# Introduction to Information Retrieval

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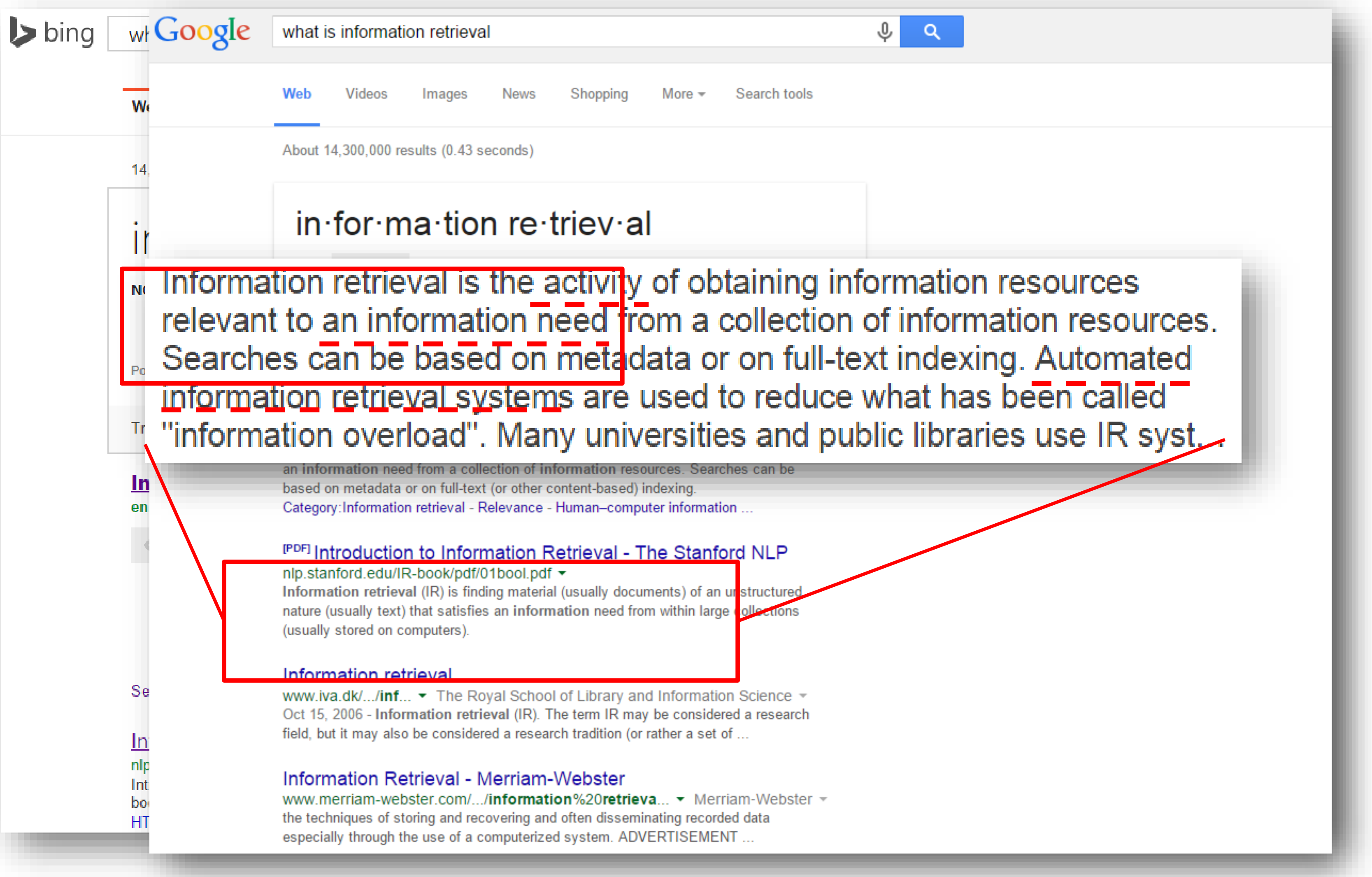
CS@UVa

# What is information retrieval?



About 14,300,000 results (0.43 seconds)

in·for·ma·tion re·triev·al

Information retrieval is the activity of obtaining information resources relevant to an information need from a collection of information resources. Searches can be based on metadata or on full-text indexing. Automated information retrieval systems are used to reduce what has been called "information overload". Many universities and public libraries use IR syst...

an **information** need from a collection of **information** resources. Searches can be based on metadata or on full-text (or other content-based) indexing.
Category:Information retrieval - Relevance - Human–computer information ...

[PDF] Introduction to Information Retrieval - The Stanford NLP
nlp.stanford.edu/IR-book/pdf/01bool.pdf
**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).

Information retrieval
www.iva.dk/.../**inf**... The Royal School of Library and Information Science
Oct 15, 2006 - **Information retrieval** (IR). The term IR may be considered a research field, but it may also be considered a research tradition (or rather a set of ...

Information Retrieval - Merriam-Webster
www.merriam-webster.com/.../**information**%20**retrieva**... Merriam-Webster
the techniques of storing and recovering and often disseminating recorded data especially through the use of a computerized system. ADVERTISEMENT ...

# What is information retrieval?

- Apple’s vision 35 years ago

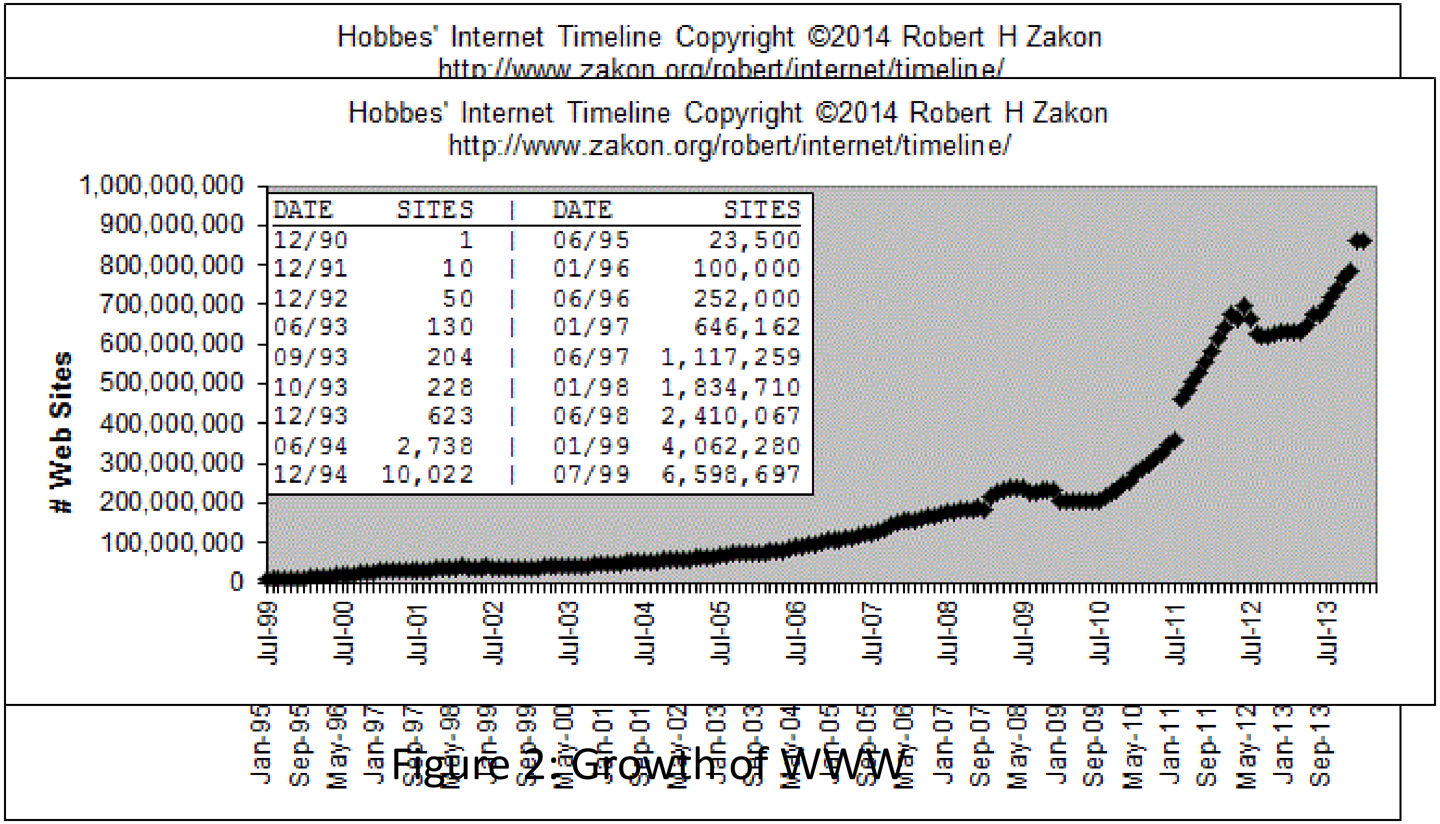
Knowledge Navigator

# Why information retrieval

- Information overload
  - *“It refers to the difficulty a person can have understanding an issue and making decisions that can be caused by the presence of too much information.”* - wiki

