

Part I

Entity Linking

Outline

- Entity Linking
 - introduction
 - methods
 - evaluation
 - test collections
 - toolkits
 - open challenges

Introduction

Image taken from Mihalcea and Csomai (2007). Wikify!: linking documents to encyclopedic knowledge. In CIKM '07.

The screenshot shows the Wikipedia page for 'Plant'. At the top, there are tabs for 'article', 'discussion', 'edit this page', and 'history'. Below the title 'Plant' is the text 'From Wikipedia, the free encyclopedia'. A green callout box points to the text 'Plants are a major group of living things including familiar organisms such as trees, flowers, herbs, ferns, and mosses.' Another green callout box points to the text 'About 350,000 species of plants, defined as seed plants, bryophytes, ferns and fern allies, have been estimated to exist. As of 2004, some 287,655 species had been identified, of which 258,650 are flowering and 15,000 bryophytes.' To the right of the main text is a sidebar with a tree image and the text 'Tree' and 'Fossil range: Middle-Late Ordovician - Recent'. Below the main text is a large image of a fern frond. To the right of the fern image is a sidebar with a green header 'Species' and the text 'Species' and 'In biology, a species is one of the basic units of biodiversity. In classification, a species is assigned a two-part name, first the genus is listed first (with its leading letter capitalized), followed by the species. For example, humans belong to the genus *Homo*, and species *Homo sapiens*. The name of the species is the whole second term. [Species](#)'.

**Let's learn something about
Spin-Optical Metamaterial**

REPORT

Spin–Optical Metamaterial Route to Spin–Controlled Photonics

Nir Shitrit, Igor Yulevich, Elhanan Maguid, Dror Ozeri, Dekel Veksler, Vladimir Kleiner, Erez Hasman*

 Author Affiliations

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ABSTRACT

EDITOR'S SUMMARY

Spin optics provides a route to control light, whereby the photon helicity (spin angular momentum) degeneracy is removed due to a geometric gradient onto a metasurface. The alliance of spin optics and metamaterials offers the dispersion engineering of a structured matter in a polarization helicity-dependent manner. We show that polarization-controlled optical modes of metamaterials arise where the spatial inversion symmetry is violated. The emerged spin-split dispersion of spontaneous emission originates from the spin-orbit interaction of light, generating a selection rule based on symmetry restrictions in a spin-optical metamaterial. The inversion asymmetric metasurface is obtained via anisotropic optical antenna patterns. This type of metamaterial provides a route for spin-controlled nanophotonic applications based on the design of the metasurface symmetry properties.

Received for publication 7 January 2013.



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Degenerate energy levels – Wikipedia, the free encyclopedia

W en.wikipedia.org/wiki/Degenerate_energy_level

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Input Text

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momentum) degeneracy of spin optical modes of matter in a polarized interaction of light optical metamaterials optical antenna pads nanophotonic applications

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Tagged text Topics

Spin optics provides momentum) degeneracy of spin optical modes of matter in a polarized interaction of light optical metamaterials optical antenna pads nanophotonic applications

Article Talk Read Edit View history

Degenerate energy levels

From Wikipedia, the free encyclopedia
(Redirected from Degenerate energy level)

This article is about different quantum states having the same energy. For other uses, see Degeneracy.
"Quantum degeneracy" redirects here. It sometimes refers to a degenerate matter.

 This article needs additional citations for verification. Please help improve this article by adding citations to reliable sources. Unsourced material may be challenged and removed. (February 2009)

In quantum mechanics, a branch of physics, two or more different states of a system are said to be degenerate if they are all at the same energy level. It is represented mathematically by the system having more than one linearly independent eigenstate with the same eigenvalue. Conversely, an energy level is said to be degenerate if it contains two or more different states at a particular energy level is called the level's degeneracy, and this phenomenon is generally known as a quantum degeneracy.

From the perspective of quantum statistical mechanics, several degenerate states at the same level are all equally probable of being filled.

Contents [hide]

- 1 Mathematics
- 2 Examples
- 3 Perturbation
- 4 See also
- 5 Further reading

Mathematics

The term comes from the fact that, for a point spectrum Hamiltonian H , degenerate eigenstates correspond to identical eigenvalues. Since eigenvalues correspond to roots of the characteristic polynomial, the degeneracy here has the same meaning as the common mathematical usage of the word.

The eigenvalue λ is called nondegenerate (or simple) when its corresponding eigenvector is unique up to a constant factor, or, the same, the corresponding eigenspace is one-dimensional. Indeed, the eigenspace $\{|\psi\rangle : H|\psi\rangle = \lambda|\psi\rangle\}$ (in bra-ket notation) is not necessarily one-dimensional. If there exist at least two linearly independent ket-vectors in it, then this eigenvalue is called degenerate. Its degree of degeneracy is then the dimension of the eigenspace, which is the same as the number of distinct (linearly independent) quantum states associated with it.

Examples

In atomic physics, electron's energy levels are often degenerate, where different possible occupation states for particles may be related by symmetry. For example, in the hydrogen atom, for a given principal quantum number n , there exist several states which have that energy, but differ in the eigenvalues of angular momentum L^2 , spin component S_z and so on. The eigenvalue of an operator which is invariant under a symmetry operation is called a quantum number.

