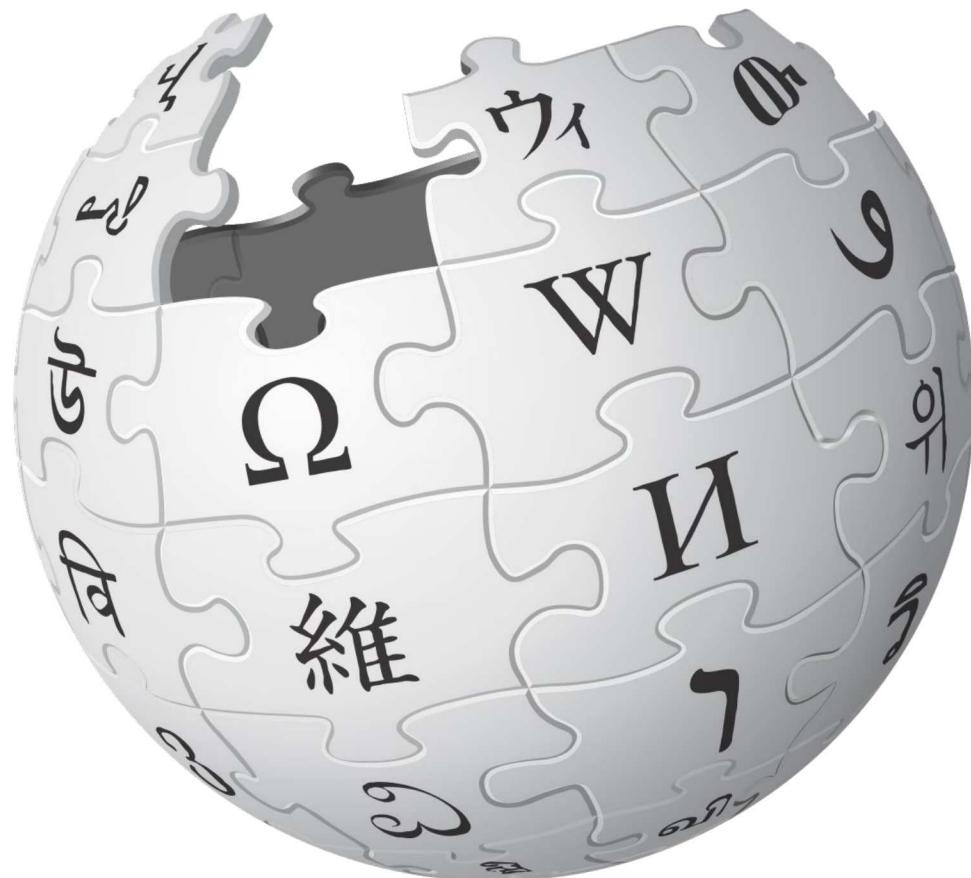


Automatic Construction and Evaluation of a Large Semantically Enriched Wikipedia

Alessandro Raganato, Claudio Delli Bovi and Roberto Navigli



WIKIPEDIA



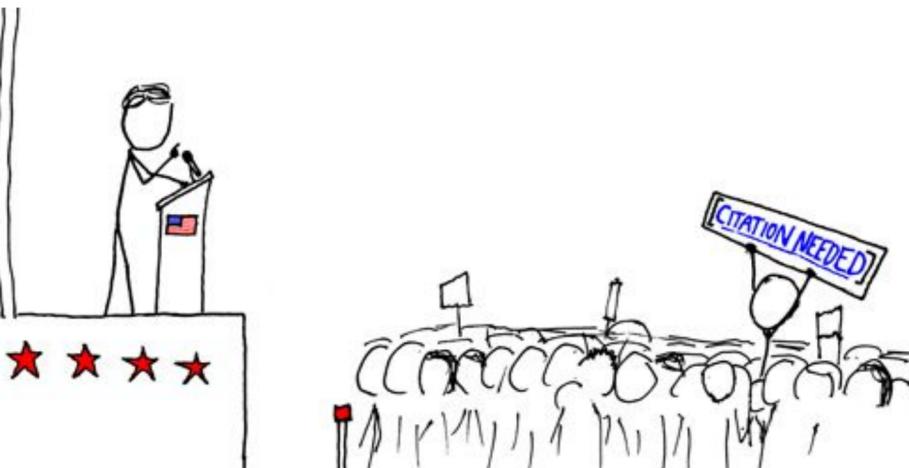
Problem: Wikipedia is designed for humans!

