

Towards a Fine-Grained Entity Linking Approach

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Supervisors: Aidan Hogan and Barbara Poblete

Dissertation Defense

June 11th, 2021

Outline

- Introduction
- Problem
- Hypothesis
- Consensus about Entity Linking
- Multilingualism
- Fine-Grained Entity Linking
- Fine-Grained Entity Linking Systems
- Conclusions

Example

Joseph Walter “Joe” Jackson, was a steelworker at U.S. Steel. In an interview with Martin Bashir for the 2003 documentary *Living with Michael Jackson*, Jackson recalled that Joe often sat in a chair with a belt in his hand as he and his siblings rehearsed.

Example - Entity Recognition

Joseph Walter “Joe” Jackson, was a steelworker at U.S. Steel. In an interview with Martin Bashir for the 2003 documentary Living with Michael Jackson, Jackson recalled that Joe often sat in a chair with a belt in his hand as he and his siblings rehearsed.

Example - Entity Disambiguation

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Martin Bashir

From Wikipedia, the free encyclopedia

For the former MSNBC show, see **Martin Bashir (TV series)**.

Martin Henry Bashir (born 18 January 1962) is a British journalist.

After initially gaining prominence on British television with his BBC interview with Clive, Francis of Walsley, and then his controversial fly-on-the-wall documentary with pop singer **Michael Jackson** on ITV, Bashir has a particular concentration for in-depth, 'hard-hitting' interviews.



Martin Bashir

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Joe Jackson

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U.S. Steel

From Wikipedia, the free encyclopedia
Redirected from US Steel

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United States Steel Corporation

Type: **Public**
Sector: **Industrial**
SIC: **3311**
NAICS: **331110**
Parent: **U.S. Steel Corporation**
Listed as: **Steel**

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Michael Jackson

From Wikipedia, the free encyclopedia

The former member **Michael Jackson**, see **Michael Jackson (disambiguation)**.

King of pop redirects here. For other uses, see **King of pop (disambiguation)**.

Michael Joseph Jackson (August 29, 1958 – June 25, 2009) was an American singer, songwriter, and dancer. Dubbed the "King of Pop", he was one of the most popular entertainers in the world, and set the first selling record ever during the year of his death.

Jack's 1971 Jackson's contributions to music, dance, and popular culture along with his published personal life made him a global figure in popular culture for over five decades.

The single child of the Jackson family, Michael made his professional debut in 1964 with his elder brothers Jermaine, Tito, Marlon, and LaToya as a member of the Jackson 5. He began his solo career in 1971 with *Got to Be Real*. In the early 1980s, Jackson became a *Billboard* figure in popular music, with music videos,



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Living with Michael Jackson

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Knowledge Bases



BabelNet



Name Variations in Entity Linking

Michael Joseph Jackson

Michael J. Jackson

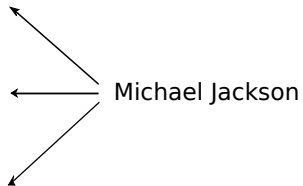
King of Pop

The screenshot shows the Wikipedia article for Michael Jackson. The title is "Michael Jackson". The introductory text reads: "For other people named Michael Jackson, see Michael Jackson (disambiguation). *King of Pop* redirects here. For other uses, see King of Pop (disambiguation). Michael Joseph Jackson (August 29, 1958 – June 25, 2009) was an American singer, songwriter, and dancer. Dubbed the "King of Pop", he was one of the most popular entertainers in the world, and was the best-selling music artist during the year of his death.^[R] Jackson's contributions to music, dance, and fashion^{[R][R]} along with his publicized personal life made him a global figure in popular culture for over four decades. The eighth child of the Jackson family, Michael made his professional debut in 1982 with his older brothers, Jackie, Tito, Jermaine, and Marlon as a member of the Jackson 5. He began his solo career in 1983 with *Michael*. He made his first solo album, *Thriller*, in 1982, which became the first Halloween-themed album and the first to be certified platinum. It was the first of five studio albums to be certified platinum. The album's success led to the creation of the *Thriller* music video, which became the first to be certified platinum. The album's success led to the creation of the *Thriller* music video, which became the first to be certified platinum. The album's success led to the creation of the *Thriller* music video, which became the first to be certified platinum.

Name Variations in Entity Linking

The image displays three screenshots of Wikipedia pages, each representing a different name variation for the same entity, Michael Jackson. Each screenshot shows the article title, a brief description, and a small portrait image.

- Top Screenshot:** The article is titled "Michael Jackson" and is described as "the free encyclopedia". The text below the title reads: "For other people named Michael Jackson, see Michael Jackson (disambiguation). 'King of Pop' redirects here. For other uses, see King of Pop (disambiguation)." A small portrait of Michael Jackson is visible on the right side of the page.
- Middle Screenshot:** The article is titled "Michael Jackson (writer)" and is described as "the free encyclopedia". The text below the title reads: "For other people named Michael Jackson, see Michael Jackson (disambiguation). Michael James Jackson (27 March 1952 – 23 August 2009) was an English writer and journalist. He was the author of many influential books about beer and whisky, the top-a regular contributor to a number of British newspapers, particularly The Independent and The Observer." A small portrait of Michael Jackson is visible on the right side of the page.
- Bottom Screenshot:** The article is titled "Michael Jackson (actor)" and is described as "the free encyclopedia". The text below the title reads: "For other people named Michael Jackson, see Michael Jackson (disambiguation). This biography of a living person needs additional citations for verification. Please help by adding reliable sources. Contentious material about living persons that is unsourced or poorly sourced must be removed immediately, especially if potentially libelous or harmful. (May 2016) (Learn how and when to remove this template message)." A small portrait of Michael Jackson is visible on the right side of the page.