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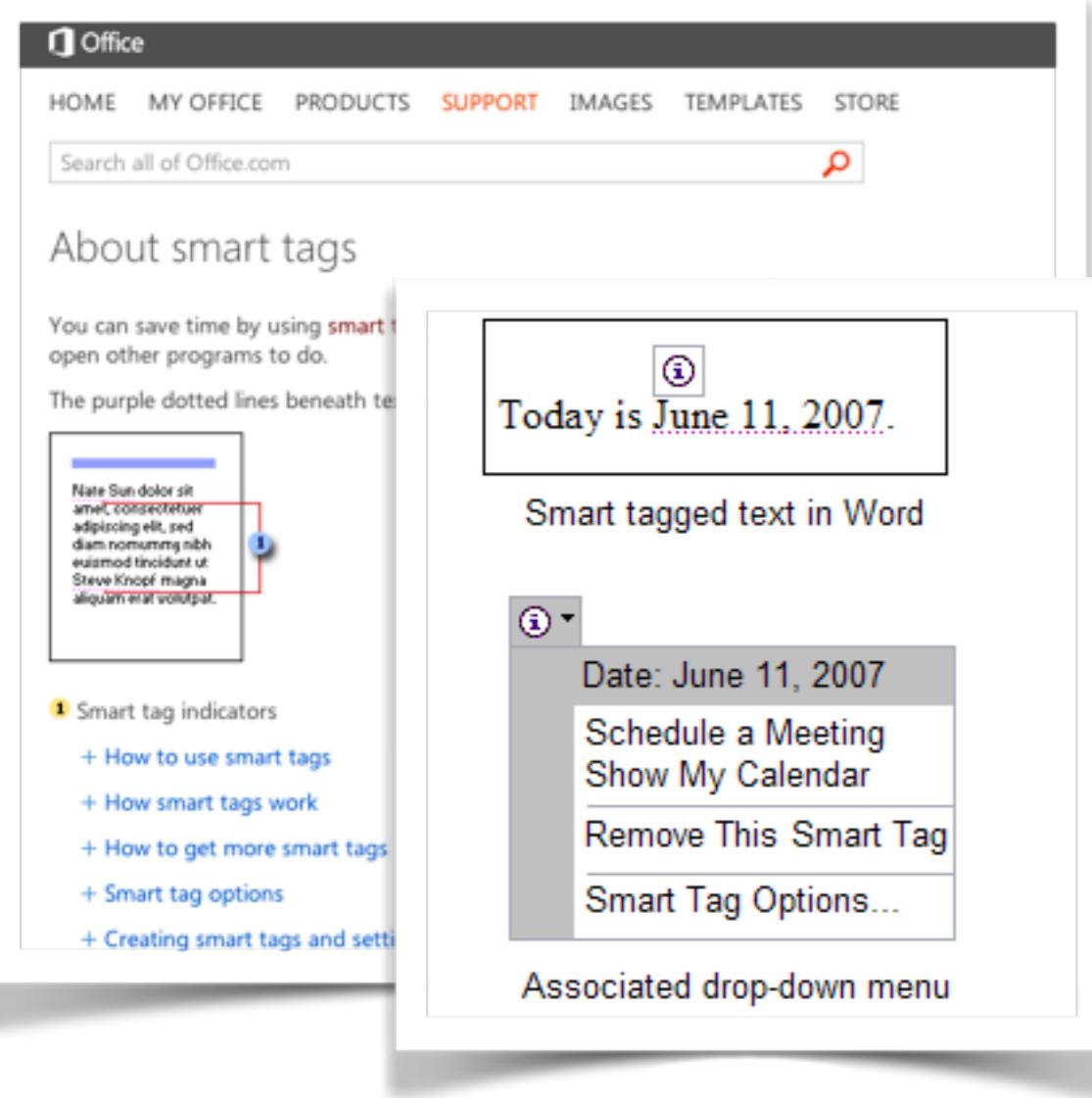
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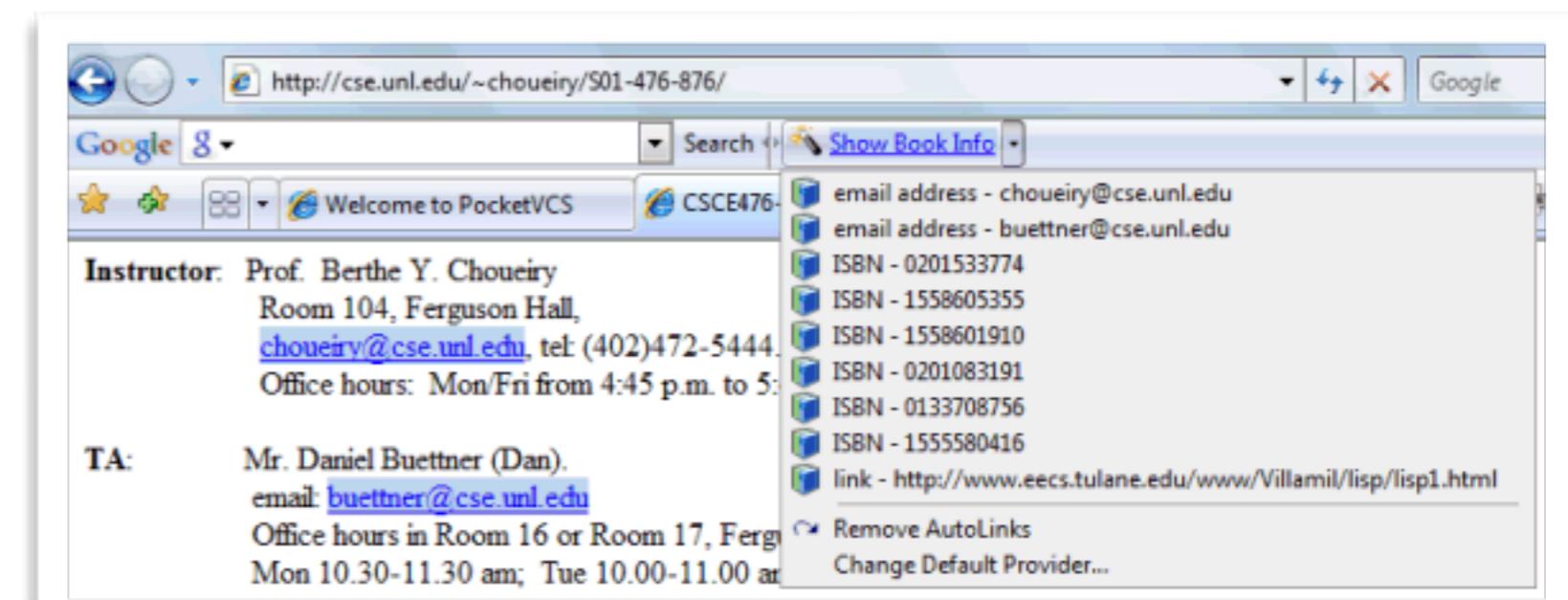
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Instructor: Prof. Berthe Y. Choueiry
Room 104, Ferguson Hall,
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Office hours: Mon/Fri from 4:45 p.m. to 5:30 p.m.

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New York City, New York
city population: 8.175 million people
pop. density: 27 013 people/mi²
area: 302.6 square miles
cost of living: 2.3 × US national average
median home price: \$441 600 (USD)
unemployment rate: 8.5%

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urban area population	17.8 million people (New York urban area) (country rank: 1 st) (2000 estimate)	
metro area population	19.02 million people (New York metro area) (country rank: 1 st) (2011 estimate)	

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Date founded: Jul 26, 1788
Population: 19.50 million (2011)
Area: 54,556 sq miles (141,300 km²)
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Senators: Chuck Schumer · Kirsten Gillibrand

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US State

New York is a state in the Northeastern and Mid-Atlantic regions of the United States. New York is the 27th-most extensive, the third-most populous, and the seventh-most densely populated of the 50 United States. [Wikipedia](#)

Capital: Albany

Population: 19.57 million (2012)

Governor: Andrew Cuomo

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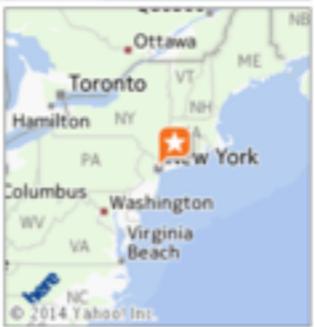
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Fast Facts
Date of Statehood: July 26, 1788
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Largest City: New York

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Flower: Rose
Tree: Sugar Maple
Bird: Bluebird
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Why do we need entity linking?

- Enable
 - semantic search
 - advanced UI/UX
 - automatic document enrichment; go-read-here
 - inline annotations (microformats, RDFa)
 - ontology learning, KB population
- “Use as feature”
 - to improve
 - classification; retrieval; word sense disambiguation; semantic similarity;...
 - dimensionality reduction (e.g., term vectors)

A little bit of history

- Text classification
- NER
- WSD
- NED/NEN
 - {person name, geo, movie name, ...} disambiguation
 - (Cross-document) coreference resolution
 - Automatic link generation
- Entity linking

Entity linking?

- NE normalization / canonicalization / sense disambiguation
- DB record linkage / schema mapping
 - (not the focus here, but see **[Demartini et al. 2013]**)
- Knowledge base population
- Entity linking
 - D2W
 - Wikification
 - Semantic linking

Main problem

- Linking free text to entities
 - Any piece of text
 - news documents
 - blog posts
 - tweets
 - queries
 - ...
 - Entities (typically) taken from a knowledge base
 - Wikipedia
 - Freebase
 - ...

Common steps

1. Determine “linkable” phrases
 - mention detection – **MD**
2. Rank>Select candidate entity links
 - link generation – **LG**
 - may include NILs (null values, i.e., no target in KB)
3. (Use “context” to disambiguate/filter/improve)
 - disambiguation – **DA**

Input Text

Italiano English

momentum) degeneracy is removed due to a geometric gradient onto a metasurface. The alliance of spin optics and metamaterials offers the dispersion engineering of a structured matter in a polarization helicity-dependent manner. We show that polarization-controlled optical modes of [metamaterials](#) arise where the spatial inversion symmetry is violated. The emerged spin-split dispersion of spontaneous emission originates from the spin-orbit interaction of light, generating a selection rule based on symmetry restrictions in a spin-optical metamaterial. The inversion asymmetric metasurface is obtained via anisotropic optical antenna patterns. This type of metamaterial provides a route for spin-controlled nanophotonic applications based on the design of the metasurface symmetry properties.

Many links

Few links

Reset

TAGME!