Only a fraction of linkable mentions is in fact **hyperlinked**:

- 580M noun tokens, only 116M covered (~19%) *

Partly due to the Wikipedia style guidelines:

- Link each concept **at most once** within a page
- Link only when **relevant** and **helpful** in the context



*English dump 11/2014

Lorenzo de' Medici

From Wikipedia, the free encyclopedia

For other uses, see [Lorenzo de' Medici \(disambiguation\)](#).

Lorenzo de' Medici (Italian pronunciation: [lo'rentso de 'me:ditʃi], 1 January 1449 – 9 April 1492) was an Italian statesman and *de facto* ruler of the Florentine Republic, who was one of the most powerful and enthusiastic patrons of the Renaissance.^{[1][2][3]} Also known as **Lorenzo the Magnificent** (*Lorenzo il Magnifico* [lo'rentso il maŋ'ni:fiko]) by contemporary Florentines, he was a magnate, diplomat, politician and patron of scholars, artists and poets. He is well known for his contribution to the art world by sponsoring artists such as [Botticelli](#) and [Michelangelo](#). His life coincided with the mature phase of Italian Renaissance and his death coincided with the end of the Golden Age of Florence.^[4] The fragile peace that he helped maintain among the various [Italian states](#) collapsed with his death. He is buried in the [Medici Chapel](#) in Florence.

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Lorenzo de' Medici	
 Portrait by Verrocchio	
	Lord of Florence
Reign	2 December 1469 – 9 April 1492
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Successor	Piero the Unfortunate
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potentially linkable
mentions!



Lorenzo de' Medici



Portrait by Verrocchio

Lord of Florence

Reign 2 December 1469 – 9 April 1492

Predecessor Piero the Gouty

Successor Piero the Unfortunate

Spouse(s) Clarice Orsini

Issue

Lucrezia de' Medici

Piero de' Medici

Maddalena de' Medici

Contessina Beatrice de' Medici

Giovanni de' Medici, Pope Leo X

Luisa de' Medici

Contessina de' Medici

Giuliano de' Medici, Duke of Nemours

Full name

Lorenzo di Piero de' Medici

A Semantically Enriched Wikipedia (SEW)



Our goal:

- **Augment** Wikipedia with as much **semantic information** as possible

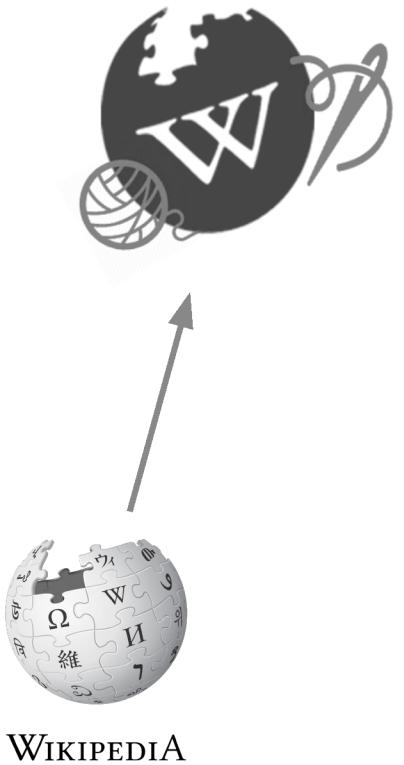
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How?