# Why information retrieval

- Information overload



| DATE | SITES | DATE | SITES |
|---|---|---|---|
| 12/90 | 1 | 06/95 | 23,500 |
| 12/91 | 10 | 01/96 | 100,000 |
| 12/92 | 50 | 06/96 | 252,000 |
| 06/93 | 130 | 01/97 | 646,162 |
| 09/93 | 204 | 06/97 | 1,117,259 |
| 10/93 | 228 | 01/98 | 1,834,710 |
| 12/93 | 623 | 06/98 | 2,410,067 |
| 06/94 | 2,738 | 01/99 | 4,062,280 |
| 12/94 | 10,022 | 07/99 | 6,598,697 |

Figure 2: Growth of WWW

Figure 1: Growth of Internet

# Why information retrieval

- Handling unstructured data
  - Structured data: database system is a good choice
  - Unst
    - Te lio, video…
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    - U

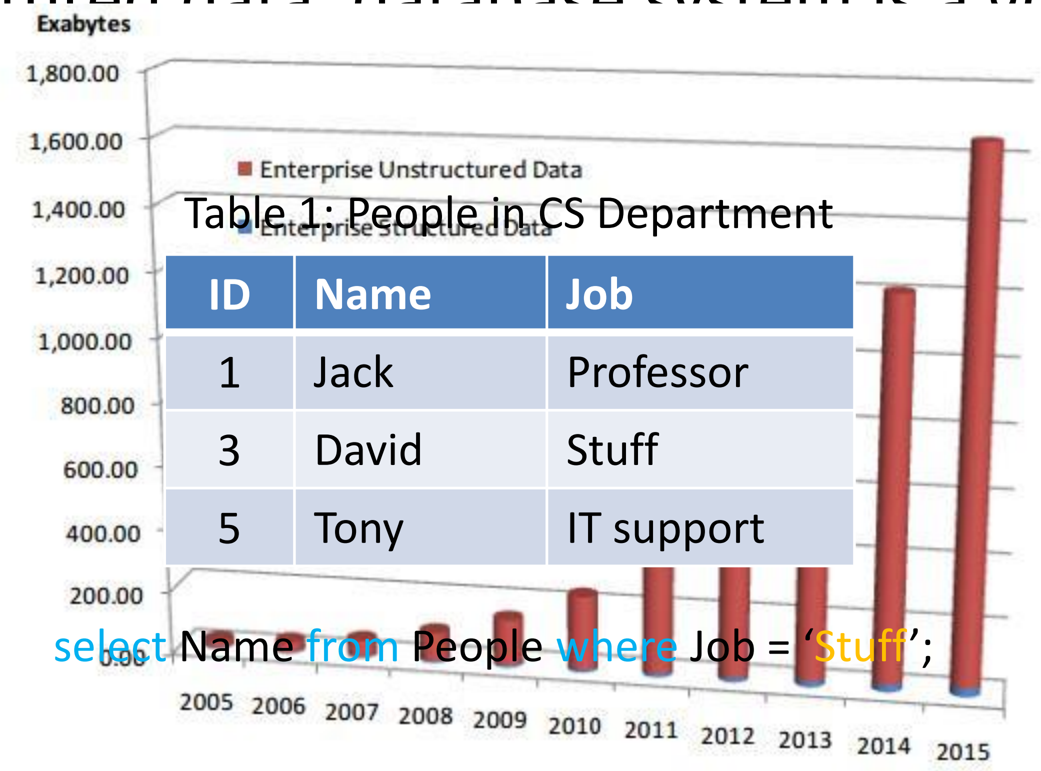


Table 1: People in CS Department

| ID | Name | Job |
|---|---|---|
| 1 | Jack | Professor |
| 3 | David | Stuff |
| 5 | Tony | IT support |

select Name from People where Job = ‘Stuff’;

Total Enterprise Data Growth 2005-2015, IDC 2012

# Why information retrieval

- An essential tool to deal with information overload

You are here!

# History of information retrieval

- Idea popularized in the pioneer article “***As We May Think***” by Vannevar Bush, 1945
  - *“Wholly new forms of encyclopedias will appear, ready-made with a mesh of associative trails running through them, ready to be dropped into the memex and there amplified.”* **-> WWW**
  - *“A memex is a device in which an individual stores all his books, records, and communications, and which is mechanized so that it may be consulted with exceeding speed and flexibility.”* **-> Search engine**

# Major research milestones

- Early days (late 1950s to 1960s): foundation of the field
  - Luhn’s work on automatic indexing
  - Cleverdon’s Cranfield evaluation methodology and index experiments
  - Salton’s early work on SMART system and experiments
- 1970s-1980s: a large number of retrieval models
  - Vector space model
  - Probabilistic models
- 1990s: further development of retrieval models and new tasks
  - Language models
  - TREC evaluation
  - Web search
- 2000s-present: more applications, especially Web search and interactions with other fields
  - Learning to rank
  - Scalability (e.g., MapReduce)
  - Real-time search

# History of information retrieval

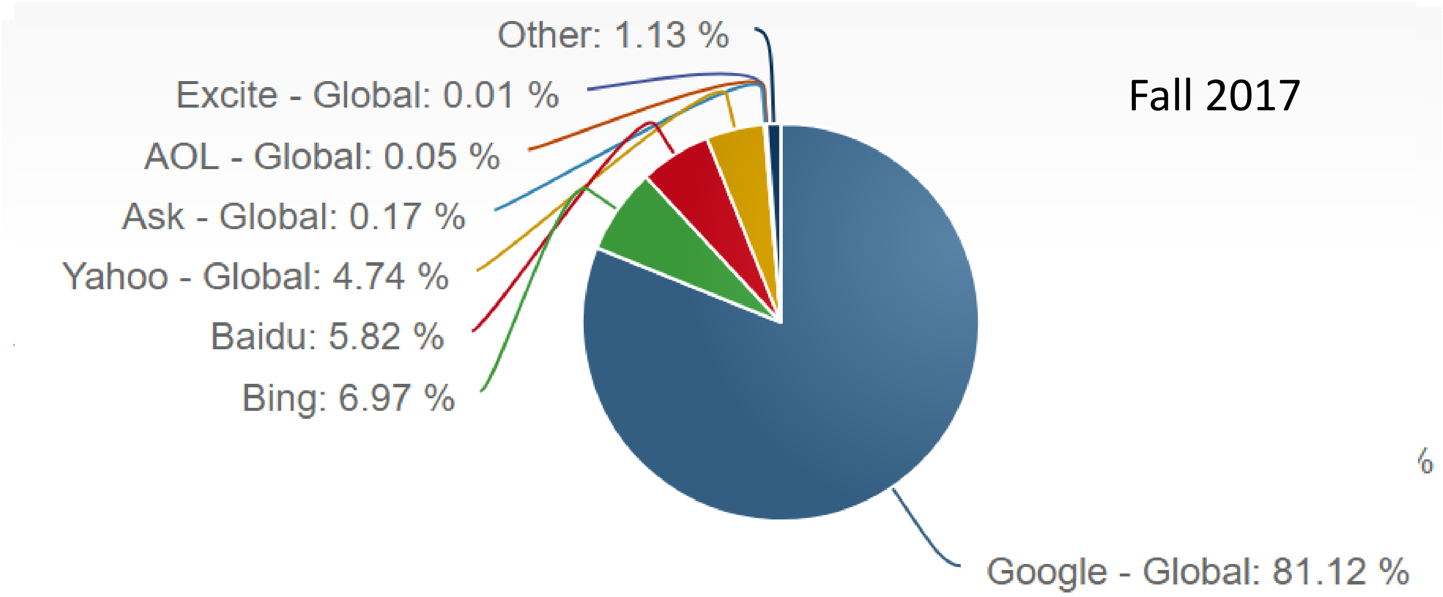
- Catalyst
  - Academia: Text Retrieval Conference (TREC) in 1992
    - *"Its purpose was to support research within the information retrieval community by providing the infrastructure necessary for large-scale <u>evaluation</u> of text retrieval methodologies."*
    - *"… about <u>one-third</u> of the improvement in web search engines from 1999 to 2009 is attributable to TREC. Those enhancements likely saved up to <u>3 billion hours</u> of time using web search engines*."
    - Till today, it is still a major test-bed for academic research in IR