Tagged text

Topics

Spin [optics](#) provides a route to [control light](#), whereby the [photon helicity](#) (spin [angular momentum](#)) [degeneracy](#) is removed due to a [geometric gradient](#) onto a metasurface. The alliance of sp

Degenerate energy levels

[matter](#) in a p
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In physics, two or more different quantum states are said to be degenerate if they are all at the same energy level. Statistically this means that they are all equally probable of being filled, and in... e dispersion engineering of a structured matter. We show that polarization-controlled spatial inversion symmetry is violated. The emission originates from the spin-orbit interaction of light, generating a selection rule based on symmetry restrictions in a spin-optical metasurface is obtained via anisotropic optical antenna patterns. This type of metamaterial provides a route for spin-controlled

MD

Q ... degeneracy is removed ...

LG

Q ... degeneracy ...

The screenshot shows a web browser window with four tabs open, each displaying a different Wikipedia page:

- Degeneracy (mathematics)**: A page about the concept in mathematics, mentioning its relation to graph theory and quantum mechanics.
- Degeneracy (biology)**: A page about the concept in biology, noting its relationship to evolutionary biology and population genetics.
- Degeneracy (graph theory)**: A page about the concept in graph theory, defining it as the maximum degree of a vertex.
- Degenerate energy levels**: A page about the concept in quantum mechanics, explaining it as states having the same energy.

Each page includes standard Wikipedia navigation links like Read, Edit, View history, and Search, along with a sidebar containing links to other Wikipedia pages and a "Did you mean?" suggestion.

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Each page includes standard Wikipedia navigation links like Read, Edit, View history, and Search, along with a sidebar containing links to other Wikipedia pages and a "Did you mean?" suggestion.

DA

Q ... degeneracy ...

The screenshot shows three separate browser windows side-by-side, each displaying a different Wikipedia page:

- Degeneracy (mathematics)**: A page about the concept in mathematics, showing navigation links for Read, Edit, View history, and Search.
- Degeneracy (biology)**: A page about the concept in biology, with a note that it needs more links to other articles. It includes sections on Biological Examples, Contribution to robustness, Theory, See also, and Further reading.
- Degeneracy (graph theory)**: A page about the concept in graph theory, which is highlighted with a green border.

The screenshot shows three separate browser windows side-by-side, each displaying a different Wikipedia page:

- Degeneracy (graph theory)**: A page about the concept in graph theory, which is highlighted with a green border.
- Degenerate energy levels**: A page about quantum states having the same energy, with a note that it needs additional citations for verification. It includes sections on Definition, Examples, Degeneracy in quantum mechanics, and Degeneracy in quantum statistical mechanics.
- Degeneracy (mathematics)**: A page about the concept in mathematics, showing navigation links for Read, Edit, View history, and Search.

Methods



Preliminaries

- Knowledge bases...
- Wikipedia-based measures
 - commonness
 - relatedness
 - keyphraseness

Wikipedia

- Basic element: article (proper)
- But also
 - redirect pages
 - disambiguation pages
 - category/template pages
 - admin pages
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 - use “unique identifiers” (URLs)
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[[United States (TV series)|TV show]]



Disambiguation pages

- Senses of an ambiguous phrase
- Short description
- (Possible) categorization
- Non-exhaustive

The screenshot shows a web browser window displaying the disambiguation page for 'New York' on Wikipedia. The title bar reads 'New York (disambiguation) - en.wikipedia.org'. The page features the Wikipedia logo and navigation links like 'Main page', 'Contents', and 'Featured content'. A sidebar on the left lists categories such as 'Places', 'England', 'United States', 'Black Sea', 'Media and entertainment', 'Film', and 'Literature', each with a list of sub-links. The main content area is currently focused on 'Places', which includes links to 'New York, Lincolnshire', 'New York, North Yorkshire', 'New York, Tyne and Wear', and several entries under 'United States'.

Some statistics

- WordNet
 - 80k entity definitions
 - 115k surface forms
 - 142k senses (entity - surface form combinations)
- Wikipedia (only)
 - ~4M entity definitions
 - ~12M surface forms
 - ~24M senses

Wikipedia-based methods

Wikipedia-based methods

- keyphraseness(w) [Mihalcea & Csomai 2007]

$$\frac{\text{CF}(w_l)}{\text{CF}(w)} \longrightarrow \begin{array}{l} \textbf{Collection frequency} \\ \text{term } w \text{ as a link to another} \\ \text{Wikipedia article} \end{array}$$



Collection frequency
term w

Wikipedia-based methods

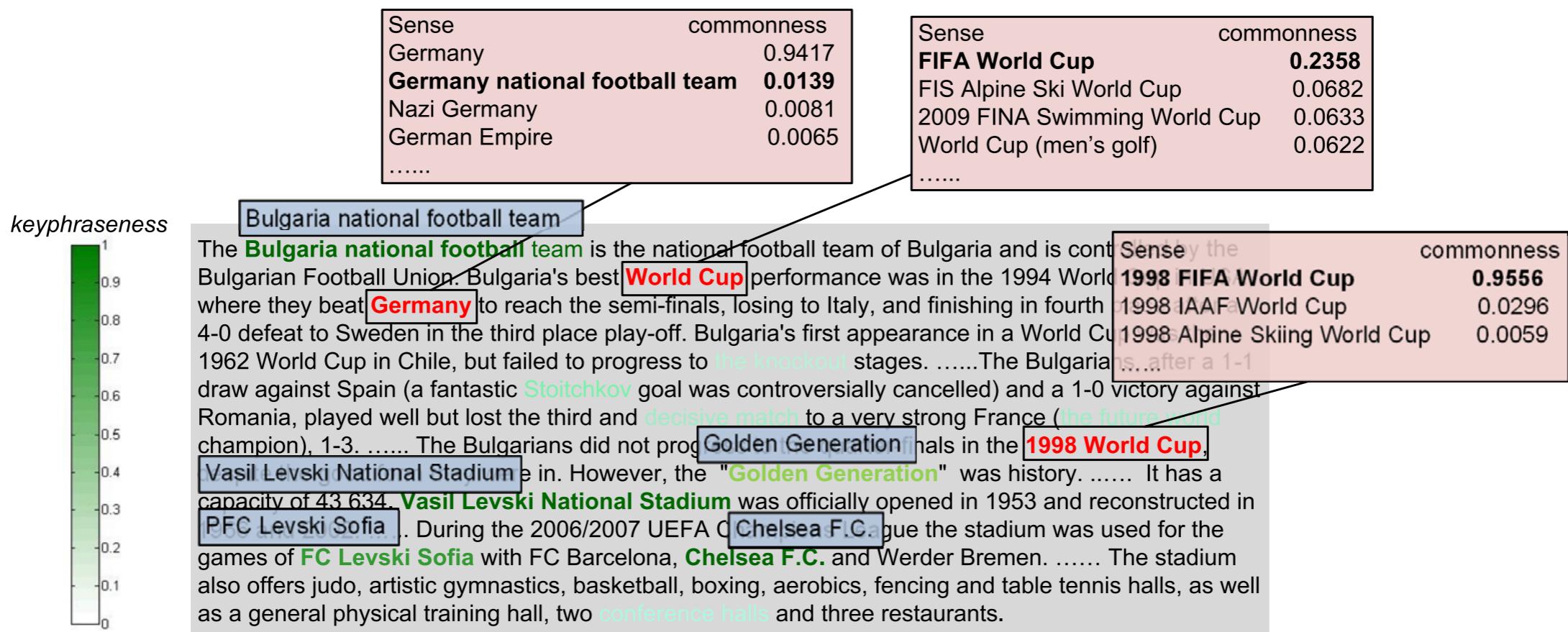
- commonness(w, c) [Medelyan et al. 2008]

$$\frac{|L_{w,c}|}{\sum_{c'} |L_{w,c'}|}$$



Number of links
with target c' and anchor text w

Commonness and keyphraseness



Wikipedia-based methods

- Of course, these can also be based on other data, e.g.,
 - (focused) web crawls
 - click logs **[Pantel et al. 2011]**

Baseline methods



Recall the steps

- 1. mention detection – MD**
- 2. link generation – LG**
- 3. (disambiguation) – DA**

Wikify!