- The existing Wikipedia **hyperlink structure**:
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 - Connections between pages and **Wikipedia categories**



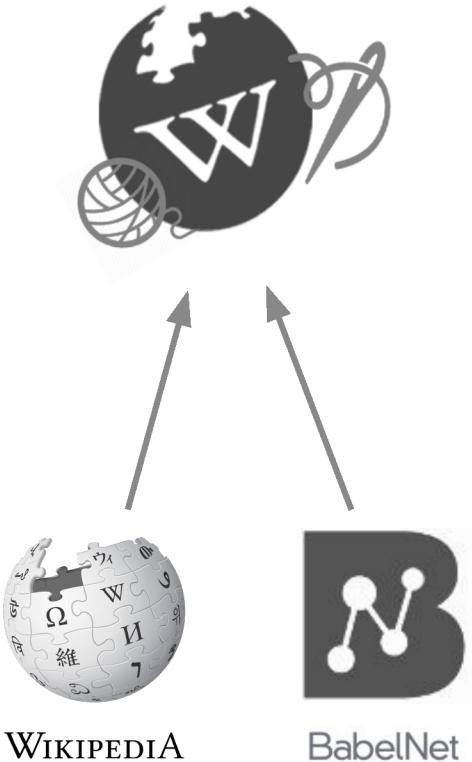
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- The multilingual sense inventory of **BabelNet**:
 - **merger** of many different resources (including WordNet and Wikipedia itself)
 - **14M** entries and **380M** semantic connections



A Semantically Enriched Wikipedia (SEW)



The algorithm:

For each Wikipedia page p in W



Preprocessing



Hyperlink Propagation



Refinement

A Semantically Enriched Wikipedia (SEW)



The algorithm:

For each Wikipedia page p in W



Preprocessing



Hyperlink Propagation



Refinement

- Tokenization
- Part-of-speech tagging
- Lemmatization
- Filtering of uninformative pages

A Semantically Enriched Wikipedia (SEW)



The algorithm:

For each Wikipedia page p in W



Preprocessing



Hyperlink Propagation



Refinement

- Cascade of **propagation heuristics**, which
- collect a list S^p of hyperlinks to be propagated across p
 - scan the text of p to match any potential lexicalization
(one-sense-per-page assumption)

A Semantically Enriched Wikipedia (SEW)



The algorithm:

For each Wikipedia page p in W



Preprocessing



Hyperlink Propagation



Refinement

Conservative policy to remove
duplicates and overlapping
mentions

A Semantically Enriched Wikipedia (SEW)

 **Hyperlink Propagation - A bird's eye view**

A Semantically Enriched Wikipedia (SEW)

Hyperlink Propagation - A bird's eye view

Intra-page heuristics:

Propagate links that occur as mentions
within p



- **Surface Mention Propagation**
- **Lemmatized Mention Propagation**
- **Person Mention Propagation**

A Semantically Enriched Wikipedia (SEW)

Hyperlink Propagation - A bird's eye view

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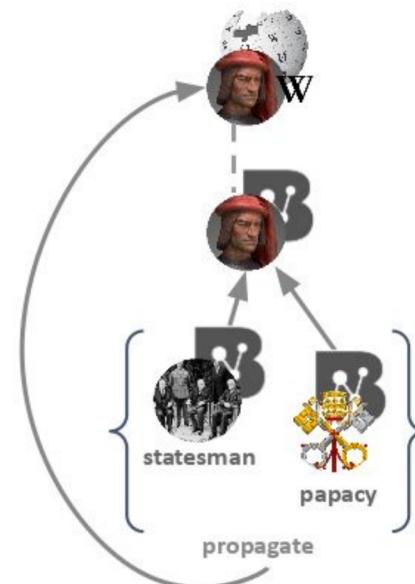


- Surface Mention Propagation
- Lemmatized Mention Propagation
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Inter-page heuristics:

Exploit the connection of **p** with other pages or categories

- Wikipedia Inlink Propagation
- BabelNet Inlink Propagation
- Category Propagation
- Monosemous Content Word



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30 Original links

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30 Original links
21 new intra-page links 

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A Semantically Enriched Wikipedia (SEW)