# History of information retrieval

- Catalyst
  - Industry: web search engines
    - WWW unleashed explosion of published information and drove the innovation of IR techniques
    - First web search engine: “*Oscar Nierstrasz at the University of Geneva wrote a series of Perl scripts that periodically mirrored these pages and rewrote them into a standard format*.” Sept 2, 1993
    - Lycos (started at CMU) was launched and became a major commercial endeavor in 1994
    - Booming of search engine industry: *Magellan*, *Excite*, *Infoseek*, *Inktomi*, *Northern Light*, *AltaVista*, *Yahoo!*, *Google*, and *Bing*

# Major players in this game

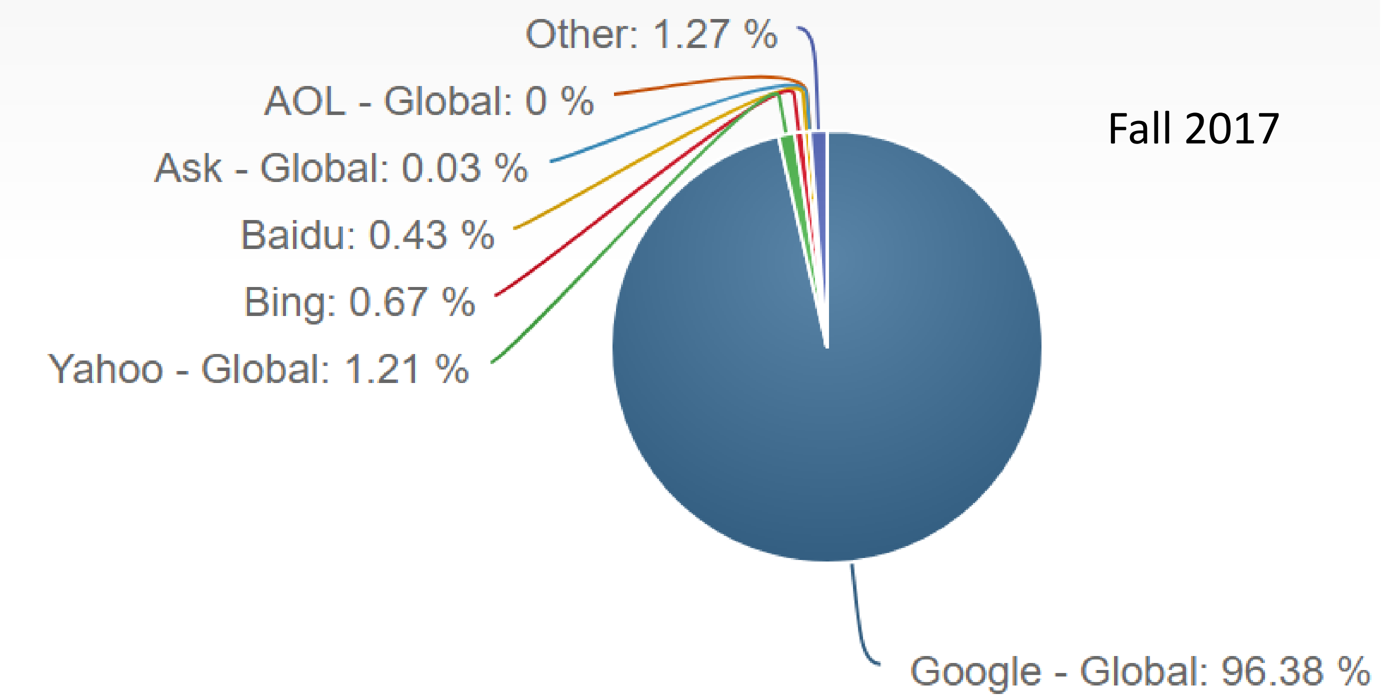
- Global search engine market - desktop
  - By http://marketshare.hitslink.com/search-engine-market-share.aspx



Fall 2017

# Major players in this game

- Global search engine market - mobile
  - By http://marketshare.hitslink.com/search-engine-market-share.aspx



Fall 2017

# How to perform information retrieval

- Information retrieval when we did not have a computer

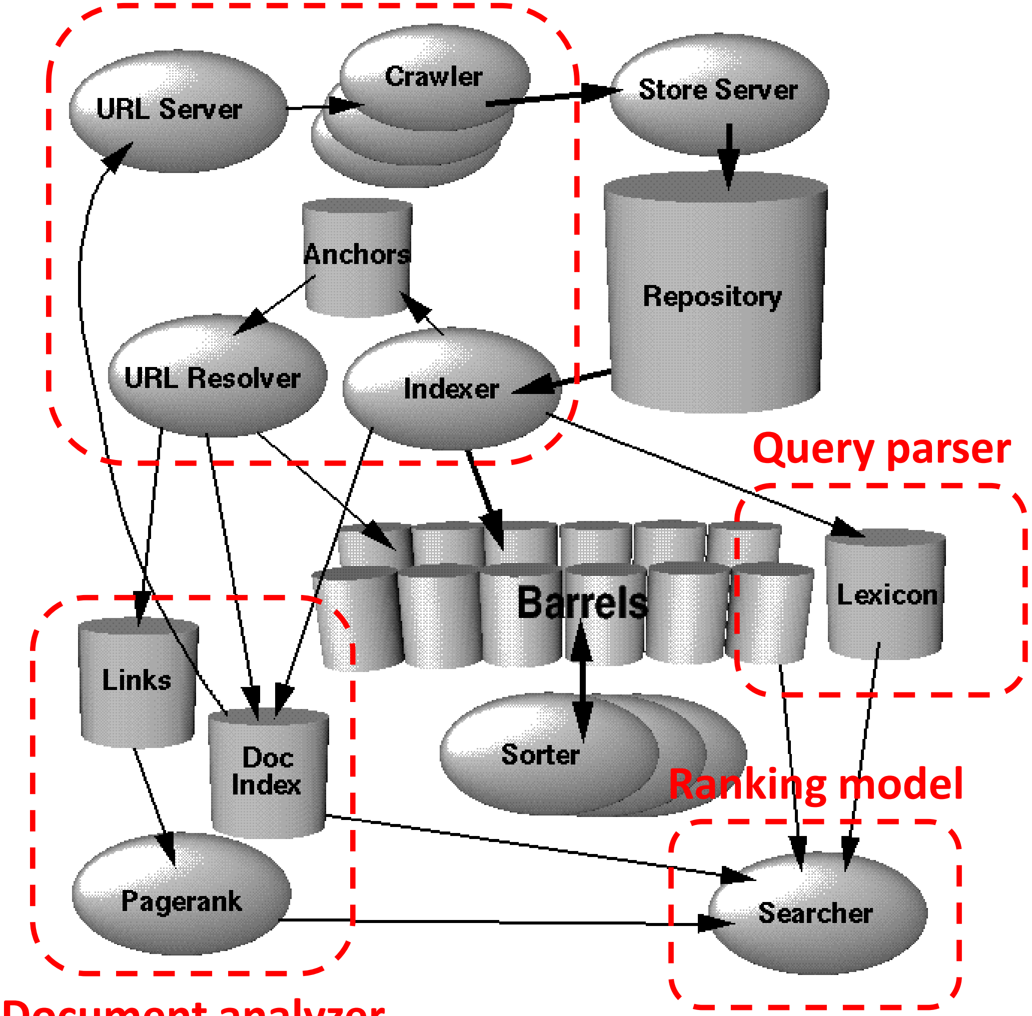
# Welcome back

- We will start our discussion at 2pm
- sli.do event code: 32233
- TA's office hour has been finalized at Mon/Wed, 1pm-2pm, via zoom, by appointment

# Recap: why information retrieval

- Handling unstructured data
  - Structured data: database system is a good choice
  - Unstructured data is more dominant
    - Text in Web documents or emails, image, audio, video…
    - "*85 percent of all business information exists as unstructured data*" - Merrill Lynch
    - Unknown semantic meaning