[Mihalcea & Csomai 2007]

- First paper on actual entity linking
- Identifies two steps
 1. identify important concepts in the text
“keyword extraction” (**MD**)
 2. link these to corresponding Wikipedia pages
“word sense disambiguation” (**LG/DA**)

Wikify!

[Mihalcea & Csomai 2007]

- MD
 - tf.idf, χ^2 , keyphraseness
- LG/DA
 1. Overlap between definition (Wikipedia page) and context (paragraph) **[Lesk 1986]**
 2. Naive Bayes **[Mihalcea 2007]**
 - context, POS, entity-specific terms
 3. Voting between (1) and (2)

Learning to Link with Wikipedia

[Milne & Witten 2008b]

- Key idea: disambiguation informs detection
 - start with unambiguous senses
 - compare each possible sense with its *relatedness* to the context sense candidates
 - So, first LG, then base MD on these results

Wikipedia-based measures

- relatedness(c, c') [Milne & Witten 2008a]

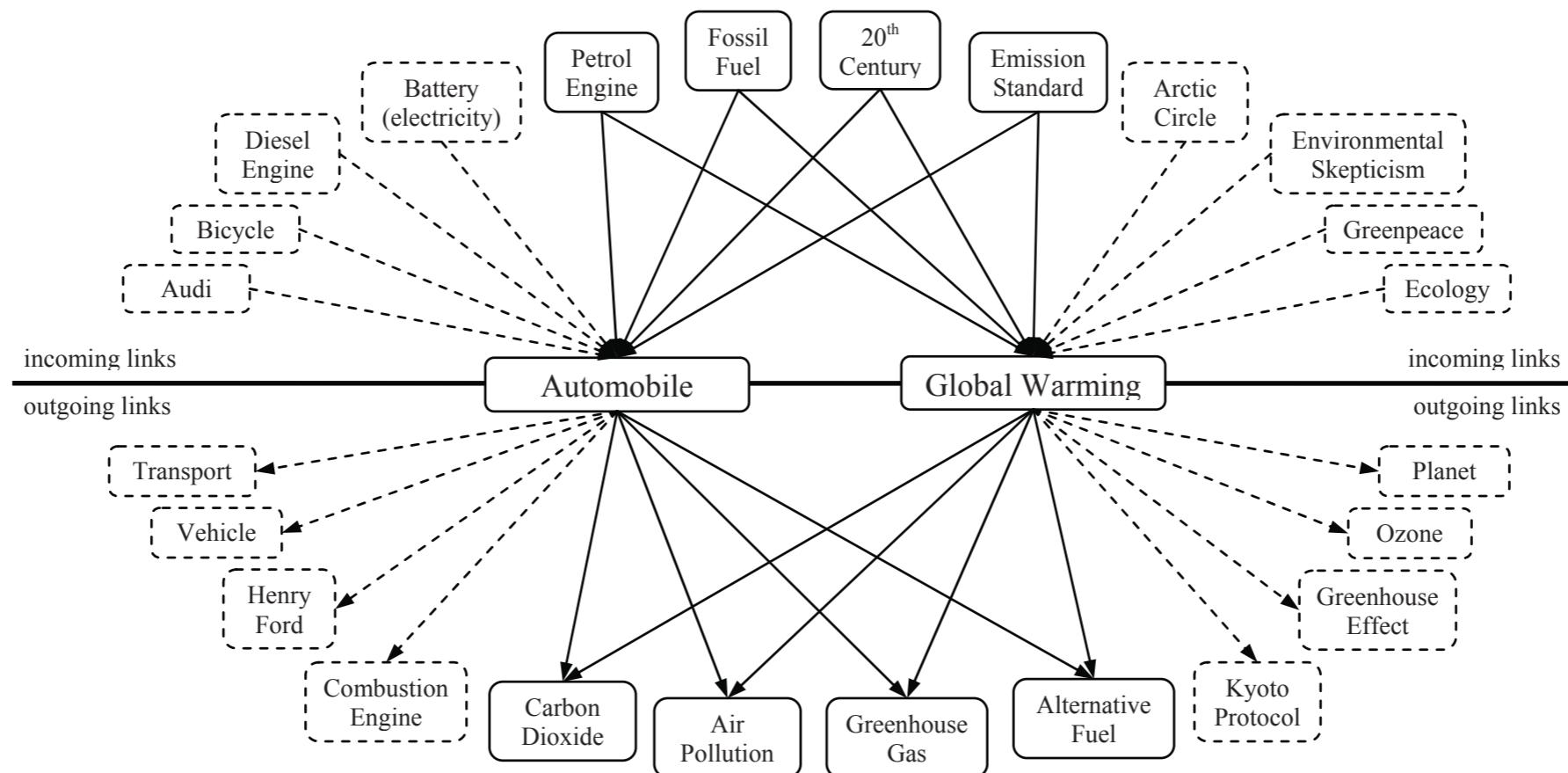


Image taken from Milne and Witten (2008a). An Effective, Low-Cost Measure of Semantic Relatedness Obtained from Wikipedia Links. In AAAI WikiAI Workshop.

Wikipedia-based measures

- relatedness(c, c') [Milne & Witten 2008a]

$$\frac{\log(\max(|L_c|, |L_{c'}|)) - \log(|L_c \cap L_{c'}|)}{\log(|WP|) - \log(\min(|L_c|, |L_{c'}|))}$$

Number of links
with target c

Intersection of inlinks
with target c and c'

Total number of
Wikipedia articles

Learning to Link with Wikipedia

[Milne & Witten 2008b]

Depth-first search

From Wikipedia, the free encyclopedia

Depth-first search (DFS) is an algorithm for traversing or searching a tree structure or graph. One starts at the root (selecting some node as the root in the graph case) and explores as far as possible along each branch before backtracking.

Formally, DFS is an uninformed search that progresses by expanding the first child node of the search tree that appears and thus going deeper and deeper until a goal node is found, or until it hits a node that has no children. Then the search backtracks, returning to the most recent node it hadn't finished exploring. In a non-recursive implementation, all freshly expanded nodes are added to a LIFO stack for exploration.



sense	commonness
Tree	92.82%
Tree (graph theory)	2.94%
Tree (data structure)	2.57%
Tree (set theory)	0.15%
Phylogenetic tree	0.07%
Christmas tree	0.07%
Binary tree	0.04%
Family tree	0.04%
...	

Learning to Link with Wikipedia

[Milne & Witten 2008b]

- MD
 - ...
- LG
 - Machine learning
 - keyphraseness, average relatedness, sum of average weights