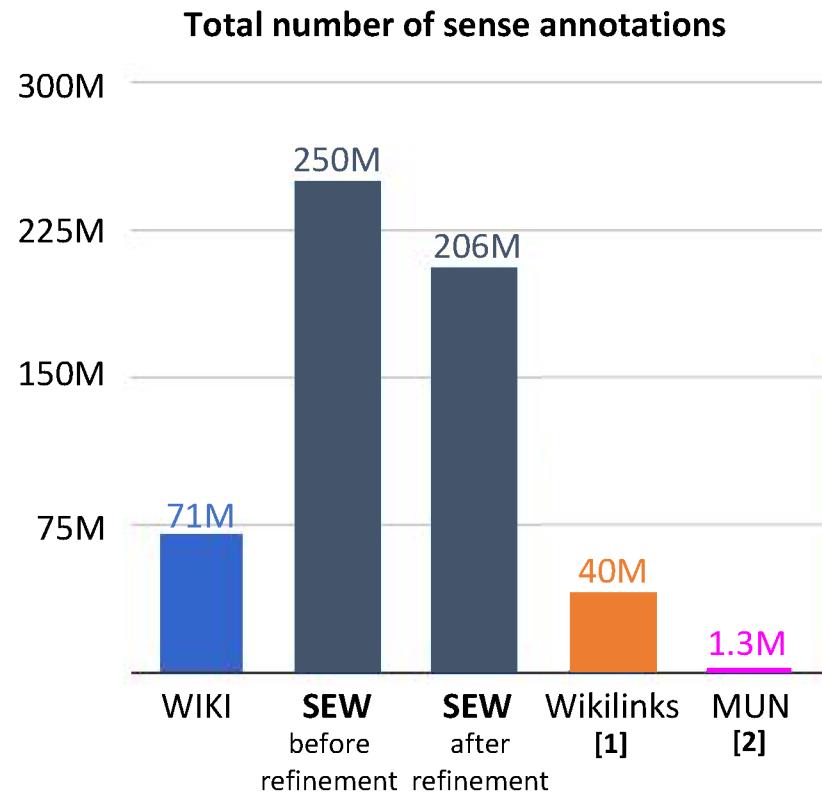


Statistics - Another bird's eye view

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Statistics - Another bird's eye view



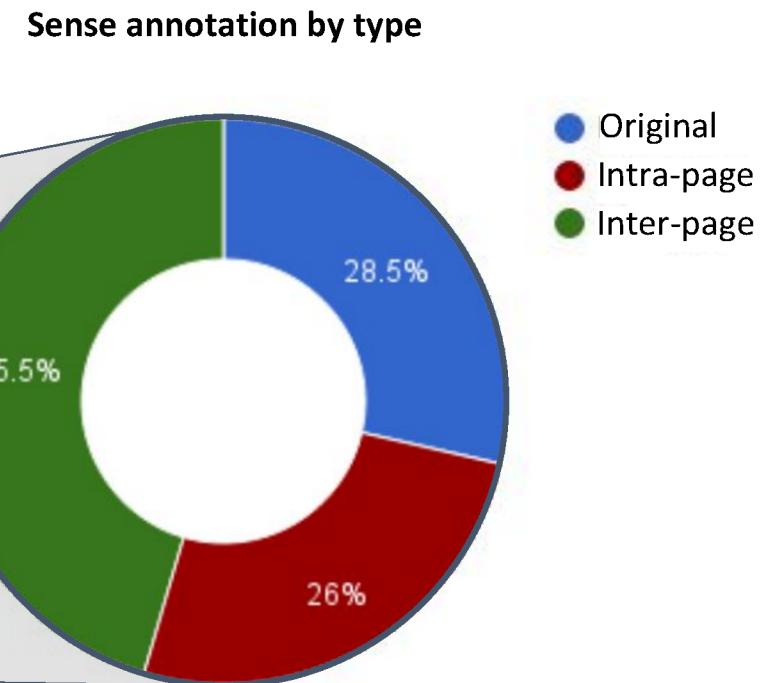
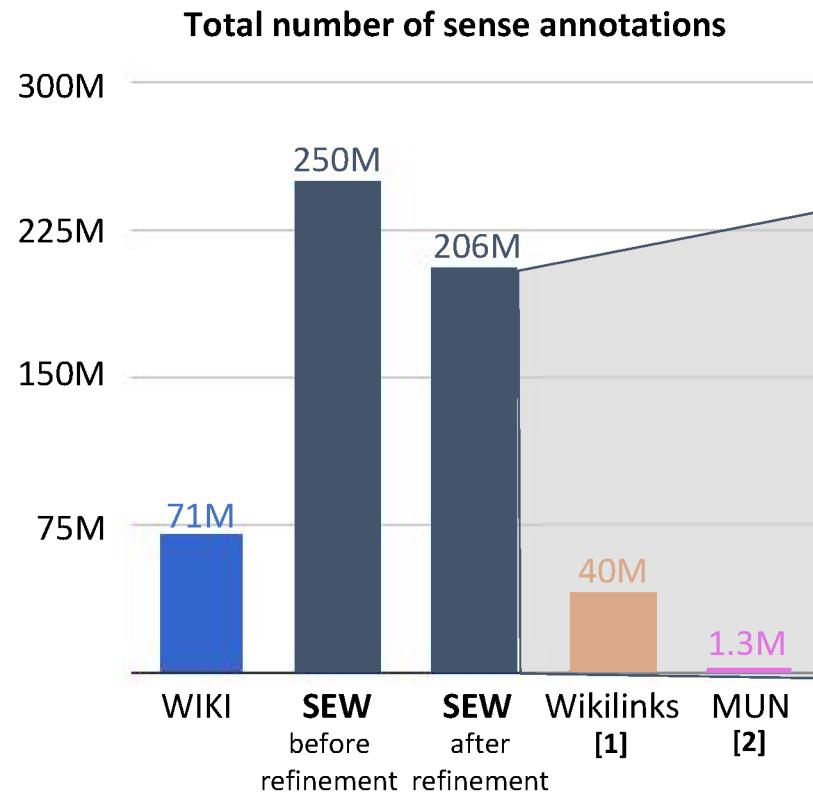
[1] S. Singh, A. Subramanya, F. Pereira, and A. McCallum.
Wikilinks: A large-scale cross-document coreference corpus
labeled via links to Wikipedia. Technical Report UM-CS-2012-015.