# How to perform information retrieval



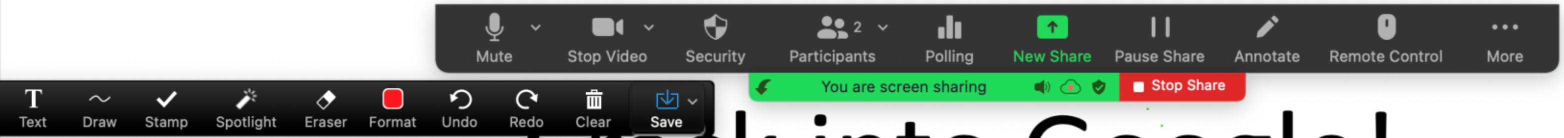
Crawler and indexer

Query parser

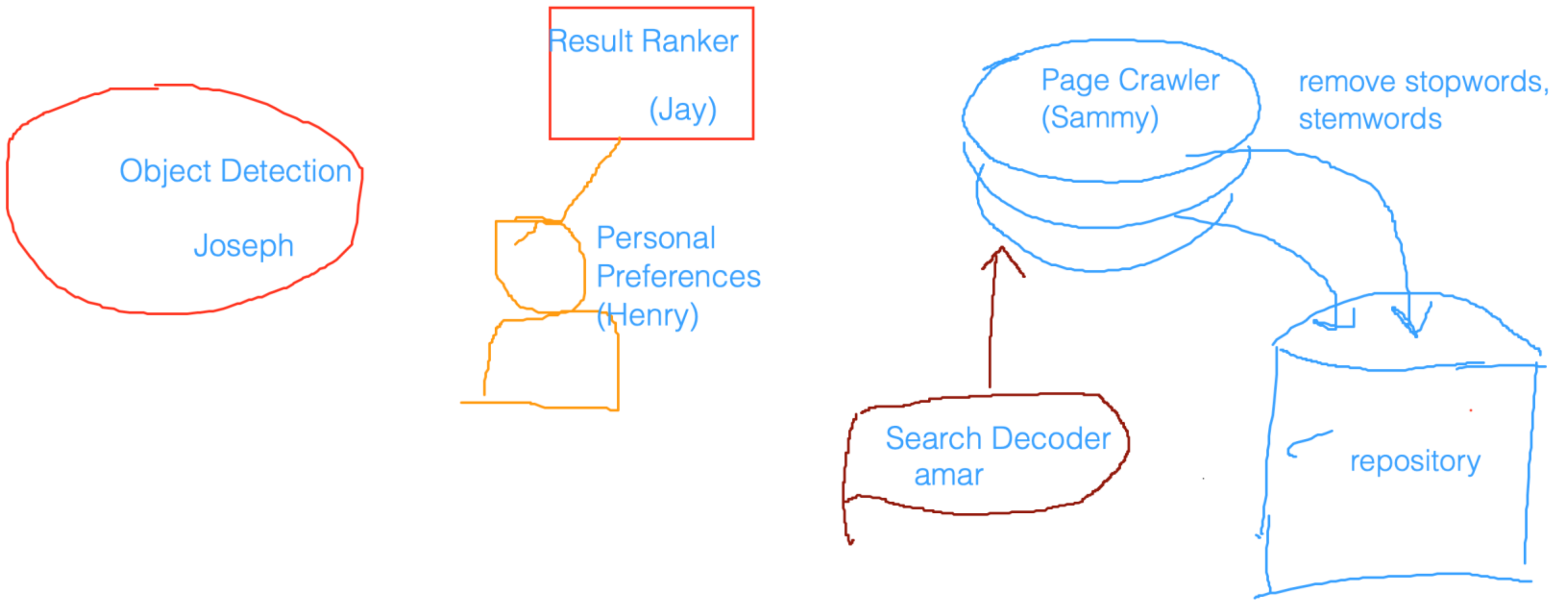
Ranking model

Document analyzer

# Crack into Google!



# Crack into Google!



Result Ranker (Jay)

Object Detection Joseph

Personal Preferences (Henry)

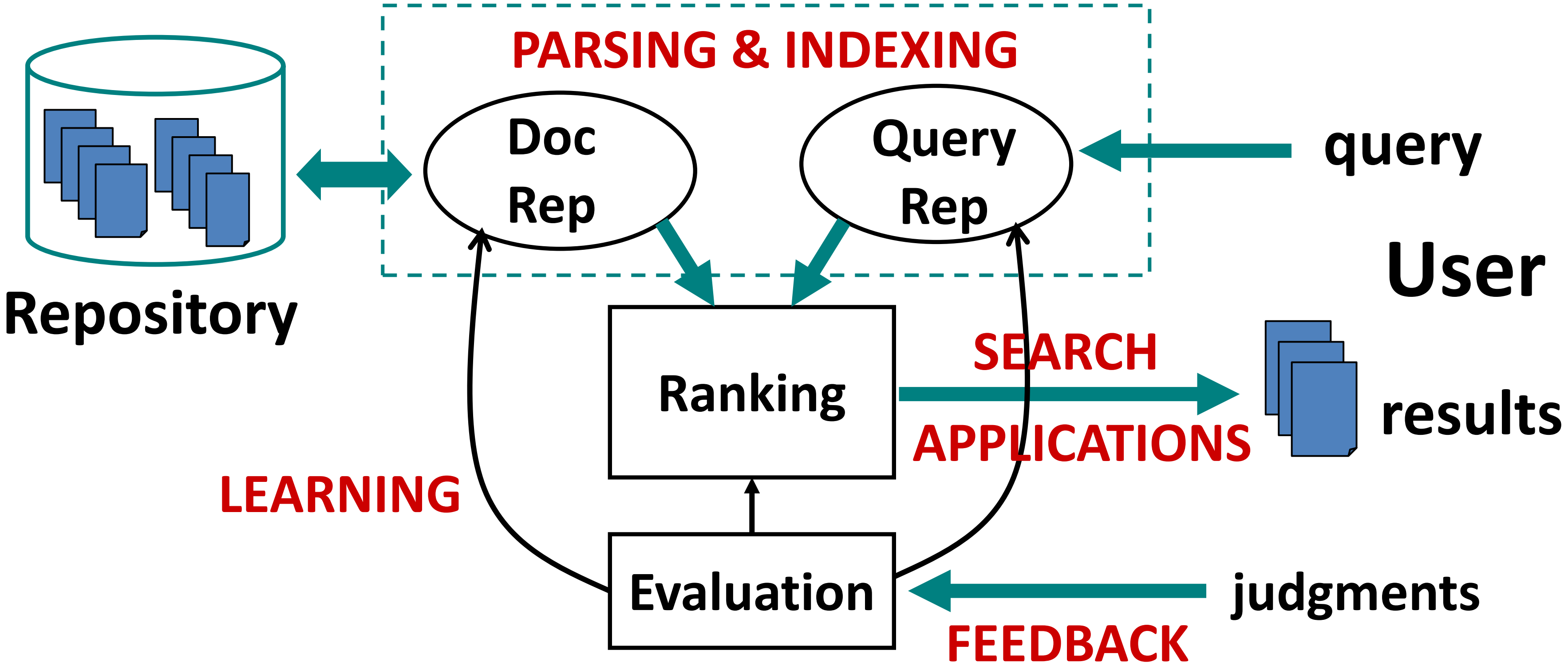
Page Crawler (Sammy)

remove stopwords, stemwords

Search Decoder amar

repository

# How to perform information retrieval



**We will cover:**

1) Search engine architecture; 2)Retrieval models;
3) Retrieval evaluation; 4) Relevance feedback;
5) Link analysis; 6) Search applications.

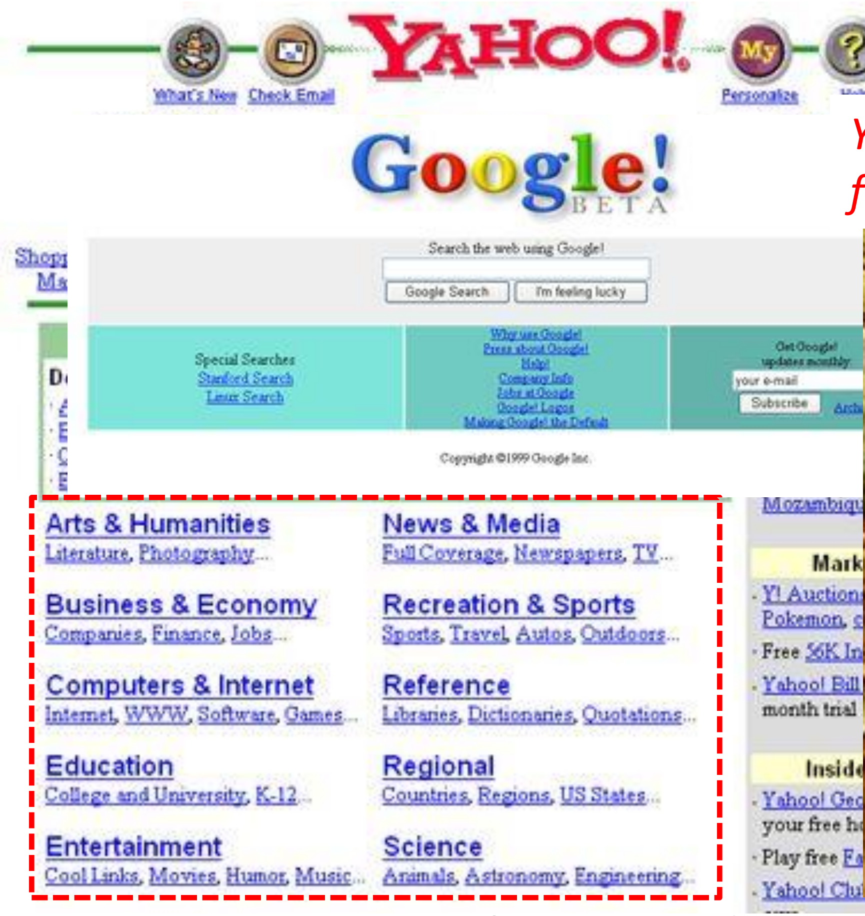
# Core concepts in IR

- Query representation
  - Lexical gap: say v.s. said
  - Semantic gap: ranking model v.s. retrieval method
- Document representation
  - Special data structure for efficient access
  - Lexical gap and semantic gap
- Retrieval model
  - Algorithms that find the ***most relevant*** documents for the given information need

# A glance of modern search engine

- In old times

*Yet Another **Hierarchical** Officious/Obstreperous/ Odiferous/Organized **Oracle***



What's New Check Email YAHOO! Personalize

Google! BETA

Search the web using Google!