Learning to Link with Wikipedia

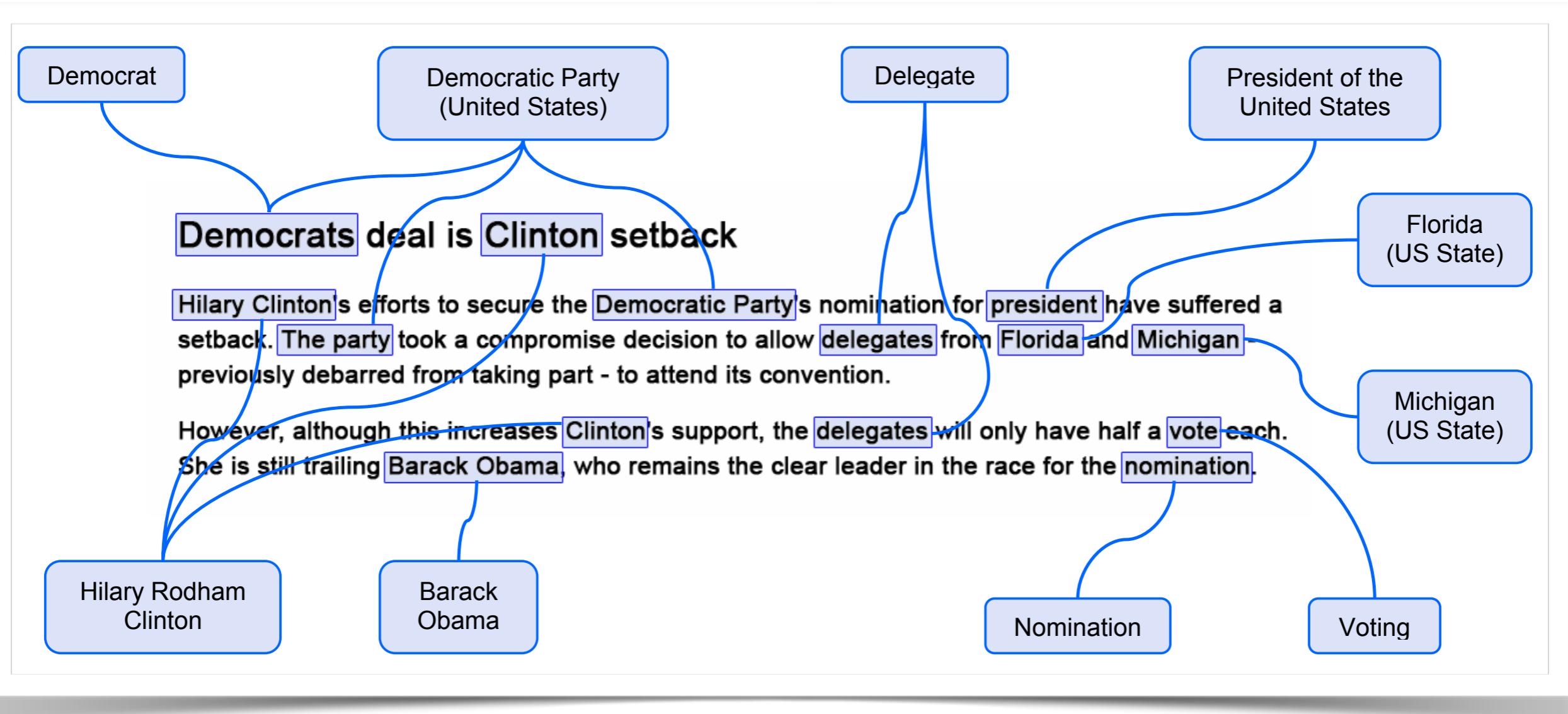
[Milne & Witten 2008b]

- MD
 - Machine learning
 - link probability, relatedness, **confidence of LG**, generality, frequency, location, spread
- LG
 - Machine learning
 - keyphraseness, average relatedness, sum of average weights

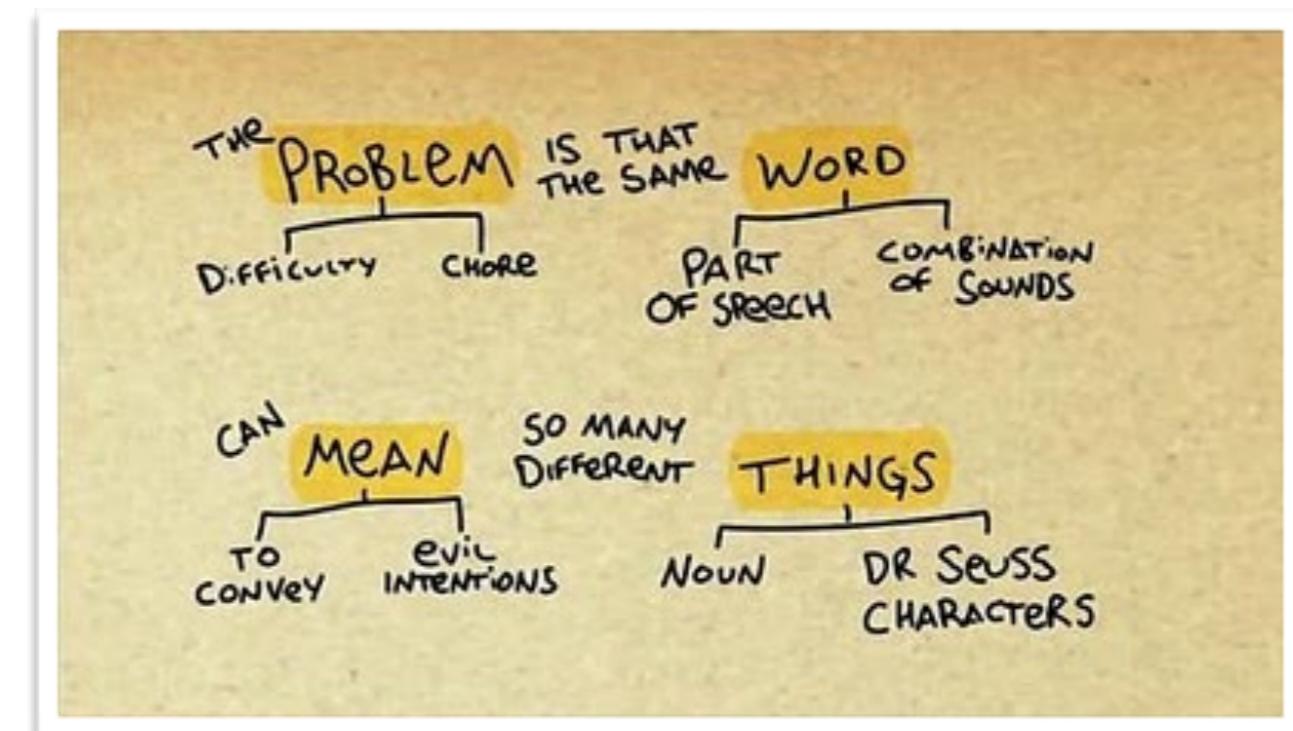
Learning to Link with Wikipedia

[Milne & Witten 2008b]

- Some heuristics
 - filter non-informative, non-ambiguous candidates (e.g., “the”)
 - based on keyphraseness, i.e., link probability
 - filter non-central candidates
 - based on average relatedness to all other context senses



Context



Main intuition

- Leverage “context” as signal for disambiguation
 - query
 - history; session; interests; ...
 - phrase
 - sentence; paragraph; document; ...
- But also candidate entity context
 - e.g., most central entities in the candidate entity graph, relatedness, ...

Local versus global context

- “Global”
 - i.e., disambiguation of the candidate entity graph
 - NP-hard
- Optimization
 - reduce the search space to a “disambiguation context”
 - all plausible (reciprocal) disambiguations **[Cucerzan 2007]**
 - unambiguous surface forms, pair-wise comparisons, and/or averages **[Milne & Witten 2008b]**
 - hill-climbing, integer linear programs **[Kulkarni et al. 2009]**
 - hybrid + ML **[Ratinov et al. 2011, Ferragina & Scaiella 2010]**

Collective annotation of Wikipedia entities in web text

[Kulkarni et al. 2009]

- Contribution
 - determine a collective score based on trade-off between local compatibility and global topical coherence between candidate entities
 - use ILP or Hill-climbing (ILP beats HC, but is slower)
- Also
 - new test collection (web pages), including NILs

Local and Global Algorithms for Disambiguation to Wikipedia

[Ratinov et al. 2011]

- Main contribution, in steps – MD + DA
 1. use “local” approach (e.g., commonness) to generate a disambiguation context
 2. apply “global” machine learning approach on pairs
 - relatedness, PMI
 - {inlinks, outlinks} in various combinations (c and c')
 - {avg, max}
- (Apply another round of machine learning) – LG

TAGME: On-the-fly Annotation of Short Text Fragments

[Ferragina & Scaiella 2010]