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Problem

- Initial steps: Multilingualism

Problem - Multilingual EL Datasets

Dataset	$ D $	$ S $	$ E $	Mn	Languages
AIDA/CoNLL-Complete	1393	22,137	34,929	✓	EN
KORE50	50	50	144	✓	EN
IITB	103	1,781	18,308	✓	EN
ACE2004	57	-	306	✗	EN
AQUAINT	50	533	727	✗	EN
MSNBC	20	668	747	✗	EN
DBpedia Spotlight	10	58	331	✓	EN
N3-RSS 500	1	500	1000	✓	EN
Reuters 128	128	-	881	✓	EN
Wes2015	331	-	28,586	✓	EN
News-100	100	-	1656	✓	DE
Thibaudet	1	3,807	2,980	✗	FR
Bergson	1	4,280	380	✗	FR
SemEval 2015 Task 13	4	137	769	✓	EN,ES,IT
DBpedia Abstracts	39,132	-	505,033	✗	DE,EN,ES,FR,IT,JA,NL
MEANTIME	120	597	2,790	✓	EN,ES,IT,NL

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AQUAINT	50	533	727	✗	EN
MSNBC	20	668	747	✗	EN
DBpedia Spotlight	10	58	331	✓	EN
N3-RSS 500	1	500	1000	✓	EN
Reuters 128	128	-	881	✓	EN
Wes2015	331	-	28,586	✓	EN
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MEANTIME	120	597	2,790	✓	EN,ES,IT,NL

Problem

- We decided to create a multilingual EL benchmark dataset.

Problem

- We decided to create a multilingual EL benchmark dataset.
- What should Entity Linking link?

Problem - Any other entity?

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Contents [show]

Early life and ancestry [edit]

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Joe Jackson

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Type: **Traded as** **Industry**

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Michael Jackson

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For other people named Michael Jackson, see Michael Jackson (disambiguation).

King of pop **rockstar** **teen idol** **pop icon** **pop prince** **disco prince**

Michael Joseph Jackson (August 29, 1958 – June 25, 2009) was an American singer, songwriter, and dancer. Dubbed the "King of Pop", he was one of the most popular entertainers in the world, and set the bar selling more acts during the year of his death.



Michael Jackson

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Living with Michael Jackson

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Problem - Any other entity?

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Joe Jackson was born to **Samuel Jackson** (1882-1965), an insurance salesman, and **Crystal Lee King** (1907-1987), in Fort Worth, TX, Arkansas, on July 26, 2008 (born in 1938, according to the Jackson Black Hall of Fame and author of Jackson's book My Family, the Jacksons' 1974 manager was the eldest of five children, which included brother's Laurence (died 2017) and Luther and sisters Lulu Mae and Verma Mae. He was one of the sons of Isaac New Jackson (1818-1904), a slave, based on the coat of rock hole, Jackson



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United States Steel Corporation

U.S.S.

Type: **Public**
 Trade as: **NYSE: XFP**
 S&P 400 Component: **Steel**

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Michael Joseph Jackson (August 28, 1958 – June 25, 2009) was an American singer, songwriter, and dancer. Dubbed the "King of Pop", he was one of the most popular entertainers in the world, and set the bar selling more than during the rest of the 20th century. Jackson's 1971 Jackson's contributions to music, dance, and popular culture along with his published personal life made him a global figure in popular culture for over five decades.

The single sold of the Jackson family, Michael made his professional debut in 1964 with his elder brother Jermaine. The Jacksons used Motown as a member of the Jackson 5. He began his solo career in 1971 with *Got to Be Real*. In the early 1980s, Jackson became a *Billboard* figure in popular music, with music videos



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Joe Jackson

Joe Jackson at work in 2007

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Type: **Industry**

Parent: **NYSE: XFP**

SAP A&E Component: **Steel**

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"Top of the world" redirects here. For other uses, see Top of the World (disambiguation).

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Living with Michael Jackson

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Genre: **Documentary**

Problem - Any other entity?

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Joe Jackson

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Type: **Public**
 Ticker: **XFP**
 S&P 400 Component: **Steel**

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Living with Michael Jackson

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Research Questions

1. What should Entity Linking link?

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 - How can we define the goal of the EL task?

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Research Questions

1. What should Entity Linking link?

- How can we define the goal of the EL task?
- Is consensus possible on the definition of an “entity”?
- How can we define benchmark EL datasets and what metrics can we use to reflect the lack of consensus?