[2] K. Taghipour and H. Ng. *One million sense-tagged instances*
for word sense disambiguation and induction. CoNLL, 2015.

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Statistics - Another bird's eye view



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Experiments

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Experiments

- **Intrinsic Evaluation - Annotation Quality**

We compared our sense annotations against those discovered by **3W** (Noraset et al. 2014), a Wikipedia-specific system designed to add automatically high-precision hyperlinks



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Experiments

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- **Extrinsic Evaluation - Entity Linking and Semantic Similarity**

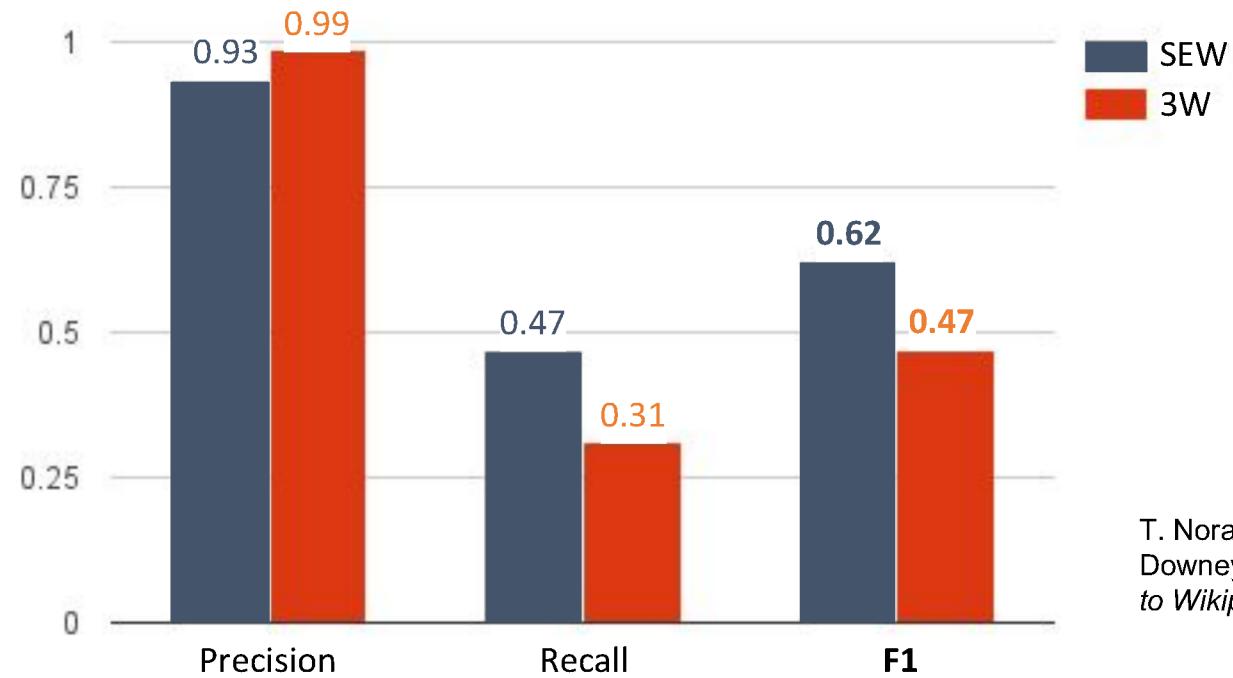
We used **SEW** both as **training set** for Entity Linking, and as **semantic network** to develop Wikipedia-based vector representations for Semantic Similarity



