Introduction to Information Retrieval
Content of this Lecture

- What is Information Retrieval
- Documents
- Queries
- Related topics
Information Retrieval (aka “Search”)

- Naïve: Find all documents containing the following words
- Advanced: „Leading the user to those documents that will best enable him/her to satisfy his/her need for information“ [Robertson 1981]
  - A user wants to know something
  - The user needs to tell the machine what he wants to know: query
  - Posing exact queries is difficult: room for interpretation
  - Machine interprets query to compute the (hopefully) best answer
  - Goodness of answer (relevance) depends on original intention of user, not on the query
  - Answer is always a set of docs
  - “Leading”: Sensible ranking of all potentially relevant docs
The Informal Problem

- Help user in **quickly** finding the **requested information** within a **given set of documents**
  - Set of documents: **Corpus**, library, collection, ...
  - Quickly: **Few queries**, **fast responses**, simple interfaces, ...
  - Requested: The “best-fitting” documents; the “most relevant” content
Difference to Database Queries

- Queries: Formal language versus natural language
- Result granularity: Set of documents versus relation as defined by query
- Exactly defined result versus loosely described relevance
- Result set versus ranked result list
- DB: Posing the right query is completely left to the user
- IR: Understanding the query is a problem of the software
Why is it hard?

- Properties of human languages
  - Homonyms (context): Fenster (Glas, Computer, Brief, ...), Berlin (BRD, USA, ...), Boden (Dach, Fussboden, Ende von etwas, ...)
  - Synonyms: Computer, PC, Rechner, Desktop, Laptop, Tablet, ...

- Properties of the corpus
  - Size: Corpora today may have billions of documents
  - Heterogeneity: Length, format, language, genre, grammatical correctness, special characters, ...

- Heterogeneous users: Precise queries versus usability
  - Lay persons: Short queries with wide spectrum of interpretations
    - Average web queries have 1,6 terms
    - Additional knowledge: Location, current trends, popular answers, ...
  - Professionals: Long queries trying to precisely define the intention
    - “Information broker” was/is a profession
Quickly

- **Time to execute a query**
  - Indexing, parallelization, compression, ...
- **Time to answer the request** (may involve multiple queries)
  - Understand request, find best matches
  - Success of search engines: Better results (and fast!)
  - **Process-orientation**: User feedback, query history, ...
- **Information overload**
  - “We are drowning in data, but starving for knowledge”
  - If the corpus is large, **ranking is a must**
  - Alternative: Result summarization (grouping on what?)
  - Different **search modes**: What’s new? What’s certain?
IR: An Iterative, Multi-Stage Process

- IR process: “Moving through many actions towards a general goal of satisfactory completion of research related to an information need.”
  - “Berry-picking” [Bates 89]
Im Information Retrieval (IR) werden Informationssysteme in Bezug auf ihre Rolle im Prozess des Wissenstransfers vom menschlichen Wissensproduzenten zum Informations-Nachfragenden betrachtet. Fragestellungen, die im Zusammenhang mit vagen Anfragen und unsicherem Wissen entstehen, auch solche, die nur im Dialog iterativ durch Reformulierung (in Abhängigkeit von den bisherigen Systemantworten) beantwortet werden können. Die Unsicherheit resultiert meist aus der begrenzten Repräsentation von dessen Semantik (z.B. bei Texten oder multimedialen Dokumenten); Aus dieser Problematik ergibt sich die Notwendigkeit zur Bewertung der Qualität der Antworten eines Informationssystems, wobei in einem weiteren Sinne die Effektivität des Systems in Bezug auf die Unterstützung des Benutzers bei der Lösung seines Anwendungsproblems beurteilt werden sollte.
Prominent Systems I: Digital Libraries

- E.g. OPAC
  - Combination of structured attributes and IR-style queries
Prominent Systems II: Desktop Search

- Much activity in 2000-2010
- Various search engines and indexing mechanisms
- Important: Search different types of files (txt, doc, mail, ppt, pdf, tex, odp, xls, ...)

[Image of desktop search interface]
Prominent Systems III: Web Search Engines

Google

Yahoo!

MetaGer

WolframAlpha
Almost Any Web Site
Properties of Information Retrieval (IR)

- IR is about **helping a user**
- IR is about **finding information**, not about finding data
- IR builds systems for **end users**, not for programmers
  - No SQL
  - IR (web) is used by almost everybody, databases are not
- IR searches **unstructured data** (e.g. text)
- **90% of all information** is presented in unstructured form
  - Claim some analysts
History

• ~300 ad. Library of Alexandria, ~700,000 „documents“
• 1450: Bookprint
• 19th century: Indices / concordance
• Probabilistic models: Maron & Kuhns (1960)
• Boolean queries: Lockheed (~1960)
• Vector Space Model: Salton, Cornell (1965)
  - Faster, simpler to implement, better search results
• 80s-90s: Digital libraries, SGML, hypertext, metadata standards
• Mid 90s: The web, web search engines, XML, federations
• End 90s: Personalized search engines, recommendations
• 2010-: Mobile search, user-generated content, social networks
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Searching only metadata

Searching tokens within documents

Interpreting natural text
Documents

- This lecture: **Natural language text**
- Might be grammatically correct (books, newspapers) or not (blogs, Twitter, spoken language)
- May have structure (title, abstract, chapters, …) or not
- May have associated (explicit or in-text) metadata or not
- May be in different languages or even have mixed content
  - Foreign characters
- May have various formats (ASCII, PDF, DOC, XML, …)
- May refer to other documents (**hyperlinks**)
- Not covered
  - Semi-structured data (XML)
  - Structured data (But: Keyword search in relational databases)
IR Queries

- Users formulate queries
  - Keywords or phrases
  - Logical operations (AND, OR, NOT, ...)
    - Also other operators: “-ulf +leser”
  - Natural language questions (e.g. MS-Word help)
  - (Semi-)Structured queries (author=... AND title~ ...)
    - Voice (Siri, Alexa, ...)