Google Search I'm feeling lucky

Special Searches
Stanford Search
Linux Search

Why use Google!
Press about Google!
Help!
Company Info
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Making Google! the Default

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Cool Links, Movies, Humor, Music...

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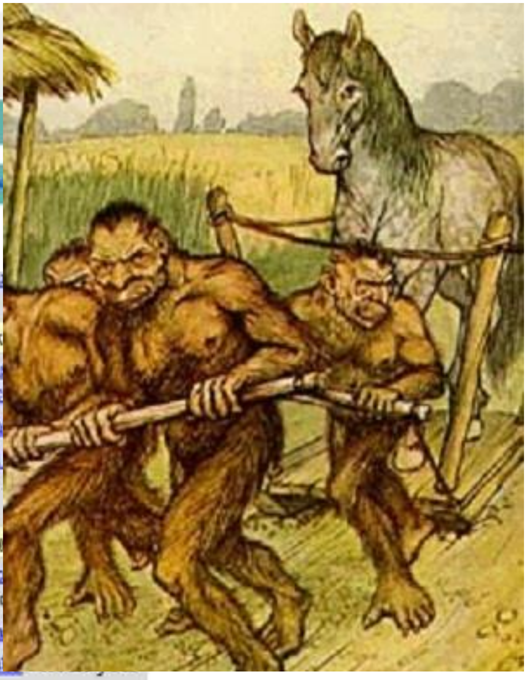
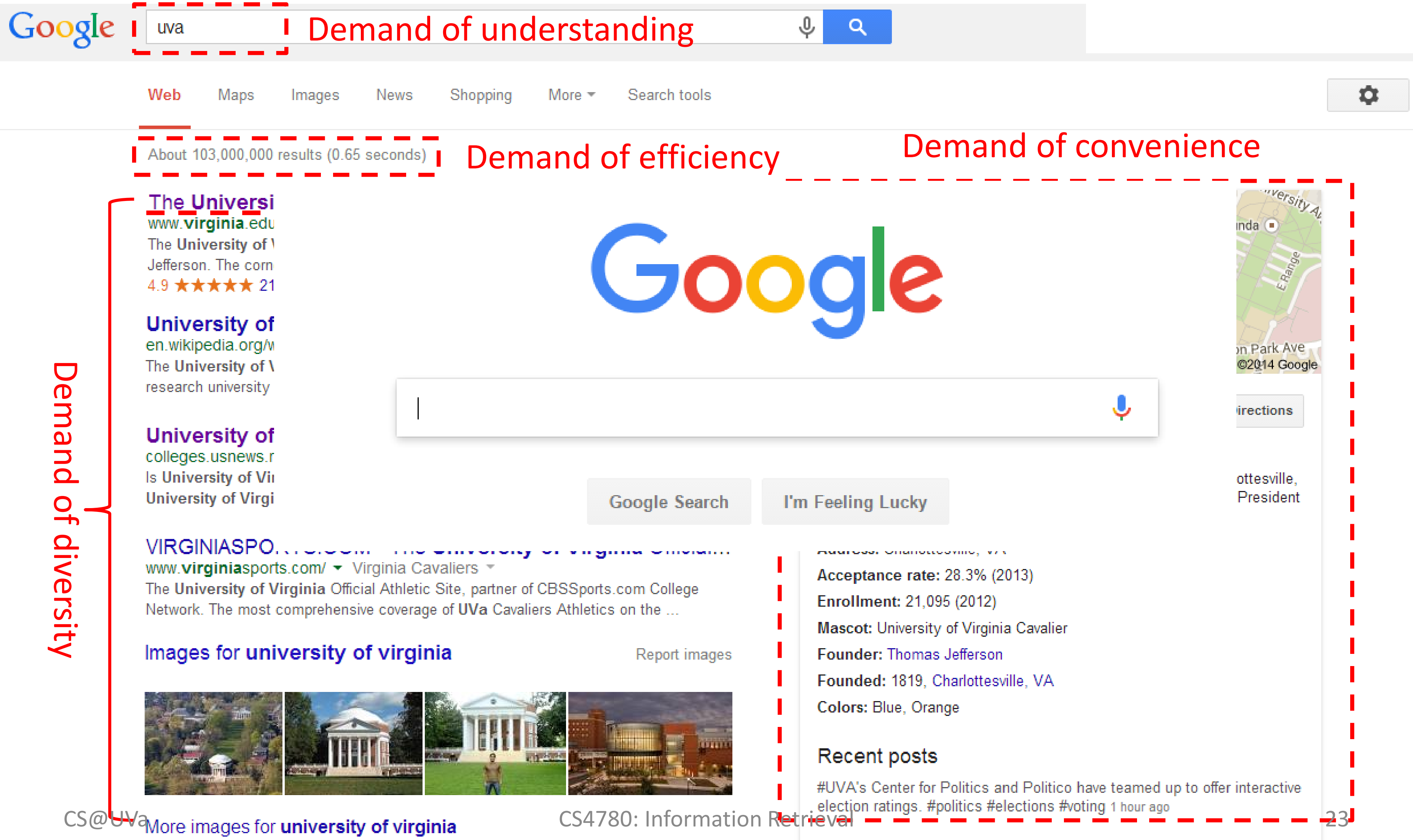
*Yahoo race of fictional beings from **Gulliver's Travels***



# A glance of modern search engine



Demand of understanding

Demand of efficiency

Demand of convenience

Demand of diversity

About 103,000,000 results (0.65 seconds)

The Universi
www.virginia.edu
The University of
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4.9 ★★★★★ 21

University of
en.wikipedia.org/w
The University of
research university

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colleges.usnews.r
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ottesville,
President

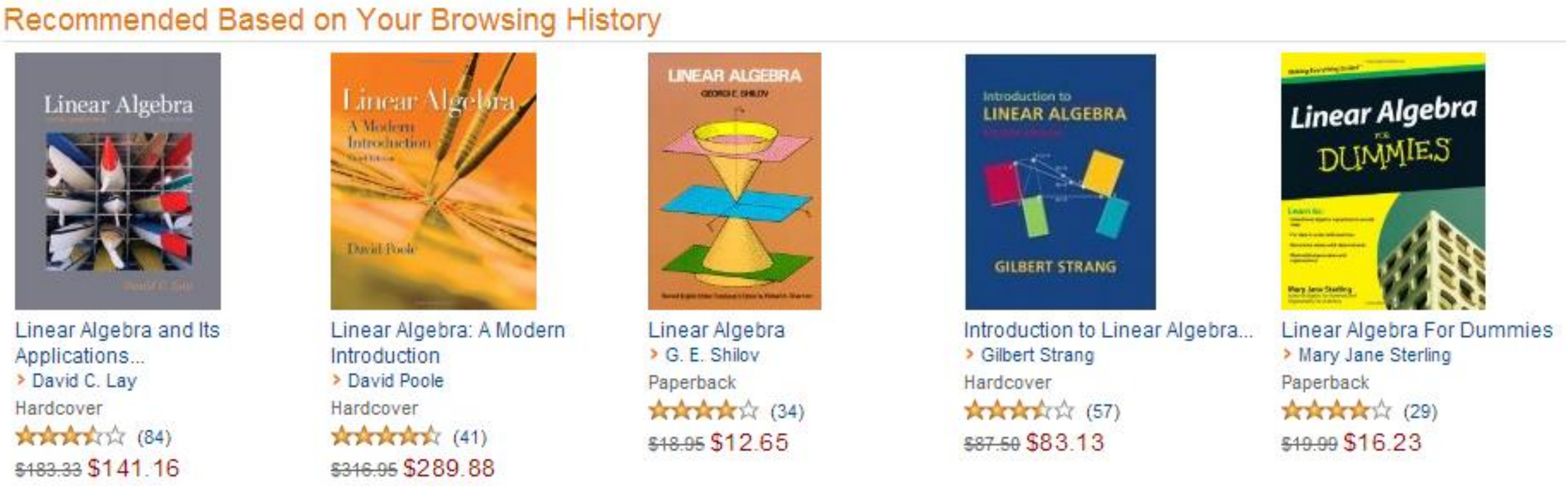
Address: Charlottesville, VA
Acceptance rate: 28.3% (2013)
Enrollment: 21,095 (2012)
Mascot: University of Virginia Cavalier
Founder: Thomas Jefferson
Founded: 1819, Charlottesville, VA
Colors: Blue, Orange