Research Questions

2. How well do EL systems perform in multilingual settings?

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 - How well do available EL systems for languages other than English?

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 - How well do available EL systems for languages other than English?
 - How does the performance of systems compare for multilingual EL?
 - How would a method based on machine translation to English compare with directly configuring the system for a particular language?

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General hypothesis

One size does not fit all: different scenarios and different applications may have different requirements for an EL system, including, but not limited to, the types of entities targeted, the languages supported, etc.

- 1 Different EL systems consider different “entity” definitions, and thus target different sets of KB entities.
- 2 Current EL quality measures are not suitable for the evaluation of approaches that consider different “entity” definitions.
- 3 The majority of multilingual EL approaches behave in different ways for different languages.
- 4 Machine translation could be used in multilingual EL scenarios and reach/improve state-of-the-art multilingual EL approaches.

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Consensus about Entity Linking

Class-based definition

person



location



organization



temporal expressions



quantities



Class-based definition

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Living with Michael Jackson

Genre | **Documentary**



person



location



organization



temporal expressions



quantities



Knowledge Base definition

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Article: **Michael Jackson** Read View source View history

From Wikipedia, the free encyclopedia

For other people named Michael Jackson, see **Michael Jackson (disambiguation)**.

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Article: **2003** Read Edit View history

From Wikipedia, the free encyclopedia

This article is about the year 2003.

2003 (**MMIII**) was a common year starting on Wednesday of the Gregorian calendar, the 2003rd year of the Common Era (CE) and Anno Domini (AD) eras, the 4th millennium, the 21st century, and the 3rd millennium.

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Article: **Chair** Read View source View history

From Wikipedia, the free encyclopedia

This article is about furniture. For other uses, see **Chair (disambiguation)**.

A **chair** is a piece of furniture with a raised surface supported by legs, commonly used to seat a single person. Chairs are supposed to be designed to support the human body in a sitting position.

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Article: **Belt (clothing)** Read Edit View history

From Wikipedia, the free encyclopedia

"**Wair belt**" redirects here. For other types of belts, see **Belt (disambiguation)**.

This article has multiple issues. Please help improve it or discuss these issues on the talk page. (June 2017)

- and often to remove these template messages
- This article may require cleanup to meet Wikipedia's quality standards. (February 2022)
- This article needs additional citations for verification. (July 2022)


A **belt** is a flexible band or strap, typically made of leather or heavy cloth, and worn around the waist. A belt supports trousers or other articles of clothing.

Contents [show]


History [edit]

Belts have been documented as male clothing since the Bronze Age. Both genders have used them off and on, depending on the current fashion. In the western world, belts have been more common for men, with the exception of the early Middle Ages, late 17th-century Moravia, and short-time contributions between 2000 and 2022. An "hourglass belt buckle" are now collectors' items.

In the latter half of the 18th century and until the First World War, the belt was a decorative as well as utilitarian part of military uniform, particularly among officers. In the armed forces of Prussia, *Tsarist Russia*, and other Eastern European nations, it was common for officers to wear extremely tight pressing into their stomachs and gaging them up, wide belts around the waist, on the outside of the uniform, both to support a sash and for aesthetic reasons. These tightly cinched belts served to draw in the waist and give the wearer



A common black leather belt



Pattern on a cloth belt that is part of one Estonian national costume.

Questionnaire

Gong-Qing Wu, Ying He, and Xuegang Hu. 2018. Entity linking: An issue to extract corresponding entity with knowledge base. IEEE Access, 6:6220–6231.

Questionnaire

In an interview with Martin Bashir for the 2003 documentary *Living with Michael Jackson*, the King of Pop recalled that Joe often sat with a white belt at hand as he and his four siblings rehearsed.

Russian daily *Kommersant* reports that Moscow will supply the Greeks with gas at rock bottom prices as Tsipras prepares to meet the Russian President.

Questionnaire

[[Russian]] daily Kommersant reports that ...

- Annotate "Russian" with <https://en.wikipedia.org/wiki/Russia> <tick all that apply>
- Annotate "Russian" with https://en.wikipedia.org/wiki/Russian_language <tick all that apply>
- Annotate "Russian" with <https://en.wikipedia.org/wiki/Russians> <tick all that apply>
- Do not annotate "Russian"

Russian [[daily]] Kommersant reports that ...

- Annotate "daily" with <https://en.wikipedia.org/wiki/Newspaper>
- Do not annotate "daily"

Questionnaire

- We sent the questionnaire to 321 researchers, of which 232 requests were delivered successfully.
- We received a total of 36 responses.

Questionnaire

In an [interview]^{.19} with [Martin Bashir]¹ for the [2003]^{.28} [documentary]^{.28} [Living with {Michael Jackson}^{.75}]^{.97}, the [{King}^{.08} of {Pop}^{.33}]^{.94} [recalled]^{.06} that [Joe]¹ often [sat]^{.08} with a [white]^{.11} [belt]^{.14} at [hand]^{.14} as [{he}^{.56} and {his}^{.39} {four}^{.08} {siblings}^{.14}]^{.50} [rehearsed]^{.08}.