- MD
 - keyphraseness [Mihalcea & Csomai 2007]
- LG
 - use “local” approach to generate a disambiguation context, very similar to [Ratinov et al. 2011]
 - Heavy pruning
 - mentions; candidate links; coherence
- Accessible at <http://tagme.di.unipi.it>

Graph-based named entity linking with Wikipedia

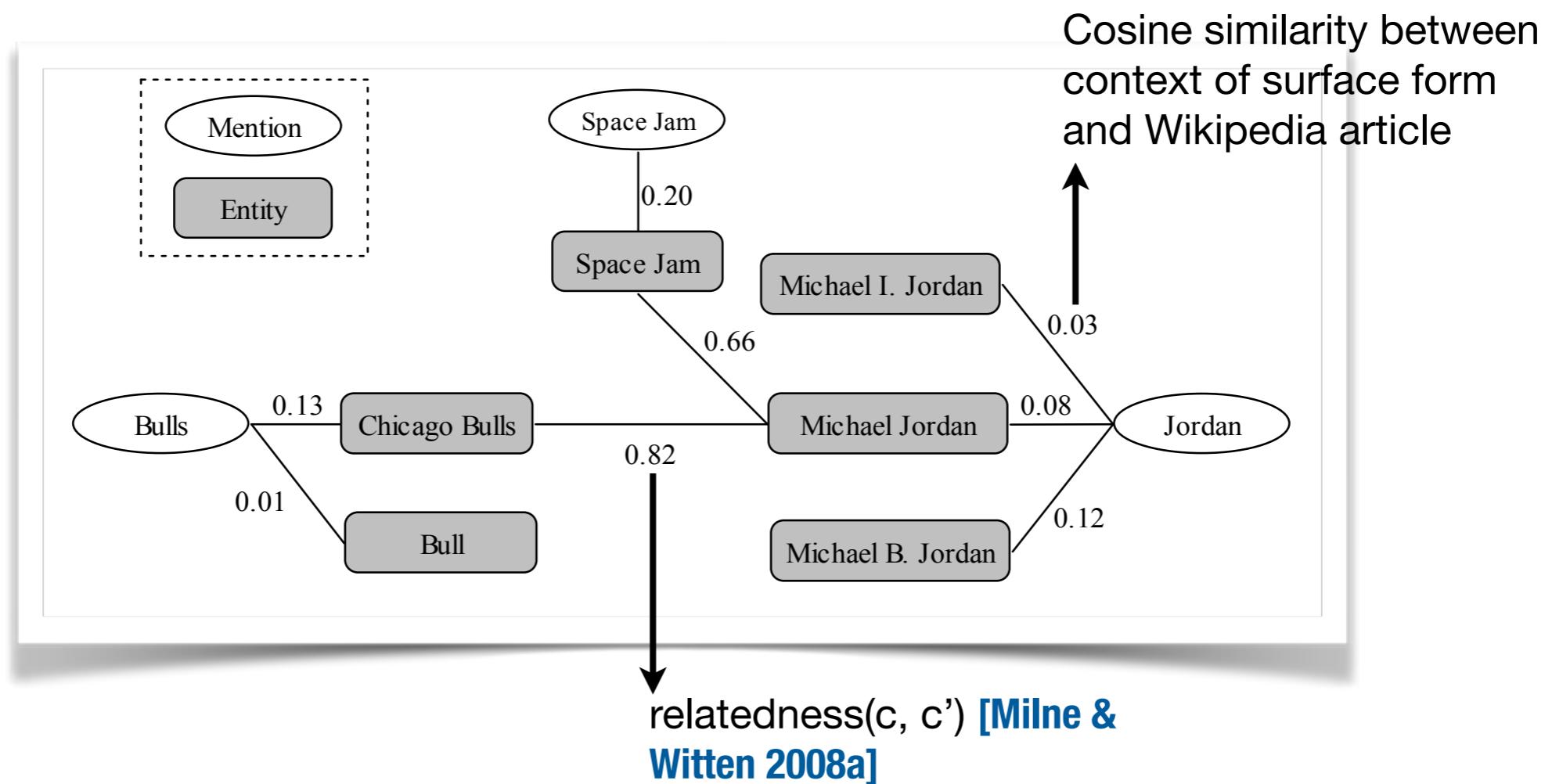
[Hachey et al. 2011]

- MD
 - generate disambiguation context
 - based on unambiguous entity links
 - edges defined by wikilinks (articles & categories)
 - max step size: 2 (articles), 3 (categories)
- LG
 - use degree centrality and PageRank to reweigh cosine-based similarity scores
- Evaluation on TAC KBP

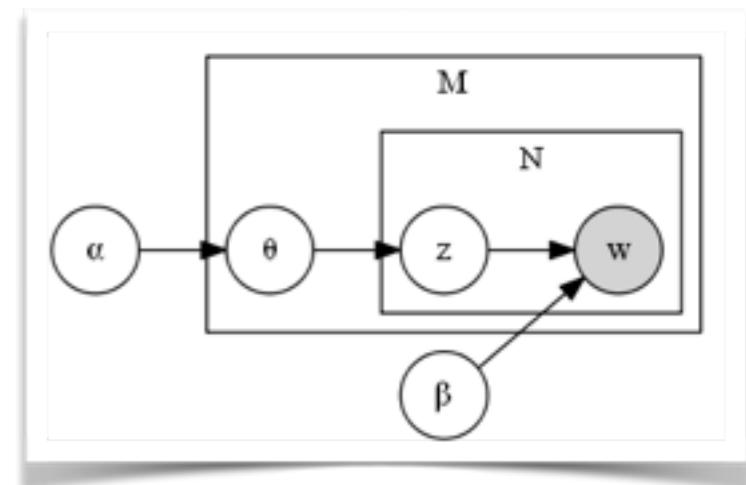
Collective Entity Linking in Web Text: A Graph-Based Method

[Han et al. 2011]

- Global approach, main contribution
 - random walk on the *referent graph*, defined by the intra-Wikipedia links



Topic modeling methods



From Names to Entities using Thematic Context Distance

[Pilz et al. 2011]

- Main contribution
 - “extend” previous BOW approaches for disambiguation with LDA topics
 - compare topic distributions of source document with candidate entities

Table 1: Topics for entities with name *John Taylor* (excerpt) with associated probability value

disambiguation term	i	$p(t_i)$	Important words (titles) of the topics
South Carolina governor	109	0.3805	unit state, state senat, lieuten governor, hous repres, elect governor, ...
	120	0.2477	north carolina, south carolina, unit state, west virginia, civil war, ...
athlete	80	0.4190	summer olymp, gold medal, world record, silver medal, world championship, ...
	135	0.1047	unit state, rhode island, baltimore maryland, new hampshire, georg washington, ...
racing driver	129	0.7407	grand prix, race driver, motor race, formula, race team, sport car, ...
jazz	141	0.5781	jazz musician, big band, new york, duke ellington, jazz band, ...
bass guitarist	18	0.2964	rock band, solo album, play guitar, band member, rock roll, ...
	70	0.1594	album releas, studio album, debut album, record label, music video, ...