Recent posts

#UVA's Center for Politics and Politico have teamed up to offer interactive election ratings. #politics #elections #voting 1 hour ago

# IR is not just about web search

- Web search is just one important area of information retrieval, but not all
- Information retrieval also includes
  - Recommendation



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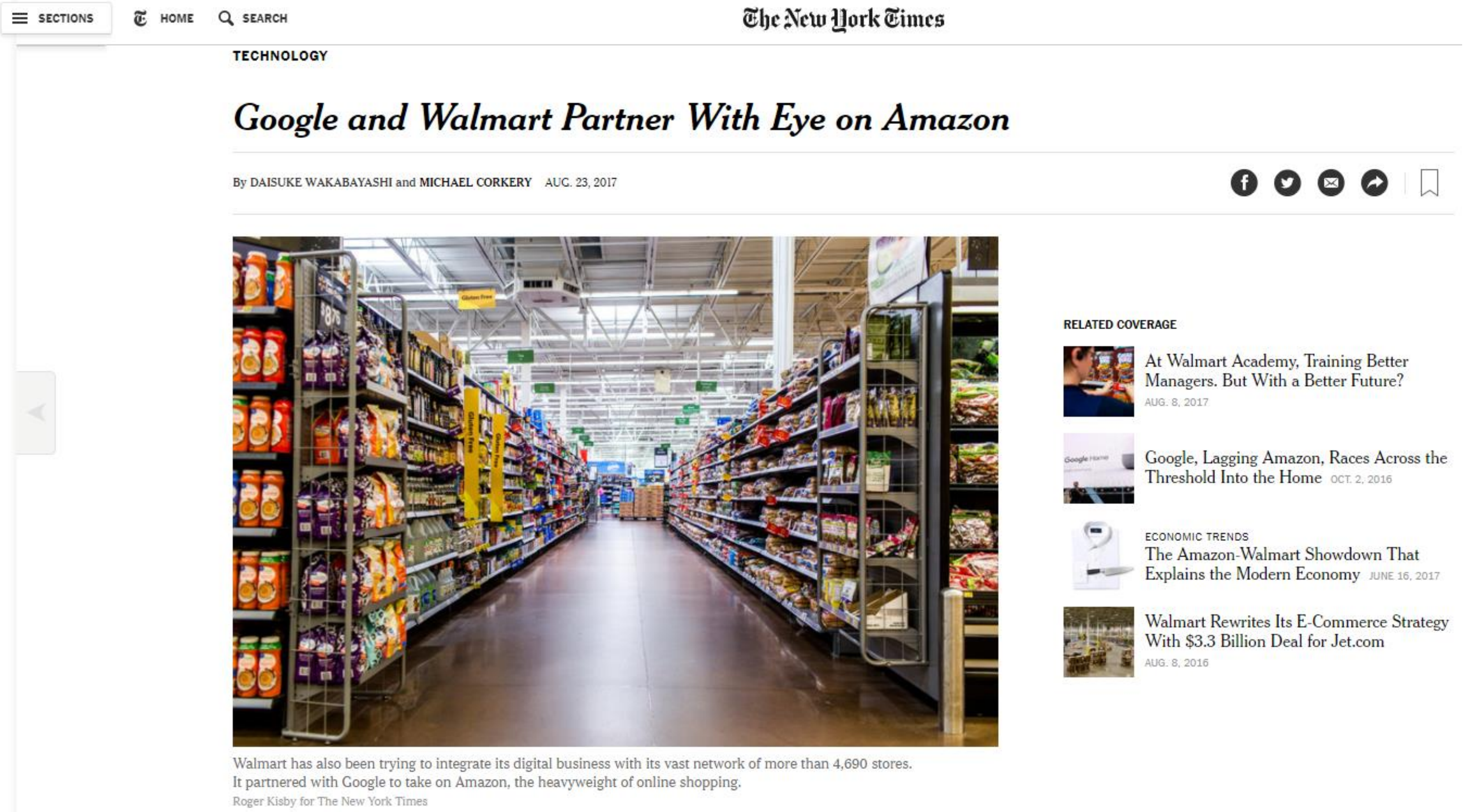
# IR is not just about web search



The New York Times

TECHNOLOGY

## *Google and Walmart Partner With Eye on Amazon*

By DAISUKE WAKABAYASHI and MICHAEL CORKERY AUG. 23, 2017

Walmart has also been trying to integrate its digital business with its vast network of more than 4,690 stores. It partnered with Google to take on Amazon, the heavyweight of online shopping.

Roger Kisby for The New York Times

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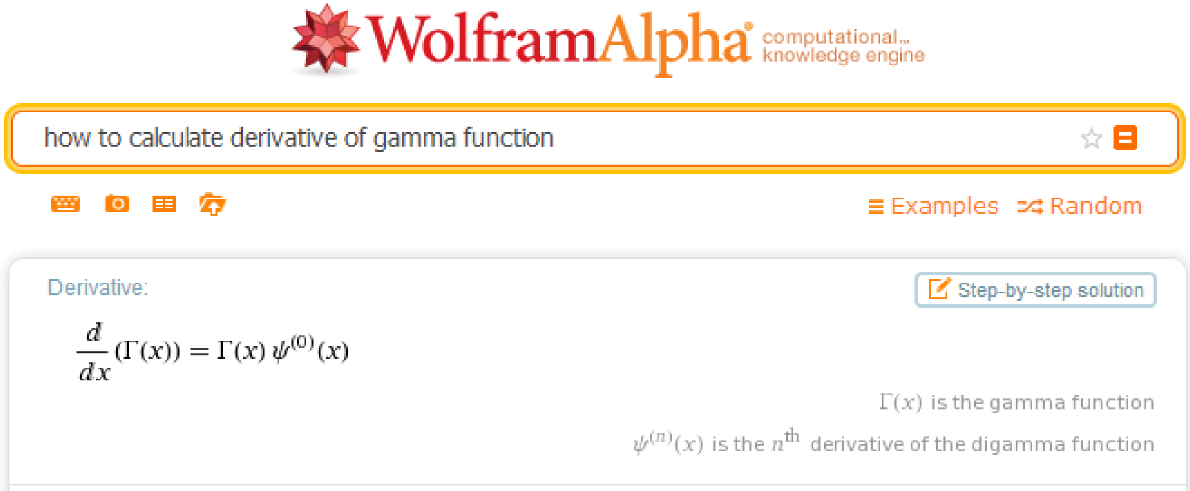
# IR is not just about web search

- Web search is just one important area of information retrieval, but not all
- Information retrieval also includes
  - Question answering



how to calculate derivative of gamma function

Derivative:

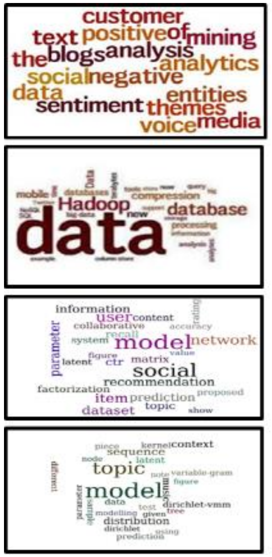
$$\frac{d}{dx}(\Gamma(x)) = \Gamma(x)\,\psi^{(0)}(x)$$

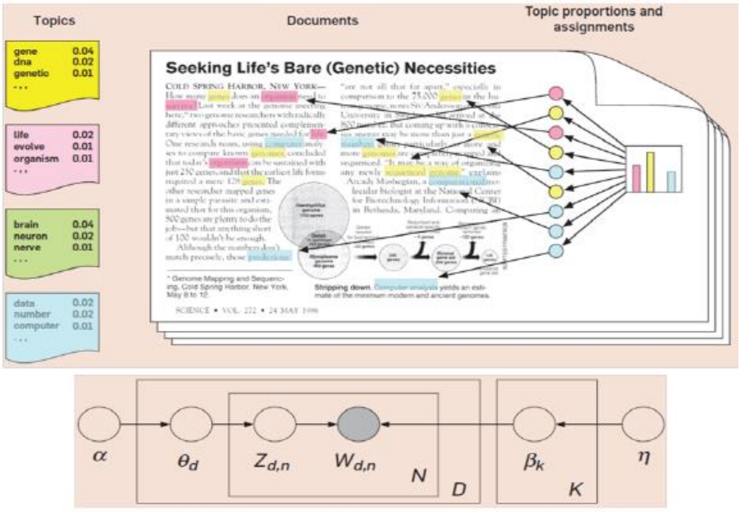
$\Gamma(x)$ is the gamma function

$\psi^{(n)}(x)$ is the $n^{\text{th}}$ derivative of the digamma function

# IR is not just about web search

- Web search is just one important area of information retrieval, but not all
- Information retrieval also includes
  - Text mining