[Russian]^{.61} [daily]^{.14} [Kommersant]^{.97} [reports]^{.06} that [Moscow]^{.94} will [supply]^{.06} the [Greeks]^{.94} with [gas]^{.36} at [{rock}¹ bottom {prices}^{.19}]^{.28} as [Tsipras]^{.92} [prepares]^{.03} to [meet]^{.06} the [{Russian}^{.53} {President}^{.12}]^{.97}.

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Our Position

- It depends on the application.

Application in Semantic Search

Application in Semantic Search

Finding all documents about US singers

Michael Joseph Jackson was an American singer, songwriter, and dancer. He was invited to the White House ...

Application in Semantic Search

Finding all documents about US singers

Michael Joseph Jackson was an American singer, songwriter, and dancer. He was invited to the White House ...

Application in Relation Extraction

Application in Relation Extraction

Extract new facts from text

Michael Joseph Jackson was an American singer, songwriter, and dancer. He was invited to the White House ...

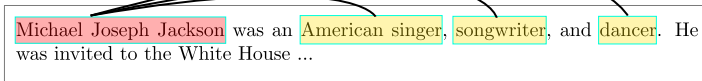
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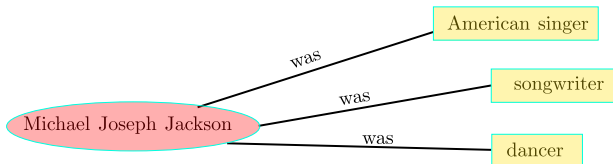
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Application in Relation Extraction

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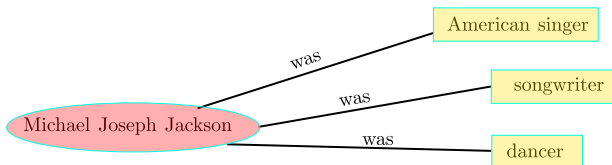
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Application in Relation Extraction

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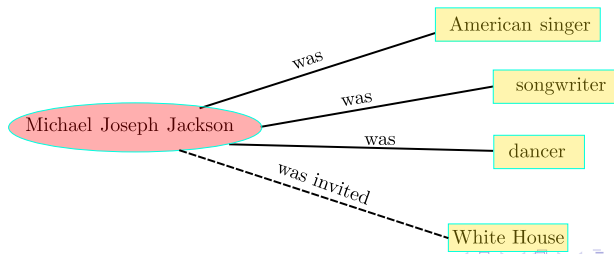
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Outline

- Introduction
- Problem
- Hypothesis
- Consensus about Entity Linking
- Multilingualism
- Fine-Grained Entity Linking
- Fine-Grained Entity Linking Systems
- Conclusions

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Multilingualism

VoxEL

- 1 Create a benchmark dataset for multilingual Entity Linking

VoxEL

- 1 Create a benchmark dataset for multilingual Entity Linking
- 2 Create two versions of the dataset: strict and relaxed.

Creation of VoxEL dataset

- It based on curated text from five languages.
- Same sentences for each corresponding document.
- Same annotations for each corresponding sentence.


Curated source: VoxEurop

VOXeurop DAS BESTE AUS EUROPAS PRESSE

Proteste in Rumänien Rettungslan Griechenland Griechenland-Krise Griechenland-Rettung Polen Quellen Autoren Länder

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Die europäische Sozialdemokratie kämpft ums politische Überleben

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Are social democrats still alive?

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VoxEurop è realizzato da una squadra di giornalisti e di traduttori volontari, ma ci sono costi di funzionamento che non possono essere evitati. Aiutaci a mantenere il sito online e ad andare avanti facendo un dono al progetto. Grazie!

NEWSLETTER

Abbonati alla nostra settimanale in italiano.

Email:

Per abbonarti in qualsiasi momento. La tua email non verrà comunicata ad altri.

EVENTI

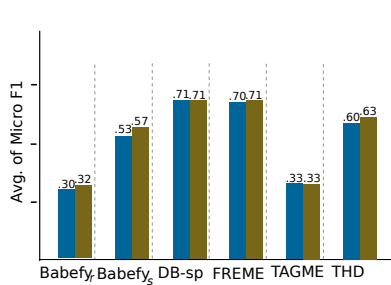
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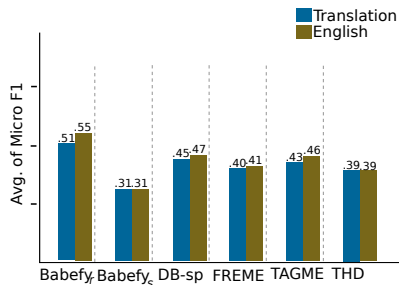
Experiments

- 1 Evaluate the performance of state-of-the-art approaches using machine translation.