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Intrinsic Evaluation

Hand-labeled evaluation set of **2000** Wikipedia pages (Noraset et al. 2014):



T. Noraset, C. Bhagavatula, and D. Downey. *Adding high-precision links to Wikipedia*. EMNLP, 2014.

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Extrinsic Evaluation #1 - Entity Linking

- **Benchmark system:**

IMS (Zhong and Ng 2010), a state-of-the-art supervised system for Word Sense Disambiguation in English based on SVMs

- **IMS + SEW** IMS trained on SEW
- **IMS + HL** IMS trained only on the original hyperlinks (baseline #1)
- **MFS** Most Frequent Sense provided by BabelNet (baseline #2)

- **Datasets:**

- **SemEval 2013, task 12**
- **SemEval 2015, task 13**
- **MSNBC**
- **AIDA-CoNLL**

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Extrinsic Evaluation #1 - Entity Linking

	SemEval-2013	SemEval-2015	MSNBC	AIDA-CoNLL
IMS+SEW	0.810	0.882	0.789	0.726
IMS+HL	0.775	0.758	0.695	0.712
MFS	0.802	0.857	0.620	0.535
UMCC-DLSI	0.548	-	-	-
Babelfy	0.874	-	-	0.821
DFKI	-	0.889	-	-
SUDOKU	-	0.870	-	-
Wikifier	-	-	0.812	0.724
M&W	-	-	0.685	0.823

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Extrinsic Evaluation #2 - Semantic Similarity

A Semantically Enriched Wikipedia (SEW)



Extrinsic Evaluation #2 - Semantic Similarity

We used **SEW** to build Wikipedia-based vector representations for **BabelNet senses**:

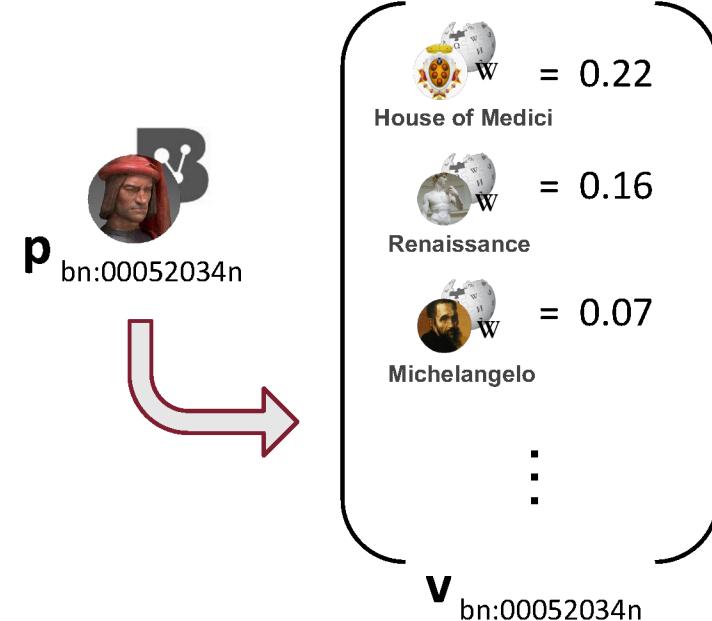
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- **WB-SEW**: associates a vector v with each sense in BabelNet, defined in the space of Wikipedia pages;