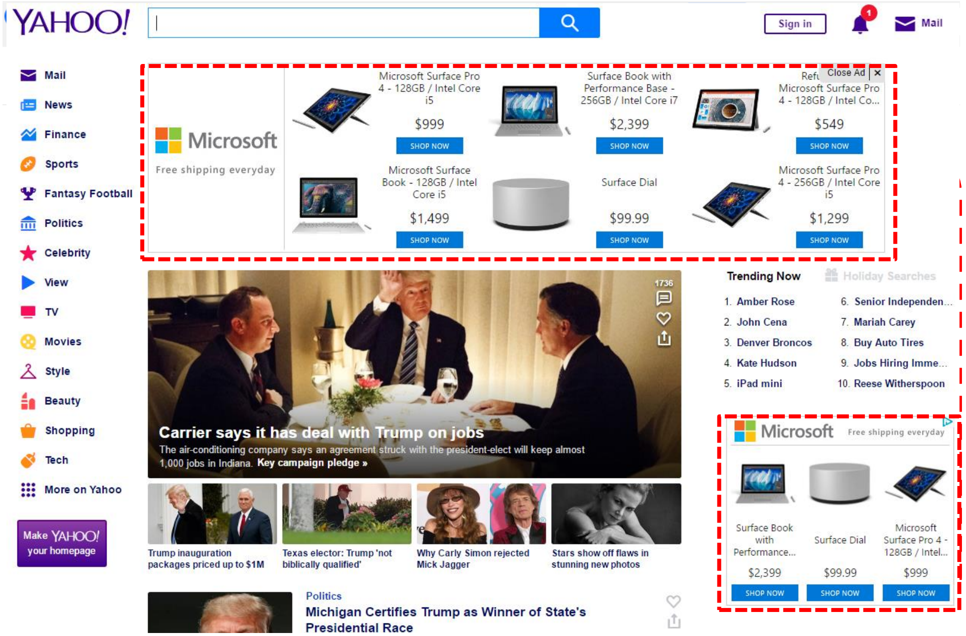




[D.M Blei, Probabilistic Topic Models. Communications of the ACM, 2012]

# IR is not just about web search

- Web search is just one important area of information retrieval, but not all
- Information retrieval also includes
  - Online advertising



Carrier says it has deal with Trump on jobs

The air-conditioning company says an agreement struck with the president-elect will keep almost 1,000 jobs in Indiana. Key campaign pledge »

Trump inauguration packages priced up to $1M

Texas elector: Trump 'not biblically qualified'

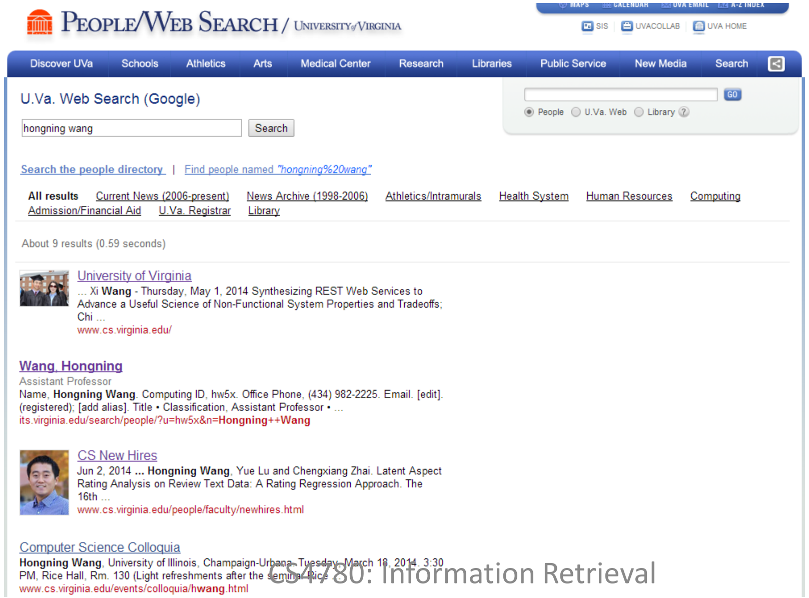
Why Carly Simon rejected Mick Jagger

Stars show off flaws in stunning new photos

Michigan Certifies Trump as Winner of State's Presidential Race

# IR is not just about web search

- Web search is just one important area of information retrieval, but not all
- Information retrieval also includes
  - Enterprise search: web search + desktop search



U.Va. Web Search (Google)

hongning wang

Search the people directory | Find people named *"hongning%20wang"*

**All results** Current News (2006-present) News Archive (1998-2006) Athletics/Intramurals Health System Human Resources Computing Admission/Financial Aid U.Va. Registrar Library

About 9 results (0.59 seconds)

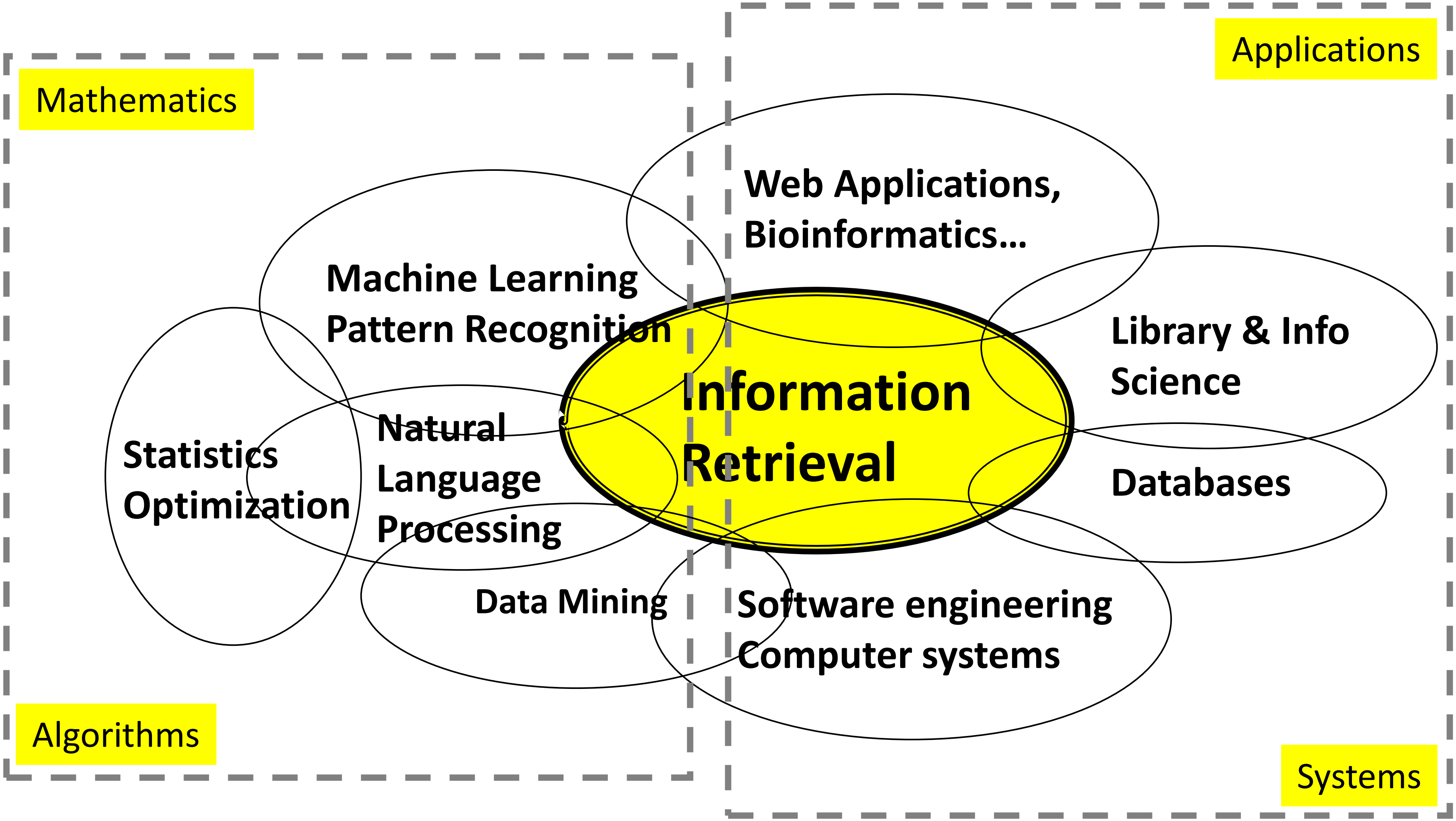
University of Virginia
... Xi **Wang** - Thursday, May 1, 2014 Synthesizing REST Web Services to Advance a Useful Science of Non-Functional System Properties and Tradeoffs; Chi ...
www.cs.virginia.edu/