Recap

- Essential ingredients
 - MD
 - commonness
 - keyphraseness
 - LG
 - commonness
 - machine learning
 - DA
 - relatedness
 - machine learning
 - topic modeling
 - graph-based methods

Outline

- Part 1 – Entity Linking
 - introduction
 - methods
 - evaluation
 - test collections
 - toolkits
 - open challenges

Evaluation



Entity linking evaluation

- Ingredients
 - knowledge base
 - document(s)
 - gold-standard annotations
 - evaluation metrics

Knowledge bases

DBpedia

- Extract structured information from Wikipedia
 - infoboxes, categories, and more
 - crowd-sourced community effort
- Open source
 - written in Scala, Java and VSP
 - Virtuoso Universal Server Operating system
- See <http://dbpedia.org/About>

Freebase

- Initially seeded from high-quality open data
 - now composed mainly by community
 - harvested from many sources
 - Wikipedia, MusicBrainz, and others.
- Acquired by Google in 2010 (GKG)
- See <http://www.freebase.com/>

Wikipedia vs Freebase

- Freebase 5x larger than Wikipedia
(in terms of the number of entities)
- Geared towards entertainment
- For 85% of Freebase entities there's no text...
 - but, there are Wikipedia-Freebase links
(for some entities)
 - initial work trying to ameliorate this problem **[Zheng et al. 2012]**

YAGO

- Accuracy manually evaluated
 - confirmed accuracy of 95%
 - relation is annotated with its confidence value.
- Anchored in Time and Space
 - Thematic domains (e.g. "music" or "science")
- Includes WordNet
- See <http://www.mpi-inf.mpg.de/yago-naga/yago/>

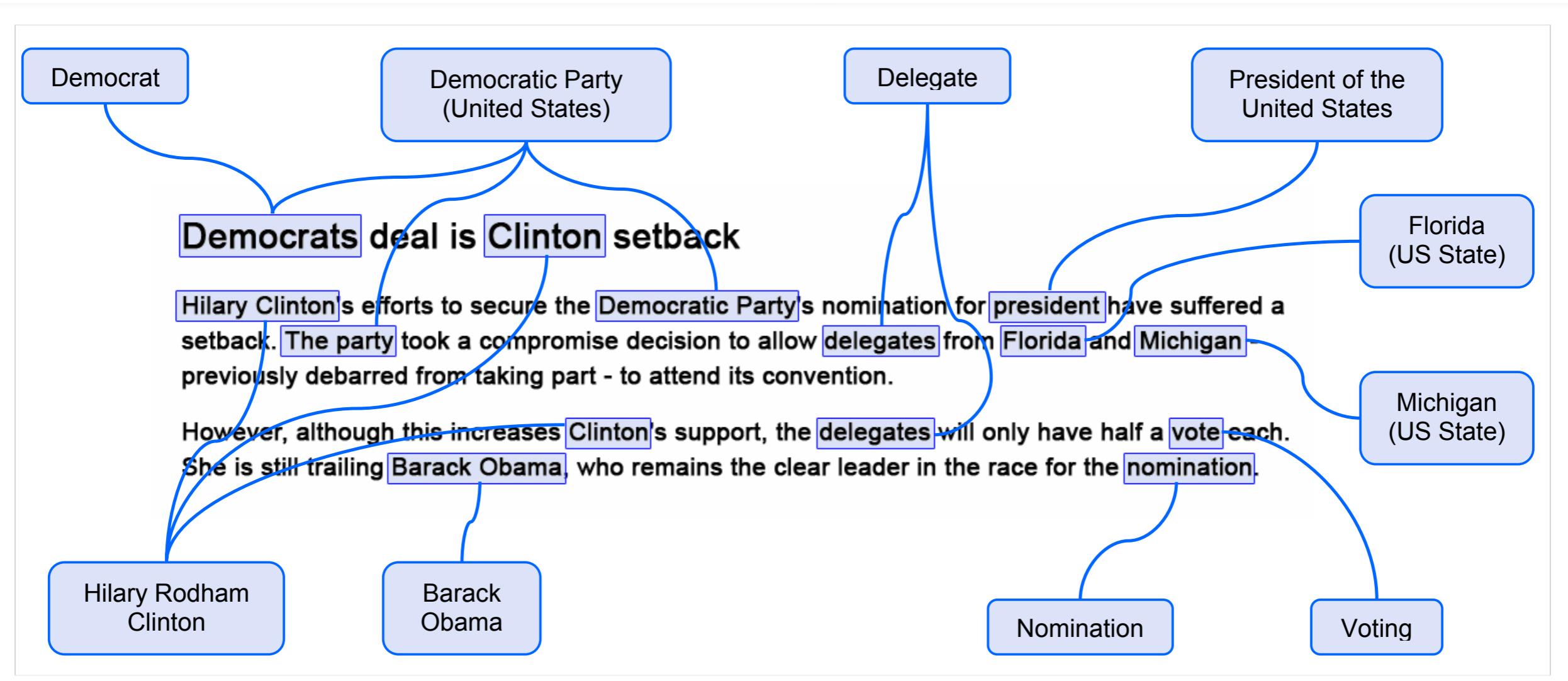
Sense of Scale

- YAGO: 10 million entities and 120 million facts
- Freebase: 37 million topics, 1,998 types, and more than 30,000 properties
- DBpedia: 3.77 million things
 - 2.35 million classified in Ontology, including:
 - 764,000 persons, 573,000 places,
 - 333,000 creative works, 192,000 organizations,
 - 202,000 species and 5,500 diseases.
 - 111 languages, together 20.8 million things

Evaluation metrics

Evaluation metrics

- What is the task?



Evaluation metrics

- Compounded problem
 - tagging/spanning – **MG**
 - entity linking – **LG/DA**

Evaluation metrics

- Set-based (similar to WSD)
 - “How many correct links were retrieved?”
 - precision, recall, F-measure
- Rank-based
 - “Was the correct link(s) retrieved with a high score?”
 - precision@k, recall@k, P1, R-prec, MRR, MAP, etc.
- macro/micro
 - per anchor phrase
 - per tweet, query, sentence, document

Test collections

Entity linking test collections

- Wikipedia
- MSNBC
- AQUAINT
- ACE
- Twitter
- AIDA (CoNLL)
- IITB (web data)
- INEX link-the-wiki
- TREC knowledge base acceleration (KBA)
- TAC knowledge base population (KBP)

Wikipedia (for evaluation)

- Widely used
- Pros
 - cheap and easy; the links are already provided
- Cons
 - biased (style guides!)
 - specific scenario
 - unbalanced

Fresh from the oven...

Webscope from Yahoo! Labs

Home Mail News Sports Finance Weather Games Groups Answers Flickr More

YAHOO! LABS

Home Demos Experiments Data Participate

Webscope

WEBSCOPE™

The Yahoo! Webscope™ Program is a reference library of interesting and scientifically useful datasets for non-commercial use by academics and other scientists. All datasets have been reviewed to conform to Yahoo!'s data protection standards, including strict controls on privacy. We have a number of datasets that we are excited to share with you. Learn how to get involved.

Latest Datasets

- ◆ R1 - Yahoo! Music User Ratings of Musical Artists, version 1.0 (423 MB)
- ◆ R2 - Yahoo! Music User Ratings of Songs with Artist, Album, and Genre Meta Information, v. 1.0 (1.4 Gbyte & 1.1 Gbyte)
- ◆ R3 - Yahoo! Music ratings for User Selected and Randomly Selected songs, version 1.0 (1.2 MB)

[See all datasets](#)

Latest Publications

- Collaborative Prediction and Ranking with Non-Random Missing Data
- Missing Data Problems in Machine Learning
- Strategic Bidder Behavior in Sponsored Search Auctions
- Internet advertising and the generalized second price auction.

[See all publications](#)

Datasets

- Language Data
- Graph and Social Data
- Ratings and Classification Data
- Advertising and Market Data
- Competition Data
- Computing Systems Data
- Image Data

My Selections

You have 1 datasets in your cart

My Requests

Pending: 0
Approved: 5
Denied: 0

My Account

Add, modify your information

Fresh from the oven...

The screenshot shows a web browser window with the title "Webscope from Yahoo! Labs". The address bar displays the URL "webscope.sandbox.yahoo.com/catalog.php?datatype=l". The page content is organized into several sections:

- A top navigation bar with links for Home, Mail, News, Sports, Finance, Weather, Games, Groups, Answers, Flickr, and More.
- A sidebar on the right labeled "My Account" with the sub-instruction "Add, modify your information".
- A main content area listing datasets:
 - (255 Gbyte)(Hosted on AWS)**
 - L20 - Yahoo! Answers browsing behavior, version 1.0 (166 GB) (Hosted on AWS)
 - L21 - Yahoo! Answers Query To Questions, version 2.0 (24K)
 - L22 - Yahoo! News Sessions Content, version 1.0 (16 MB)
 - L23 - Yahoo Answers Synthetic Questions, version 1.0
 - L24 - Yahoo Search Query Log To Entities, version 1.0(1.7MB)**

With this dataset you can train, test, and benchmark entity linking systems on the task of linking web search queries – within the context of a search session – to entities. Entities are a key enabling component for semantic search, as many information needs can be answered by returning a list of entities, their properties, and/or their relations. A first step in any such scenario is to determine which entities appear in a query – a process commonly referred to as named entity resolution, named entity disambiguation, or semantic linking.