Experiments



Results of the Strict version of VoxEL



Results of the Relaxed version of VoxEL

- VoxEL does not consider intermediate definitions of entities

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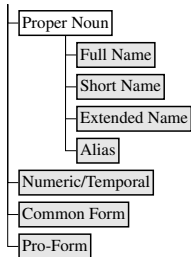
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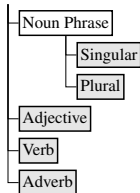
Fine-Grained Entity Linking

Categories

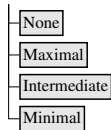
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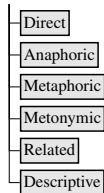
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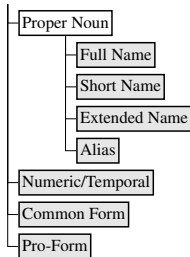


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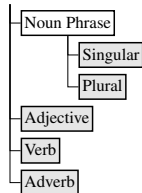


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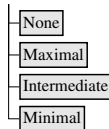
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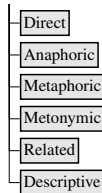
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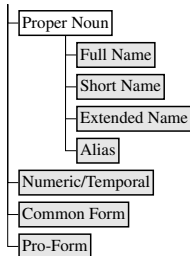
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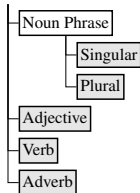
Joseph Walter, was a steelworker at U.S Steel.

Categories

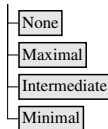
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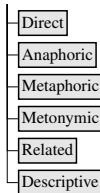
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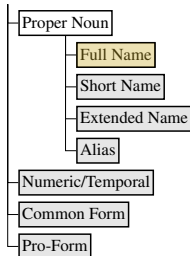


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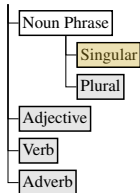
[https://en.wikipedia.org/wiki/Joseph.Walter_\(manager\)](https://en.wikipedia.org/wiki/Joseph.Walter_(manager))

Categories

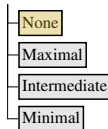
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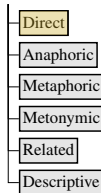
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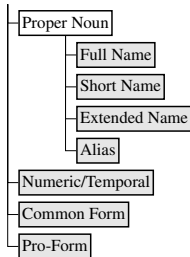


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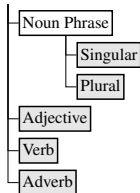
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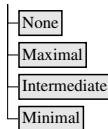
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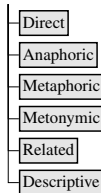
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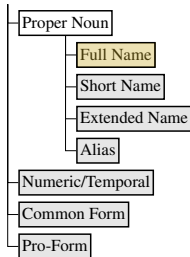
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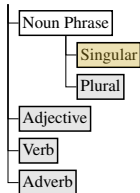
Joseph Walter, was a steelworker at **U.S Steel**.
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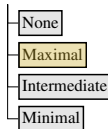
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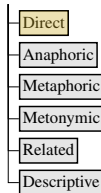
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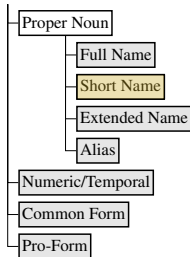


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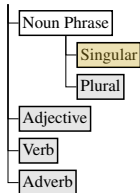
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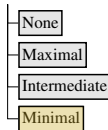
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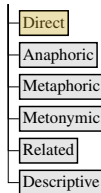
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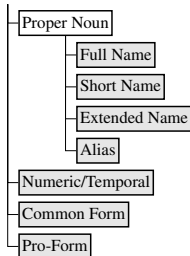
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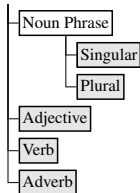
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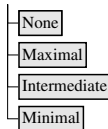
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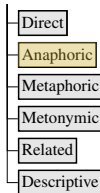
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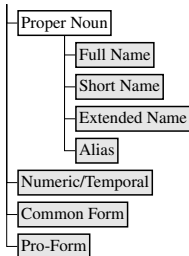
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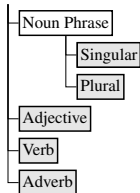
Michael Jackson was an American singer, songwriter, and dancer. He is regarded worldwide as one of the most significant cultural figures of the 20th century.

Categories

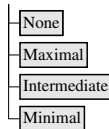
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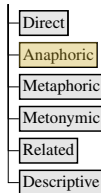
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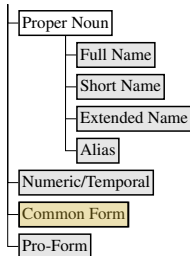


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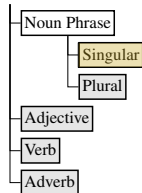
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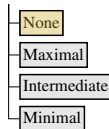
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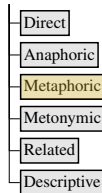
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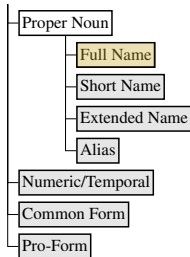


David and Victoria added **spice** to their marriage.

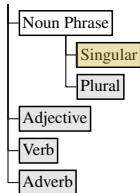
<https://en.wikipedia.org/wiki/Spice>

Categories

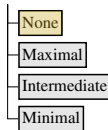
BASE FORM



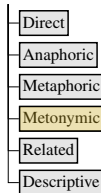
PART OF SPEECH



OVERLAP



REFERENCE

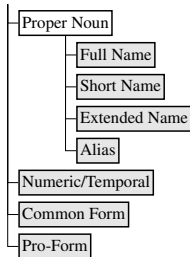


Greece beat England in the Euro Finals.