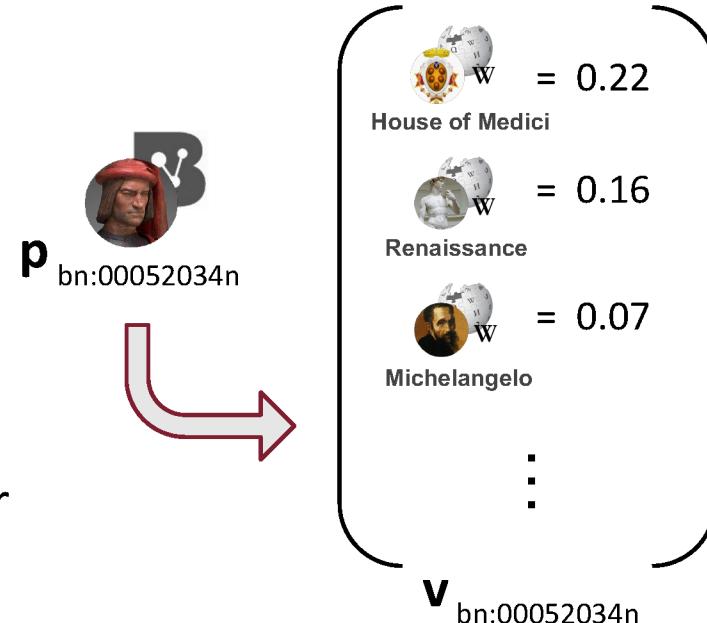
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- Each component of \mathbf{v} is an estimated frequency based on either **raw count (RC)** or **lexical specificity (LS)**



A Semantically Enriched Wikipedia (SEW)



Extrinsic Evaluation #2 - Semantic Similarity

Pearson (r) and Spearman (ρ) correlation in the word similarity task:

		WB-SEW		WB-HL	
		RC	LS	RC	LS
WS-Sim	r	0.65	0.64	0.58	0.58
	ρ	0.69	0.70	0.59	0.61
SimLex-666	r	0.38	0.38	0.32	0.32
	ρ	0.40	0.41	0.31	0.32

Baseline:
only original
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A Semantically Enriched Wikipedia (SEW)



Extrinsic Evaluation #2 - Semantic Similarity

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only original
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ADW (Pilehvar et al. 2013) on WS-Sim: $r = 0.63$ $\rho = 0.69$

ESA (Gabrilovich and Markovitch, 2007) on WS-Sim: $r = 0.40$ $\rho = 0.47$

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Extrinsic Evaluation #2 - Semantic Similarity (cont.)

A Semantically Enriched Wikipedia (SEW)



Extrinsic Evaluation #2 - Semantic Similarity (cont.)

Pearson (r) and Spearman (ρ) for multilingual word similarity on RG-65:

		WB-SEW		WB-HL		Word2Vec		Polyglot
		RC	LS	RC	LS	original	retro	
EN	r	0.673	0.674	0.619	0.614	-	-	0.51
	ρ	0.608	0.620	0.592	0.592	0.73	0.77	0.55
FR	r	0.808	0.811	0.773	0.778	-	-	0.38
	ρ	0.755	0.759	0.693	0.681	0.47	0.61	0.35
DE	r	0.639	0.639	0.584	0.580	-	-	0.18
	ρ	0.689	0.695	0.637	0.615	0.53	0.60	0.15
ES	r	0.811	0.804	0.757	0.740	-	-	0.51
	ρ	0.815	0.812	0.764	0.759	-	-	0.56