This dataset allows researchers and other practitioners to evaluate their systems for linking web search engine queries to entities. The dataset contains manually identified links to entities in the form of Wikipedia articles and provides the means to train, test, and benchmark such systems using manually created, gold standard data. With releasing this dataset publicly, we aim to foster research into entity linking systems for web search queries. To this end, we also include sessions and queries from the TREC Session track (years 2010–2013). Moreover, since the linked entities are aligned with a specific part of each query (a "span"), this data can also be used to evaluate systems that identify spans in queries, i.e., that perform query segmentation for web search queries, in the context of search sessions.
- A note at the bottom left: "All datasets have been reviewed to conform to Yahoo!'s data protection standards, including strict controls on privacy. We have a number of datasets that we are excited to share with you. Learn how to get involved."
- Buttons at the bottom: "Select" (green) and "View Selections" (blue).

Evaluation - recap

- Even with so many test collections to choose from, there's still quite some variation
- People create their own “extracts” from WP
- Same method, same test collection, but different results in different papers
 - tokenization, normalization, ...
- We need meta-evaluations...

Meta-evaluations

- [Hachey et al. 2013]
- [Cornolti et al. 2013]

Evaluating Entity Linking with Wikipedia

[Hachey et al. 2013]

- Named entity linking, a.k.a., “NEL”
 - include NILs
 - Wikipedia articles not always named entities
- Explicit focus on separating “search” (LG) and “disambiguation” (DA)
- Reimplement and evaluate three NEL systems
 - [Bunescu & Pasça 2006]
 - [Cucerzan 2007]
 - [Varna et al. 2009] (TAC system paper)

A Framework for Benchmarking Entity-Annotation Systems

[Cornolti et al. 2013]

- Compare five publicly available entity linkers
 - [Hoffart et al. 2007] (AIDA)
 - [Ratinov et al. 2011]
 - [Ferragina & Scaiella 2010] (TAGME)
 - [Milne & Witten 2008] (wikipedia-miner)
 - DBpedia Spotlight
- And also investigate parameter/cut-off settings

A Framework for Benchmarking Entity-Annotation Systems

[Cornolti et al. 2013]

- On five publicly available test collections
 - AIDA **[Hoffart et al. 2007]**
 - based on CoNLL 2003: noun annotations
 - 1393 Reuters newswire articles
 - hand-annotated all nouns with entities in YAGO2
 - AQUAINT **[Milne & Witten 2008]**
 - MSNBC **[Cucerzan 2007]**
 - IITB **[Kulkarni et al. 2010]** (web data)
 - Twitter **[Meij et al. 2012]**

A Framework for Benchmarking Entity-Annotation Systems

[Cornolti et al. 2013]

- Benchmarking framework
- Introduces “fuzzy” evaluation measures
- Main findings
 - different systems perform well in different scenarios
 - AIDA and TagMe seem to be the winners overall

DIY Entity Linking – footnotes

- ClueWeb annotated with Freebase (FACC1)
- wiki-links
- Dictionaries for Linking Text, Entities and Ideas

concept: “soccer”			
football <i>and</i>			
Football			
Soccer <i>and</i>			
soccer			
Association football	サッカー	piłkarz	
fútbol <i>and</i>	축구	voetbalclub	
Fútbol	footballeur	ฟุตบอล	
footballer	Fußballspieler	bóng đá	
Futbol <i>and</i>	sepak bola	voetbal	
futbol	足球	Foutbaal	
Fußball	فوتبال	futebolista	
futebol	футболист	لعبة كرة القدم	
futbolista	כדורגל	fotbal	

Outline

- Entity Linking
 - introduction
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 - toolkits
 - open challenges

Toolkits



Public Toolkits and Web Services for Entity Linking

- Wikipedia Miner
- TagMe
- DBpedia Spotlight
- Illinios Wikifier
- AIDA
- (OpenCalais)

	Programming Language	Service	Available Languages	Open Source
Wikipedia Miner	Java	Web API, Application	any WP	✓
TagMe	Java	Web API	EN, IT	✗
DBpedia Spotlight	Java	Web API, Application	EN + any WP	✓
Illinois Wikifier	Java	Application	EN	✓
AIDA	Java	Web API	EN	✓
OpenCalais	?	Web API	EN, FR, SP	✗

	Matching	Target KB	Context	Comment
Wikipedia Miner	Lexical	Wikipedia	ML on Relatedness	
TagMe	Lexical	Wikipedia	Vote on Relatedness	Focus on Short texts
DBpedia Spotlight	Lexical?	DBpedia	Cosine Similarity	Structure
Illinois Wikifier	NER	Wikipedia	Global Coherence	
AIDA	NER	YAGO2	Multiple	Structure
OpenCalais	?	Calais	?	

Open challenges



Open challenges

- Difficulty prediction
 - similar to ambiguity, but not the same
 - dependent on context, candidate links, ...
- Multi/Cross-lingual entity linking
 - **[Wang et al. 2013]**
 - CrossLink-2 (NTCIR-9), CJK - EN **[Tang et al. 2013]**
 - TAC...
- Cross-KB entity linking (“Freebase”)
 - directly? use Wikipedia as pivot?

Open challenges

- Generic test collections
 - What's the task? User model? Evaluation?
 - TAC? set-based? ranking? known-item finding? top- k ?
 - exhaustive linking? first mention only?
 - "aboutness"
- Moving beyond entities
 - events/news, concepts, relations
- Moving beyond "ad hoc" entity linking:
 - incorporate contextual evidence in the task (and evaluation)
 - {users, history, profile, social, trending, ...}

Follow-up reading

- Detecting **unlinkable** entities [Lin et al. 2012a]
- Linking entities to **any database** [Sil et al. 2012]
- Hyperlinking for **multimedia** data [Eskevich et al. 2013]
- Automatically generating **Wikipedia articles** [Sauper & Barzilay 2009]
- **Scaling up** to the web [Lin et al. 2012b]
- Serendipitous **suggestions** based on **personalized** entity links [Bordino et al. 2013]
- **Actionable** entities/queries [Lin et al. 2012]

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References – Entity linking

The screenshot shows a web browser window displaying a Mendeley group page. The title of the group is "Entity Linking and Retrieval". The page includes a sidebar with navigation links like "Get Mendeley", "What is Mendeley?", "Papers", "Groups", and a "Feedback" button. The main content area shows a list of papers tagged with "entity linking". The first paper listed is "ZenCrowd" by Gianluca Demartini, Djellel Eddine Difallah, Philippe Cudré-Mauroux in Proceedings of the 21st international conference on World Wide Web - WWW '12 (2012). The second paper is "Relational Inference for Wikification" by Cheng Xiao, Dan Roth in EMNLP '13 (2013). The third paper is "Re-ranking for Joint Named-Entity Recognition and Linking" by Avirup Sil, Alexander Yates in CIKM '13 (2013). The fourth paper is "Wikimantic: Toward effective disambiguation and expansion of queries" by Christopher Boston, Hui Fang, Sandra Carberry, Hao Wu, Xitong Liu in Data & Knowledge Engineering (2013). On the right side of the page, there is a "Top tags in this group" section showing various terms related to entity linking and retrieval.

<http://www.mendeley.com/groups/3339761/entity-linking-and-retrieval-tutorial/papers/added/0/tag/entity+linking/>