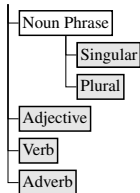
https://en.wikipedia.org/wiki/Greece_national_football_team

Categories

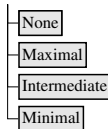
BASE FORM



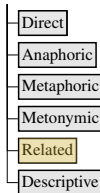
PART OF SPEECH



OVERLAP



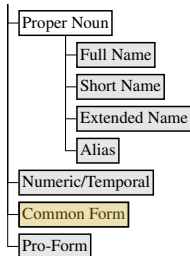
REFERENCE



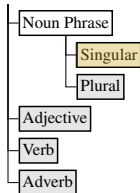
Today I am presenting my Dissertation Defense
<https://en.wikipedia.org/wiki/Present>

Categories

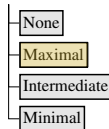
BASE FORM



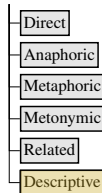
PART OF SPEECH



OVERLAP



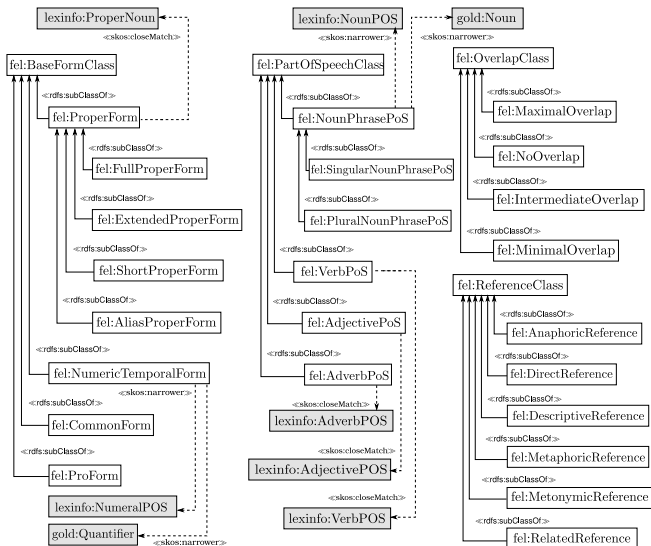
REFERENCE



The capital of Chile is an incredible city.

<https://en.wikipedia.org/wiki/Santiago>

FEL Ontology



Re-annotation and categorization

- ① KORE50: 1 doc, 50 sentences
- ② VoxEL: 15 doc, 94 sentences
- ③ ACE04: first 20 doc, 214 sentences

Validating by tag

	[A]	B _s			B _r			T			D			A			F		
		P	R	F ₁	P	R	F ₁	P	R	F ₁	P	R	F ₁	P	R	F ₁	P	R	F ₁
Full Mention	766	0.93	0.46	0.61	0.75	0.53	0.62	0.82	0.59	0.69	0.84	0.57	0.68	0.78	0.57	0.66	0.82	0.55	0.65
Short Mention	497	0.44	0.16	0.23	0.37	0.24	0.29	0.54	0.44	0.48	0.5	0.30	0.37	0.50	0.36	0.42	0.39	0.28	0.33
Extended Mention	9	1.00	0.56	0.71	0.83	0.56	0.67	1.00	0.44	0.62	1.00	0.44	0.62	1.00	0.44	0.62	0.80	0.44	0.57
Alias	112	0.56	0.16	0.25	0.33	0.21	0.25	0.52	0.32	0.40	0.67	0.38	0.48	0.60	0.29	0.40	0.55	0.29	0.38
Numeric/Temporal	404	0.45	0.01	0.02	0.82	0.24	0.37	0.14	0.03	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Common Form	2,452	0.21	0.00	0.01	0.66	0.33	0.44	0.49	0.28	0.35	0.88	0.04	0.08	0.43	0.00	0.00	0.56	0.00	0.01
Pro-form	153	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Singular Noun	2,623	0.79	0.17	0.28	0.73	0.45	0.56	0.62	0.38	0.47	0.87	0.24	0.38	0.79	0.20	0.32	0.74	0.19	0.31
Plural Noun	746	0.33	0.01	0.02	0.61	0.33	0.43	0.56	0.28	0.37	0.83	0.03	0.06	0.70	0.03	0.07	0.66	0.04	0.07
Adjective	516	0.77	0.02	0.04	0.26	0.07	0.11	0.56	0.24	0.34	0.65	0.14	0.23	0.72	0.21	0.32	0.60	0.14	0.22
Verb	334	0.00	0.00	0.00	0.86	0.02	0.04	0.37	0.17	0.23	1.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Adverb	12	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.42	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non-Overlapping	2,871	0.75	0.12	0.20	0.67	0.33	0.45	0.58	0.38	0.46	0.84	0.19	0.32	0.78	0.19	0.30	0.71	0.17	0.27
Maximal Overlap	464	0.87	0.17	0.29	0.85	0.36	0.50	0.73	0.34	0.46	0.89	0.19	0.32	0.84	0.08	0.15	0.84	0.12	0.22
Intermediate Overlap	71	0.76	0.18	0.30	0.71	0.52	0.60	0.57	0.30	0.39	0.56	0.13	0.21	0.54	0.10	0.17	0.78	0.10	0.17
Minimal Overlap	825	0.82	0.04	0.09	0.61	0.37	0.46	0.50	0.15	0.23	0.80	0.09	0.17	0.72	0.09	0.16	0.66	0.06	0.12
Direct	3,106	0.79	0.13	0.23	0.71	0.43	0.53	0.63	0.38	0.47	0.83	0.21	0.33	0.76	0.19	0.30	0.70	0.17	0.27
Anaphoric	153	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Metaphoric	69	0.00	0.00	0.00	0.57	0.29	0.38	0.43	0.35	0.38	0.91	0.14	0.25	0.00	0.00	0.00	0.00	0.00	0.00
Metonymic	73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Related	829	0.64	0.06	0.11	0.36	0.14	0.20	0.39	0.24	0.30	0.76	0.10	0.18	0.81	0.08	0.15	0.83	0.09	0.16
Descriptive	189	0.33	0.01	0.01	0.44	0.02	0.04	0.16	0.02	0.03	0.60	0.02	0.03	0.00	0.00	0.00	0.6	0.02	0.03
All	4231	0.77	0.11	0.19	0.67	0.35	0.46	0.59	0.33	0.42	0.84	0.17	0.29	0.77	0.16	0.26	0.72	0.14	0.24

