Information Retrieval in Practice: Search Engines

http://www.search-engines-book.com/

Information Retrieval

- Information Retrieval (IR) is finding material (usually documents) of an unstructured nature (usually text) that satisfies an information need from within large collections (usually stored on computers).
  - These days we frequently think first of **web search**, but there are many other cases:
    - E-mail search
    - Searching your laptop
    - Corporate knowledge bases
    - Legal information retrieval

Basic assumptions of Information Retrieval

- Collection: A set of documents
  - Assume it is a static collection for the moment

- Goal: Retrieve documents with information that is relevant to the user's information need and helps the user complete a task

Data Mining vs Information Retrieval

- The key different is the query parameter
  - DM methods can work without a user query
  - IR methods are query centric
- IR is done upon stored data
  - Focus: efficient search
- DM method can work on unseen instances
  - Focus: discovering hidden/actionable patterns

Search and Information Retrieval

- Search on the Web is a daily activity for many people throughout the world
- Search and communication are most popular uses of the computer
- Applications involving search are everywhere
- The field of computer science that is most involved with R&D for search is *information retrieval (IR)*

Information Retrieval

- *"Information retrieval is a field concerned with the structure, analysis, organization, storage, searching, and retrieval of information."* (Salton, 1968)
- General definition that can be applied to many types of information and search applications
- Primary focus of IR since the 50s has been on *text* and *documents*

What is a Document?

- Examples:
  - web pages, email, books, news stories, scholarly papers, text messages, Word™, Powerpoint™, PDF, forum postings, patents, IM sessions, etc.
- Common properties
  - Significant text content
  - Some structure (e.g., title, author, date for papers; subject, sender, destination for email)

Documents vs. Database Records

- Database records (or *tuples* in relational databases) are typically made up of well-defined fields (or *attributes*)
  - e.g., bank records with account numbers, balances, names, addresses, social security numbers, dates of birth, etc.
- Easy to compare fields with well-defined semantics to queries in order to find matches
- Text is more difficult

Documents vs. Records

- Example bank database query
  - *Find records with balance > $50,000 in branches located in Amherst, MA.*
  - Matches easily found by comparison with field values of records
- Example search engine query
  - *bank scandals in western mass*
  - This text must be compared to the text of entire news stories

Comparing Text

- **Comparing the query text to the document text and determining what is a good match is the core issue of information retrieval**
- Exact matching of words is not enough
  - Many different ways to write the same thing in a "natural language" like English
  - e.g., does a news story containing the text *"bank director in Amherst steals funds"* match the query?
  - Some stories will be better matches than others

Dimensions of IR

- IR is more than just text, and more than just web search
  - although these are central
- People doing IR work with different media, different types of search applications, and different tasks

Other Media

- New applications increasingly involve new media
  - e.g., video, photos, music, speech
- Like text, content is difficult to describe and compare
  - text may be used to represent them (e.g. tags)
- IR approaches to search and evaluation are appropriate

Dimensions of IR

Content	Applications	Tasks
Text	Web search	Ad hoc search
Images	Vertical search	Filtering
Video	Enterprise search	Classification
Scanned docs	Desktop search	Question answering
Audio	Forum search	
Music	P2P search	
	Literature search	

IR Tasks

- Ad-hoc search
  - Find relevant documents for an arbitrary text query
- Filtering
  - Identify relevant user profiles for a new document
- Classification
  - Identify relevant labels for documents
- Question answering
  - Give a specific answer to a question

Big Issues in IR

- Relevance
  - What is it?
  - Simple (and simplistic) definition: A relevant document contains the information that a person was looking for when they submitted a query to the search engine
  - Many factors influence a person's decision about what is relevant: e.g., task, context, novelty, style
  - *Topical relevance* (same topic) vs. *user relevance* (everything else)

Big Issues in IR

- Relevance
  - *Retrieval models* define a view of relevance
  - *Ranking algorithms* used in search engines are based on retrieval models
  - Most models describe statistical properties of text rather than linguistic
    - i.e. counting simple text features such as words instead of parsing and analyzing the sentences
    - Statistical approach to text processing started with Luhn in the 50s
    - Linguistic features can be part of a statistical model

Big Issues in IR

- Evaluation
  - Experimental procedures and measures for comparing system output with user expectations
    - Originated in Cranfield experiments in the 60s
  - IR evaluation methods now used in many fields
  - Typically use *test collection* of documents, queries, and relevance judgments
    - Most commonly used are TREC collections
  - *Recall* and *precision* are two examples of effectiveness measures

Big Issues in IR

- Users and Information Needs
  - Search evaluation is user-centered
  - Keyword queries are often poor descriptions of actual information needs
  - Interaction and context are important for understanding user intent
  - Query refinement techniques such as *query expansion*, *query suggestion*, *relevance feedback* improve ranking

IR and Search Engines

- A search engine is the practical application of information retrieval techniques to large scale text collections
- Web search engines are best-known examples, but many others
  - *Open source* search engines are important for research and development
    - e.g., Lucene, Lemur/Indri, *Galago*
- Big issues include main IR issues but also some others

IR and Search Engines

Information Retrieval

Relevance

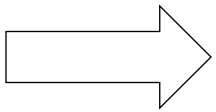
-Effective ranking

Evaluation

-Testing and measuring

Information needs

-User interaction



Search Engines

Performance

-Efficient search and indexing

Incorporating new data

-Coverage and freshness

Scalability

-Growing with data and users

Adaptability

-Tuning for applications

Specific problems

-e.g. Spam

Search Engine Issues

- Performance
  - Measuring and improving the efficiency of search
    - e.g., reducing *response time*, increasing *query throughput*, increasing *indexing speed*
  - *Indexes* are data structures designed to improve search efficiency
    - designing and implementing them are major issues for search engines

Search Engine Issues

- Dynamic data
  - The “collection” for most real applications is constantly changing in terms of updates, additions, deletions
    - e.g., web pages
  - Acquiring or “crawling” the documents is a major task
    - Typical measures are *coverage* (how much has been indexed) and *freshness* (how recently was it indexed)
  - Updating the indexes while processing queries is also a design issue

Search Engine Issues

- Scalability
  - Making everything work with millions of users every day, and many terabytes of documents
  - Distributed processing is essential
- Adaptability
  - Changing and tuning search engine components such as ranking algorithm, indexing strategy, interface for different applications

Spam

- For Web search, spam in all its forms is one of the major issues
- Affects the efficiency of search engines and, more seriously, the effectiveness of the results
- Many types of spam
  - e.g. spamdexing or term spam, link spam, "optimization"
- New subfield called *adversarial IR*, since spammers are "adversaries" with different goals