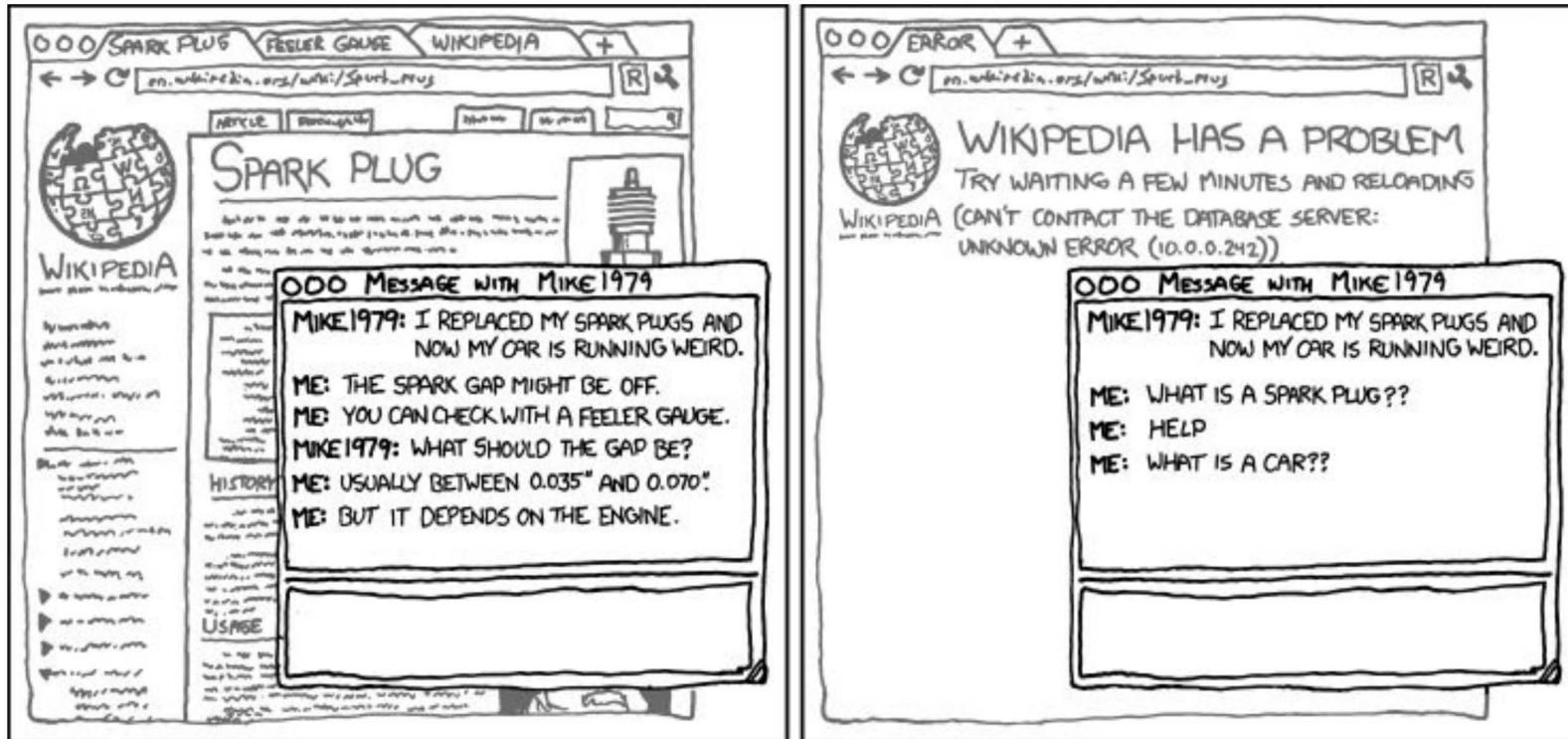
A Semantically Enriched Wikipedia (SEW)

Conclusion

- **SEW**: A Semantically Enriched Wikipedia with more than **200M** annotations of over **4M** different word senses and named entities from the very same, wide-coverage sense inventory of BabelNet
- The cascade of **propagation heuristics** used for SEW is surprisingly simple, fully automatic and self contained (no need for training, validation or tuning any off-the-shelf system)
- Our **extensive evaluation**, beside proving the quality of SEW's annotations, sets important performance baselines for multiple tasks and datasets

Thank you!

(and see you at the poster session this evening)



WHEN WIKIPEDIA HAS A SERVER OUTAGE, MY APPARENT IQ DROPS BY ABOUT 30 POINTS.



<http://lcl.uniroma1.it/sew>