Results per category for Babelfy (strict/relaxed), TagME, DBpedia Spotlight, AIDA and FRENTE

Validating by tag

	[A]	B _s			B _r			T			D			A			F		
		P	R	F ₁	P	R	F ₁	P	R	F ₁	P	R	F ₁	P	R	F ₁	P	R	F ₁
Full Mention	766	0.93	0.46	0.61	0.75	0.53	0.62	0.82	0.59	0.69	0.84	0.57	0.68	0.78	0.57	0.66	0.82	0.55	0.65
Short Mention	497	0.44	0.16	0.23	0.37	0.24	0.29	0.54	0.44	0.48	0.5	0.30	0.37	0.50	0.36	0.42	0.39	0.28	0.33
Extended Mention	9	1.00	0.56	0.71	0.83	0.56	0.67	1.00	0.44	0.62	1.00	0.44	0.62	1.00	0.44	0.62	0.80	0.44	0.57
Alias	112	0.56	0.16	0.25	0.33	0.21	0.25	0.52	0.32	0.40	0.67	0.38	0.48	0.60	0.29	0.40	0.55	0.29	0.38
Numeric/Temporal	404	0.45	0.01	0.02	0.82	0.24	0.37	0.14	0.03	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Common Form	2,452	0.21	0.00	0.01	0.66	0.33	0.44	0.49	0.28	0.35	0.88	0.04	0.08	0.43	0.00	0.00	0.56	0.00	0.01
Pro-form	153	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Singular Noun	2,623	0.79	0.17	0.28	0.73	0.45	0.56	0.62	0.38	0.47	0.87	0.24	0.38	0.79	0.20	0.32	0.74	0.19	0.31
Plural Noun	746	0.33	0.01	0.02	0.61	0.33	0.43	0.56	0.28	0.37	0.83	0.03	0.06	0.70	0.03	0.07	0.66	0.04	0.07
Adjective	516	0.77	0.02	0.04	0.26	0.07	0.11	0.56	0.24	0.34	0.65	0.14	0.23	0.72	0.21	0.32	0.60	0.14	0.22
Verb	334	0.00	0.00	0.00	0.86	0.02	0.04	0.37	0.17	0.23	1.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Adverb	12	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.42	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non-Overlapping	2,871	0.75	0.12	0.20	0.67	0.33	0.45	0.58	0.38	0.46	0.84	0.19	0.32	0.78	0.19	0.30	0.71	0.17	0.27
Maximal Overlap	464	0.87	0.17	0.29	0.85	0.36	0.50	0.73	0.34	0.46	0.89	0.19	0.32	0.84	0.08	0.15	0.84	0.12	0.22
Intermediate Overlap	71	0.76	0.18	0.30	0.71	0.52	0.60	0.57	0.30	0.39	0.56	0.13	0.21	0.54	0.10	0.17	0.78	0.10	0.17
Minimal Overlap	825	0.82	0.04	0.09	0.61	0.37	0.46	0.50	0.15	0.23	0.80	0.09	0.17	0.72	0.09	0.16	0.66	0.06	0.12
Direct	3,106	0.79	0.13	0.23	0.71	0.43	0.53	0.63	0.38	0.47	0.83	0.21	0.33	0.76	0.19	0.30	0.70	0.17	0.27
Anaphoric	153	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Metaphoric	69	0.00	0.00	0.00	0.57	0.29	0.38	0.43	0.35	0.38	0.91	0.14	0.25	0.00	0.00	0.00	0.00	0.00	0.00
Metonymic	73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Related	829	0.64	0.06	0.11	0.36	0.14	0.20	0.39	0.24	0.30	0.76	0.10	0.18	0.81	0.08	0.15	0.83	0.09	0.16
Descriptive	189	0.33	0.01	0.01	0.44	0.02	0.04	0.16	0.02	0.03	0.60	0.02	0.03	0.00	0.00	0.00	0.6	0.02	0.03
All	4231	0.77	0.11	0.19	0.67	0.35	0.46	0.59	0.33	0.42	0.84	0.17	0.29	0.77	0.16	0.26	0.72	0.14	0.24