**Wang, Hongning**
Assistant Professor
Name, **Hongning Wang**. Computing ID, hw5x. Office Phone, (434) 982-2225. Email. [edit]. (registered); [add alias]. Title • Classification, Assistant Professor • ...
its.virginia.edu/search/people/?u=hw5x&n=**Hongning++Wang**

CS New Hires
Jun 2, 2014 **... Hongning Wang**, Yue Lu and Chengxiang Zhai. Latent Aspect Rating Analysis on Review Text Data: A Rating Regression Approach. The 16th ...
www.cs.virginia.edu/people/faculty/newhires.html

Computer Science Colloquia
**Hongning Wang**, University of Illinois, Champaign-Urbana. Tuesday, March 18, 2014. 3:30 PM, Rice Hall, Rm. 130 (Light refreshments after the seminar. Rice ...
www.cs.virginia.edu/events/colloquia/**hwang**.html

# Related Areas



Mathematics

Applications

Web Applications, Bioinformatics…

Machine Learning Pattern Recognition

Library & Info Science

Information Retrieval

Statistics Optimization

Natural Language Processing

Databases

Data Mining

Software engineering Computer systems

Algorithms

Systems

# IR v.s. DBs

- Information Retrieval:
  - Unstructured data
  - Semantics of objects are subjective
  - Simple keyword queries
  - Relevance-drive retrieval
  - Effectiveness is primary issue, though efficiency is also important

- Database Systems:
  - Structured data
  - Semantics of each object are well defined
  - Structured query languages (e.g., SQL)
  - Exact retrieval
  - Emphasis on efficiency

# IR and DBs are getting closer

- IR => DBs
  - Approximate search is available in DBs
  - Eg. in mySQL

```
mysql> SELECT * FROM articles
    -> WHERE MATCH (title,body)
       AGAINST ('database');
```

- DBs => IR
  - Use information extraction to convert unstructured data to structured data, e.g., knowledge base
  - Semi-structured representation: XML data; queries with structured information

# IR v.s. NLP

- Information retrieval
  - Computational approaches
  - Statistical (shallow) understanding of language
  - Handle large scale problems

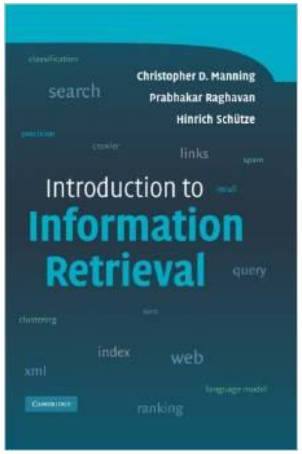
- Natural language processing
  - Cognitive, symbolic and computational approaches
  - Semantic (deep) understanding of language
  - (often times) small scale problems

# IR and NLP are getting closer

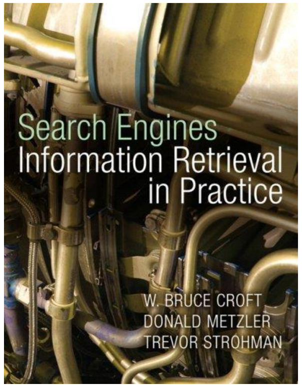
- IR => NLP
  - Larger data collections
  - Scalable/robust NLP techniques, e.g., translation models

- NLP => IR
  - Deep analysis of text documents and queries
  - Information extraction for structured IR tasks
  - Natural language based QA systems

# Text books

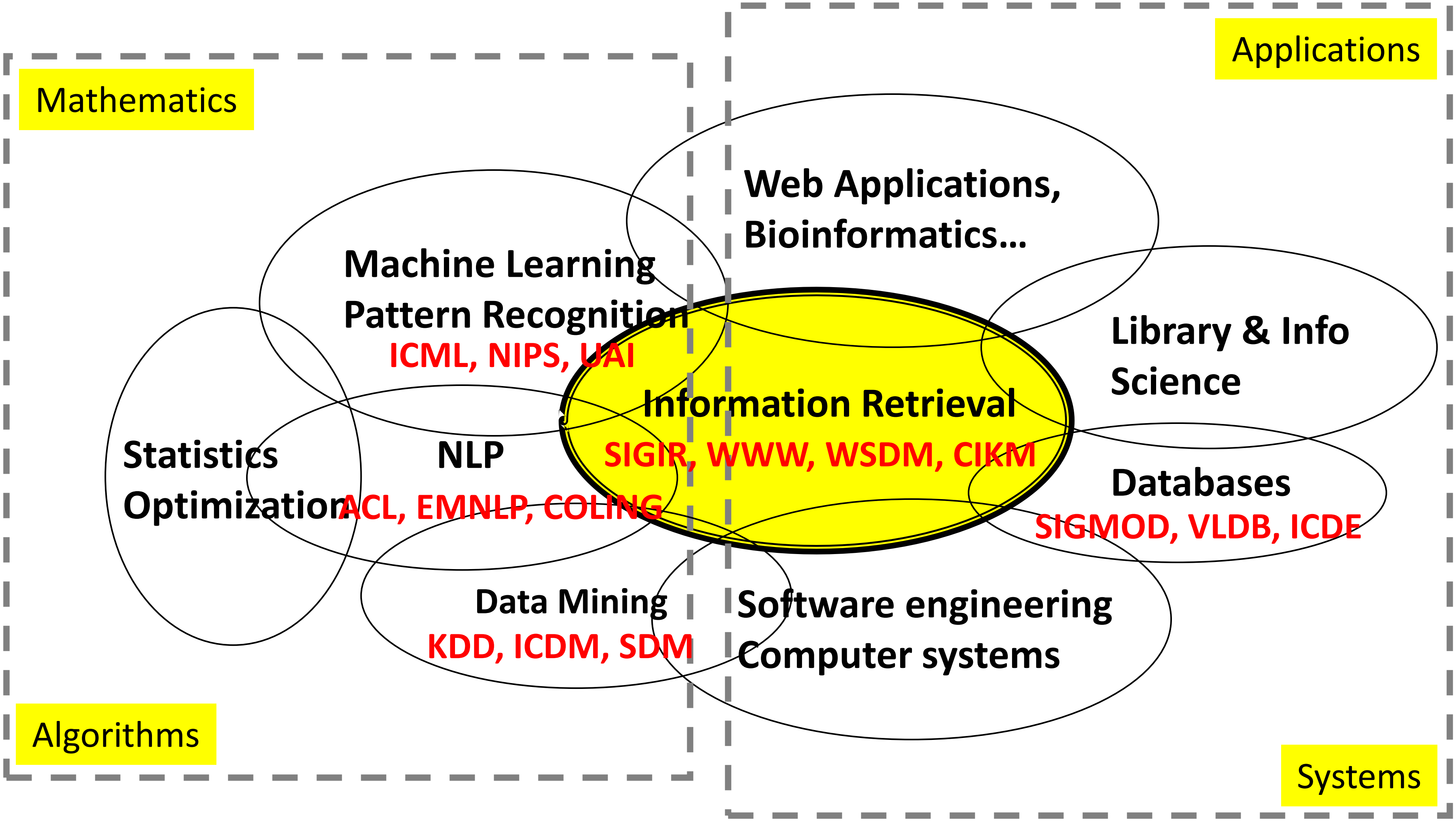


- ***Introduction to Information Retrieval***. Christopher D. Manning, Prabhakar Raghavan, and Hinrich Schuetze, Cambridge University Press, 2007.



- ***Search Engines: Information Retrieval in Practice***. Bruce Croft, Donald Metzler, and Trevor Strohman, Pearson Education, 2009.

# What to read?



- Find more on course website for resource

# IR in future

- Mobile search
  - Desktop search + location? Not exactly!!
- Interactive retrieval
  - Machine collaborates with human for information access
- Personal assistant
  - Proactive information retrieval
  - Knowledge navigator
- And many more
  - You name it!

# What you should know

- IR originates from library science for handling unstructured data
- IR has many important application areas, e.g., web search, recommendation, and question answering
- IR is a highly interdisciplinary area with DBs, NLP, ML, HCI

# Today's reading

- *Bush, Vannevar. "As we may think." The atlantic monthly 176, no.1 (1945): 101-108.*
- Introduction to Information Retrieval
  - Chapter 1: Boolean Retrieval