- Documents as queries: Find documents similar to this one

- Query refinement based on previous results
  - Find documents matching the new query within the result set of the previous search
  - Use relevant answers from previous queries to create next query
Searching with Metadata (PubMed/Medline)
Query Refinement

*PubMed History - Mozilla Firefox*

- Search query: `Myers-g[au] sequence[ti]`
- Results include:
  - Myers-g[au] sequence[ti] Nucleic acids res[ta]
  - Myers-g[au] sequence[ti] Nucleic acids res[ta]
  - Myers-g[au] sequence[ti] Nucleic acids res[ta]
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Dublin Core Metadata Initiative (W3C), 1995

- identifier: ISBN/ISSN, URL/PURL, DOI, ...
- format: MIME-Typ, media type,
- type: Collection, image, text, ...
- language
- title
- subject: Keywords
- coverage: Scope of doc in space and/or time
- description: Free text
- creator: Last person manipulating the doc
- publisher:
- contributor:
- rights: Copyright, licenses, ...
- source: Other doc
- relation: To other docs
- date: Date or period
Usage in HTML

<head profile="http://dublincore.org/documents/dcq-html/">
<title>Dublin Core</title>
<link rel="schema.DC" href="http://purl.org/dc/..." />
<link rel="schema.DCTERMS" href="http://purl.org/..." />
<meta name="DC.format" scheme="..." content="text/htm" />
<meta name="DC.type" scheme="..." content="Text" />
<meta name="DC.publisher" content="Jimmy Whales" />
<meta name="DC.subject" content="Dublin Core Metadata" />
<meta name="DC.creator" content="Björn G. Kulms" />
<meta name="DCTERMS.license" scheme="DCTERMS.URI" content="http://www.gnu.org/copyleft/fdl.html" />
</head>
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Multimedia Retrieval

- Note: Neither searches within images
  - Flickr: tags (“folksonomy”)
  - Google: text in neighborhood
„Search by Image“ (10/2014)
Search by Image 4/2018 – it’s difficult ...
Question Answering

• Asking for a specific bit of information
  - What was the score of Bayern München versus Stuttgart in the DFB Pokal finals in 1998?
  - How many hours of sunshine has a day in Crete in May?
  - When does the next S9 leave this station?

• Prominent until recently: IBM Watson
  - “IBM Watson is a technology platform that uses natural language processing and machine learning to reveal insights from large amounts of unstructured data” [2011]

• Hot topic for personal assistants
  - E.g. Amazon Echo, Apple Siri, Google Assistant, …

• QA: Mixture of statistical NLP, Machine learning and IR
Historic Texts

- Sachsenspiegel, ~1250
  - "Swerlenrecht kûnnen wil•d~ volge dis buches lere.alrest sul wi mer ken, daz ..."

- Multiple representations
  - Facsimile
  - Digitalization / diplomacy
    - How well can the facsimile be reproduced from the dig. form?
  - Differences in individual writers (proliferating errors)
  - Different translations
  - Different editions
Other Buzzwords

• Document management systems (DMS)
  – Large commercial market, links to OCR, workflow systems, etc.
  – Many legal issues (compliance, reporting, archival, …)
  – Essentially all companies run some form of a DMS
  – Every DMS includes an IR system

• Knowledge management
  – “More sophisticated” DMS with semantic searching
    • Ontologies, thesauri, topic maps, …
  – Social aspects: Incentives, communities, enterprise standards, …

• Digital libraries
  – Somewhat broader and less technical
  – Includes social aspects, archiving, multimedia, …
Enterprise Content Management

- „The technologies used to capture, manage, store, deliver, and preserve information to support business processes”

- Authorization and authentication
- Business process management and document flow
- **Compliance**: legal requirements
  - Record management
  - Pharma, Finance, …
- Collaboration and sharing
  - Inter and intra organizations
  - Transactions, locks, …
- **Publishing**: What, when, where
  - Web, catalogues, mail push, …
- …
Technique versus Content

• IR is about techniques for searching a given doc collection
• Creating doc collections is a business: Content provider
  – Selection/filtering: classified business news, new patents, …
  – Augmentation: Annotation with metadata, summarization, linking of additional data, …

• Examples
  – Medline: >5000 Journals, >28M citations, >700K added per year
  – Thompson Reuter
    • Impact factors: which journals count how much?
  – Web catalogues ala Yahoo
  – “Pressespiegel”, web monitoring
Self Assessment

- Give a definition of „Information retrieval“
- How is information retrieval different from database query evaluation?
- What means to shorten the number of queries necessary to fulfil an information request?
- What is the difference between classical IR and Question Answering?
- What are possible types of answers to a IR query?