Introduction:
A Brief History of IR

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Overview

• What is information retrieval?
• How do search engines work?
• The internet & web search
• Adversarial IR
Text management applications

- **Access**
  - Select information

- **Mining**
  - Create Knowledge

- **Organization**
  - Add Structure/Annotations
Text management applications

- Retrieval Applications
  - Information Access
  - Summarization
  - Filtering
  - Search
  - Categorization

- Natural Language Content Analysis

- Information Organization
  - Visualization
  - Mining
  - Extraction
  - Clustering

- Mining Applications
  - Knowledge Acquisition

Text
Information filtering

- Stable & long term interest, dynamic info source
- System must make a delivery decision immediately as a document “arrives”
Collaborative filtering

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Customers who shopped for Managing Gigabytes also shopped for:

1. *Information Retrieval* by William B. Preisers, Ricardo Baeza-Yates
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2. *Understanding Search Engines* by Michael W. Berry, Murray Browne
   Price: $41.50
   *Used & new* from $26.50
   Add to cart

3. *Survey of Text Mining* by Michael W. Berry (Editor)
   Price: $58.93
   *Used & new* from $54.59
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Categorization

- Pre-given categories and labeled document examples (Categories may form hierarchy)
- Classify new documents
- A standard supervised learning problem
Clustering

- Discover “natural structure”
- Group similar objects together
- Object can be document, term, passages
• Discover “natural structure”
• Group similar objects together
• Object can be document, term, passages
Clustering

- Discover “natural structure”
- Group similar objects together
- Object can be document, term, passages
Search (ad-hoc IR)

User

query

"robotics applications"

Retrieval System

relevant docs

text docs

database/collection

relevant docs

non-relevant docs

Robotics

others
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Basic Idea

- Much of IR depends upon idea that
  \textit{similar vocabulary} \rightarrow \textit{similar "meaning"}

- Usually look for documents matching query words

- "Similar" can be measured in many ways...
Bag of words

- An effective and popular approach
- Compares words without regard to order
- Consider reordering words in a headline:
  - **Random**: beating takes points falling another Dow 355
  - **Alphabetical**: 355 another beating Dow falling points
  - **“Interesting”**: Dow points beating falling 355 another
  - **Actual**: Dow takes another beating, falling 355 points
What is this about?

16 × said 14 × McDonalds
12 × fat 11 × fries
8 × new 6 × company french nutrition
5 × food oil percent reduce taste Tuesday
4 × amount change health Henstenburg make obesity
3 × acids consumer fatty polyunsaturated US
2 × amounts artery Beemer cholesterol clogging director
down eat estimates expert fast formula impact initiative
moderate plans restaurant saturated trans win
1 × ...

added addition adults advocate affect afternoon age
Americans Asia battling beef bet brand Britt Brook Browns
calorie center chain chemically ... crispy customers cut ...
vegetable weapon weeks Wendys Wootan worldwide years York
McDonald's slims down spuds
Fast-food chain to reduce certain types of fat in its french fries with new cooking oil.

NEW YORK (CNN/Money) - McDonald's Corp. is cutting the amount of "bad" fat in its french fries nearly in half, the fast-food chain said Tuesday as it moves to make all its fried menu items healthier.

But does that mean the popular shoestring fries won't taste the same? The company says no. "It's a win-win for our customers because they are getting the same great french-fry taste along with an even healthier nutrition profile," said Mike Roberts, president of McDonald's USA.

But others are not so sure. McDonald's will not specifically discuss the kind of oil it plans to use, but at least one nutrition expert says playing with the formula could mean a different taste.

Shares of Oak Brook, Ill.-based McDonald's (MCD: down $0.54 to $23.22, Research, Estimates) were lower Tuesday afternoon. It was unclear Tuesday whether competitors Burger King and Wendy's International (WEN: down $0.80 to $34.91, Research, Estimates) would follow suit.

Neither company could immediately be reached for comment.
Text representation

• Text representation
  – what makes a “good” representation?
  – how is a representation generated from text?
  – what are retrievable objects and how are they organized?

• Representing information needs
  – what is an appropriate query language?

