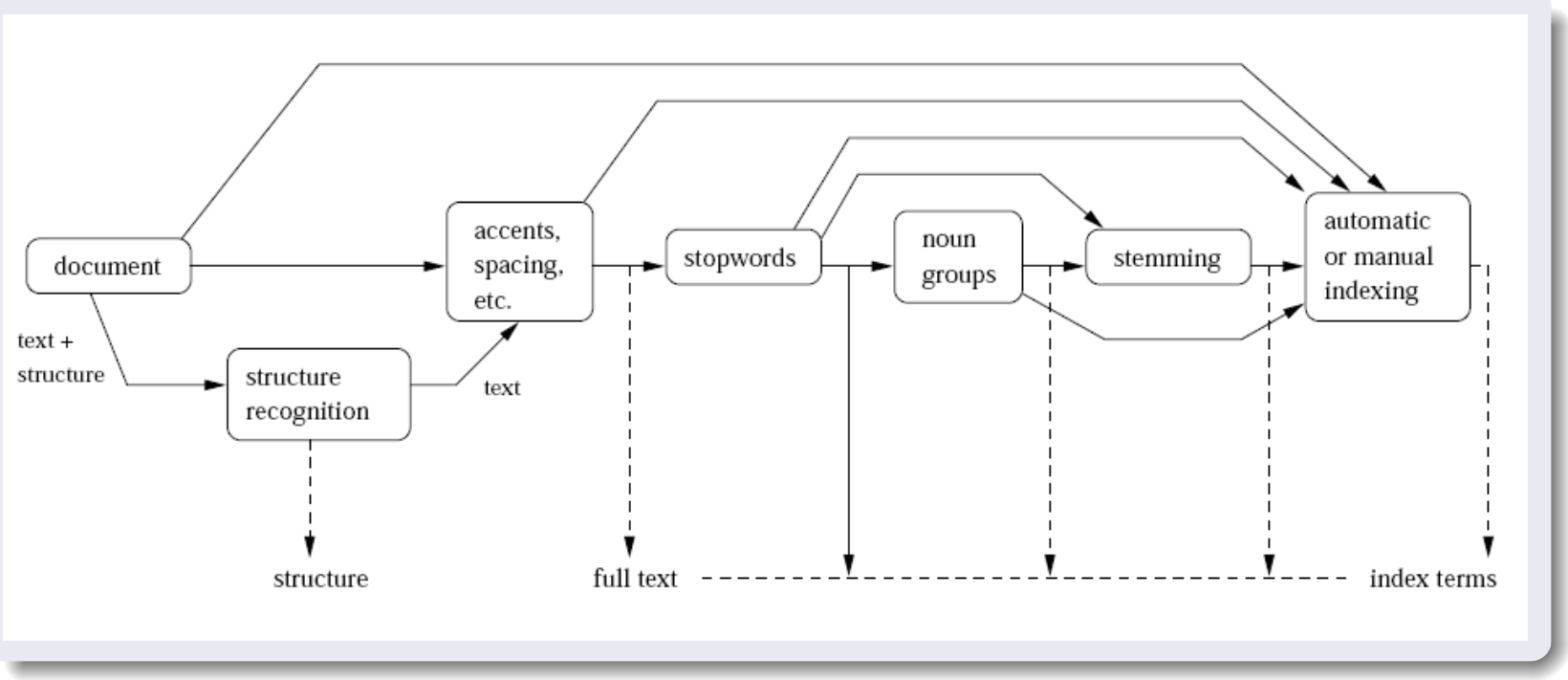
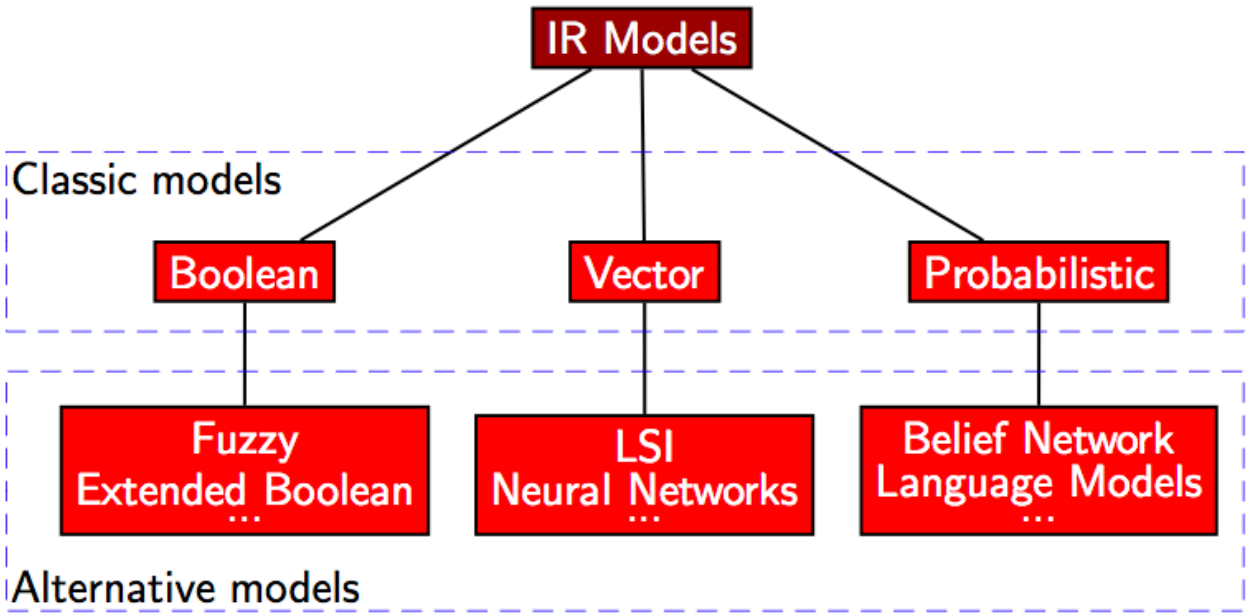