• Comparing representations
  – what is a “good” model of retrieval?
Retrieval process

1. Information Need
   - Representation
   - Query

2. Text Objects
   - Representation
   - Indexed Objects

3. Comparison

4. Retrieved Objects

5. Evaluation/Feedback
Basic approaches

- Boolean: exact match vs. best match
- Geometric: vector space model
- Probabilistic: language models
- Graph-based: PageRank
Vector-space Model

- Represent documents and queries as vectors in the term space
- Issue: find the right coefficients...
- Use a geometric similarity measure, often angle-related
Example

- cat
- cat cat
- cat cat cat
- cat lion
- lion cat
- cat lion dog
- cat cat lion dog dog
Vector similarity: angles
Weights

Figure 2.1. A plot of the hyperbolic curve relating $f$, the frequency of occurrence and $r$, the rank order (Adapted from Schultz, page 120)
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Top online activities

- Email: 0.96
- Web Search: 0.88
- Product Info. Search: 0.72

- Total Internet users = 111 M
- Do a search on any given day = 33 M
- Have used Internet to search = 85%
Search on the web

- Corpus: The publicly accessible Web: static + dynamic
- Goal: Retrieve high quality results relevant to the user’s need – (not docs!)
- Need
  - **Informational** - want to learn about something (~40%)
  - **Navigational** - want to go to that page (~25%)
  - **Transactional** - want to do something (web-mediated) (~35%)
    - Access a service
    - Downloads
    - Shop
  - Gray areas
    - Find a good hub
    - Exploratory search “see what’s there”
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    - United Airlines
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    - Tampere weather
    - Mars surface images
    - Nikon CoolPix
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    - Downloads - **Mars surface images**
    - Shop - **Nikon CoolPix**
  - Gray areas
    - Find a good hub
    - Exploratory search “see what’s there” - **Car rental Finland**
Immense amount of content
- 10-20B static pages, doubling every 8-12 months
- Lexicon Size: 10s-100s of millions of words

Authors galore (1 in 4 hosts run a web server)
Diversity

- Languages/Encodings
  - Hundreds (thousands ?) of languages, W3C encodings: 55
  - Home pages (1997): English 82%, Next 15: 13%
  - Google (mid 2001): English: 53%

- Popular Query Topics (from 1M Google queries, 06/2000)

<table>
<thead>
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<th>Category</th>
<th>Percentage</th>
<th>Subcategory</th>
<th>Percentage</th>
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<td>Arts: Music</td>
<td>6.1%</td>
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<td>Computers</td>
<td>13.8%</td>
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<td>5.3%</td>
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<tr>
<td>Adult</td>
<td>8%</td>
<td>Computers: Internet</td>
<td>3.2%</td>
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<tr>
<td>Recreation</td>
<td>7.3%</td>
<td>Business: Industries</td>
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<td>7.2%</td>
<td>Regional: Europe</td>
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<tr>
<td>...</td>
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<td>...</td>
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</tr>
</tbody>
</table>
Rate of change

720K pages from 270 popular sites sampled daily from Feb 17 - Jun 14, 1999

Mathematically, what does this seem to be?

Figure 11: Change intervals for pages with the average change interval of 10 days

Figure 12: Percentage of pages with given average interval of change
Distributed authorship

- Millions of people creating pages with their own style, grammar, vocabulary, opinions, facts, falsehoods ...

- Not all have the purest motives in providing high-quality information - commercial motives drive “spamming” - 100s of millions of pages.
Web search users

- Ill-defined queries
  - Short
    - AV 2001: 2.54 terms avg, 80% 3 words or less
  - Imprecise terms
  - Sub-optimal syntax (80% queries without operator)
  - Low effort

- Specific behavior
  - 85% look over one result screen only (mostly above the fold)
  - 78% of queries are not modified (one query/session)
  - Follow links - “the scent of information” ...

- Wide variance in
  - Needs
  - Expectations
  - Knowledge
  - Bandwidth
Evolution of search engines

1995-1997 AV, Excite, Lycos, etc


present
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- First generation -- use only “on page”, text data
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  - Click-through data (What results people click on)
  - Anchor-text (How people refer to this page)

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- Third generation -- answer "the need behind the query"
  - Semantic analysis -- what is this about?
  - Focus on user need, rather than on query
  - Context determination
  - Helping the user
  - Integration of search and text analysis

1995-1997 AV, Excite, Lycos, etc


present
Second generation

- Ranking -- use off-page, web-specific data
  - Link (or connectivity) analysis
  - Click-through data (results people click on)
  - Anchor-text (how people refer to this page)

- Crawling
  - Algorithms to create the best possible corpus
Connectivity analysis

- Idea: Mine hyperlink information

- Assumptions:
  - Links often connect related pages
  - A link between pages is a recommendation "people vote with their links"
PageRank scoring
Imagine a browser doing a random walk on web pages...

"In the steady state" each page has a long-term visit rate - the PageRank score

PageRank scoring
PageRank summary

- Preprocessing:
  - Crawl web & create graph
  - Compute PageRank
  - Recompute often...

- Query processing:
  - Retrieve pages meeting query.
  - Rank them by PageRank.
  - Order is query-independent!

- Pagerank is a global property
  - Your pagerank score depends on “everybody” else
  - Harder to spam than simple popularity counting

- In reality: Hundreds of features (e.g., anchor text)
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Motives
- Commercial, political, religious, lobbies
- Promotion funded by advertising budget

Operators
- Contractors (Search Engine Optimizers)
- Web masters
- Hosting services

Forum
- Web master world (www.webmasterworld.com)
  - Search engine specific tricks
  - Discussions about academic papers 😊
A few spam technologies

- **Cloaking**
  - Serve fake content to search engine robot
  - DNS cloaking: Switch IP address. Impersonate
- **Doorway pages**
  - Pages optimized for a single keyword that re-direct to the real target page
- **Keyword Spam**
  - Misleading meta-keywords, excessive repetition of a term, fake “anchor text”
  - Hidden text with colors, CSS tricks, etc.
- **Link spamming**
  - Mutual admiration societies, hidden links, awards
  - Domain flooding: numerous domains that point or re-direct to a target page
- **Robots**
  - Fake click stream
  - Fake query stream
  - Millions of submissions via Add-Url

**Meta-keywords** =

“... London hotels, hotel, holiday inn, hilton, discount, booking, reservation, sex, mp3, britney spears, viagra, …”
The war against spam

• Quality signals - Prefer authoritative pages based on:
  - Votes from authors (linkage signals)
  - Votes from users (usage signals)

• Policing of URL submissions
  - Anti robot test

• Limits on meta-keywords

• Robust link/text analysis
  - Ignore statistically implausible linkage (or text)
  - Use link analysis to detect spammers (guilt by association)

• Spam recognition by machine learning
  - Training set based on known spam

• Family friendly filters
  - Linguistic analysis, general classification techniques, etc.
  - For images: flesh tone detectors, source text analysis, etc.

• Editorial intervention
  - Blacklists
  - Top queries audited
  - Complaints addressed
Google Bombs

Anchor text “link” spam...

- Biography of President George W. Bush
  Biography of the president from the official White House web site.
  www.whitehouse.gov/president/gwbio.html - 29k - Cached - Similar pages
  Past Presidents - Kids Only - Current News - President
  More results from www.whitehouse.gov »

- Welcome to MichaelMoore.com!
  Official site of the gadfly of corporations, creator of the film Roger and Me
  and the television show The Awful Truth. Includes mailing list, message board, ...
  www.michaelmoore.com/ - 35k - Sep 1, 2005 - Cached - Similar pages

- BBC NEWS | Americas | Miserable failure' links to Bush
  Web users manipulate a popular search engine so an unflattering description leads
  to the president's page.
  news.bbc.co.uk/2/h/americas/3298443.stm - 31k - Cached - Similar pages

- Google's (and Inktomi's) Miserable Failure
  A search for miserable failure on Google brings up the official George W.
  Bush biography from the US White House web site. Dismissed by Google as not a ...
  searchenginewatch.com/sereport/article.php/3296101 - 45k - Sep 1, 2005 - Cached - Similar pages
Google Bombs Live Demo...
Conclusions

- Web search is hard:
  - Web is vast, growing, and changing constantly
  - Bottleneck in specification of information need

- NextGen IR:
  - Multimedia (all info, all the time)
  - NLP & specification of information needs
  - Spam, spam, spam...