Retrieval Models



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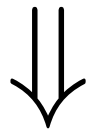
Motivation for IR Research & Development

- Growing importance of access to information
- Growing volume of electronically stored information



- Growing need of efficient and effective means to organize, store and provide access to information
- None of these are trivial tasks

How the Web Changed Search

Search is everywhere

- Web search is today the most prominent application of IR and its techniques;
- The ranking and indexing components of any search engine are fundamentally IR pieces of technology.
- A search box is now common in every web site, app, ...

Five major impacts...

First Major Impact

The first major impact of the Web on search is related to the characteristics of the document collection itself

- The traditional Web is composed of pages distributed over millions of sites and connected through hyperlinks
- This requires collecting all documents and storing copies of them in a central repository, prior to indexing
- This new phase in the IR process, introduced by the Web, is called crawling
  - Many challenges related to the fact that Web contents are very dynamic, and are often hidden behind forms

Second Major Impact

The second major impact of the Web on search is related to:

- The size of the collection
- The volume of user queries submitted on a daily basis

As a consequence, performance and scalability have become critical characteristics of IR systems

Modern Web-based services (e.g., social media platforms) are further extending the scope of these scalability problems

Third Major Impact

In a very large and diverse collection (e.g., documents in multiple languages, of different types, often quite short and ambiguous), predicting relevance is much harder than before

Fortunately, the Web also includes new sources of evidence

- hyperlinks
- user clicks in documents in the answer set
- complex user profiles
- ...

Fourth Major Impact

The Web is also a medium to do business

Search problem has been extended beyond the seeking of text information to also encompass entities and other user needs:

- the price of a book,
- the phone number of a hotel,
- the location of a restaurant,
- the link for downloading a software,
- ...

Mobile and voice-based access to the Web has further extended the scope of the problem

- Increasing importance of automated assistants leveraging natural language technologies

Fourth Major Impact and Relation to IE

Advanced search services (e.g., focusing on entities and their properties) often involve Information Extraction (IE)

Search is made over structured knowledge bases, build through large-scale extraction (e.g., from the Web, e-mails, ...)

- Knowledge graphs associated to major search engines,
- Price comparison services,
- Services like Google Trips,
- Dialogue services: Siri, Cortana, Alexa, Google Assistant, ...

Many different Information Extraction challenges:

- recognizing and disambiguating entities in text,
- extracting properties and relations
- ...

Fifth Major Impact

The fifth major impact of the Web on search is Web spam

Web spam:

abusive availability of commercial information disguised in the form of informational content

This difficulty is so large that today we even talk of Adversarial Web Retrieval.

Practical Issues in the Web

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Security

Commercial transactions over the Internet are not yet a completely safe procedure

Privacy

Frequently, people are willing to exchange information as long as it does not become public

Copyright and patent rights

It is far from clear how the widespread data on the Web affects copyright and patent laws in the various countries

Interfaces

Modern trends relate to multi-modality (e.g., voice interaction through mobile devices) and going beyond *search boxes* (e.g., tools that assist in solving complex tasks)

Questions?