Results per category for Babelfy (strict/relaxed), TagME, DBpedia Spotlight, AIDA and FRENTE

Validating by tag

	[A]	B _s			B _r			T			D			A			F		
		P	R	F ₁	P	R	F ₁	P	R	F ₁	P	R	F ₁	P	R	F ₁	P	R	F ₁
Full Mention	766	0.93	0.46	0.61	0.75	0.53	0.62	0.82	0.59	0.69	0.84	0.57	0.68	0.78	0.57	0.66	0.82	0.55	0.65
Short Mention	497	0.44	0.16	0.23	0.37	0.24	0.29	0.54	0.44	0.48	0.5	0.30	0.37	0.50	0.36	0.42	0.39	0.28	0.33
Extended Mention	9	1.00	0.56	0.71	0.83	0.56	0.67	1.00	0.44	0.62	1.00	0.44	0.62	1.00	0.44	0.62	0.80	0.44	0.57
Alias	112	0.56	0.16	0.25	0.33	0.21	0.25	0.52	0.32	0.40	0.67	0.38	0.48	0.60	0.29	0.40	0.55	0.29	0.38
Numeric/Temporal	404	0.45	0.01	0.02	0.82	0.24	0.37	0.14	0.03	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Common Form	2,452	0.21	0.00	0.01	0.66	0.33	0.44	0.49	0.28	0.35	0.88	0.04	0.08	0.43	0.00	0.00	0.56	0.00	0.01
Pro-form	153	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Singular Noun	2,623	0.79	0.17	0.28	0.73	0.45	0.56	0.62	0.38	0.47	0.87	0.24	0.38	0.79	0.20	0.32	0.74	0.19	0.31
Plural Noun	746	0.33	0.01	0.02	0.61	0.33	0.43	0.56	0.28	0.37	0.83	0.03	0.06	0.70	0.03	0.07	0.66	0.04	0.07
Adjective	516	0.77	0.02	0.04	0.26	0.07	0.11	0.56	0.24	0.34	0.65	0.14	0.23	0.72	0.21	0.32	0.60	0.14	0.22
Verb	334	0.00	0.00	0.00	0.86	0.02	0.04	0.37	0.17	0.23	1.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Adverb	12	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.42	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non-Overlapping	2,871	0.75	0.12	0.20	0.67	0.33	0.45	0.58	0.38	0.46	0.84	0.19	0.32	0.78	0.19	0.30	0.71	0.17	0.27
Maximal Overlap	464	0.87	0.17	0.29	0.85	0.36	0.50	0.73	0.34	0.46	0.89	0.19	0.32	0.84	0.08	0.15	0.84	0.12	0.22
Intermediate Overlap	71	0.76	0.18	0.30	0.71	0.52	0.60	0.57	0.30	0.39	0.56	0.13	0.21	0.54	0.10	0.17	0.78	0.10	0.17
Minimal Overlap	825	0.82	0.04	0.09	0.61	0.37	0.46	0.50	0.15	0.23	0.80	0.09	0.17	0.72	0.09	0.16	0.66	0.06	0.12
Direct	3,106	0.79	0.13	0.23	0.71	0.43	0.53	0.63	0.38	0.47	0.83	0.21	0.33	0.76	0.19	0.30	0.70	0.17	0.27
Anaphoric	153	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Metaphoric	69	0.00	0.00	0.00	0.57	0.29	0.38	0.43	0.35	0.38	0.91	0.14	0.25	0.00	0.00	0.00	0.00	0.00	0.00
Metonymic	73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Related	829	0.64	0.06	0.11	0.36	0.14	0.20	0.39	0.24	0.30	0.76	0.10	0.18	0.81	0.08	0.15	0.83	0.09	0.16
Descriptive	189	0.33	0.01	0.01	0.44	0.02	0.04	0.16	0.02	0.03	0.60	0.02	0.03	0.00	0.00	0.00	0.6	0.02	0.03
All	4231	0.77	0.11	0.19	0.67	0.35	0.46	0.59	0.33	0.42	0.84	0.17	0.29	0.77	0.16	0.26	0.72	0.14	0.24

Results per category for Babelfy (strict/relaxed), TagME, DBpedia Spotlight, AIDA and FRENTE

Validating by tag

	[A]	B _s			B _r			T			D			A			F		
		P	R	F ₁	P	R	F ₁	P	R	F ₁	P	R	F ₁	P	R	F ₁	P	R	F ₁
Full Mention	766	0.93	0.46	0.61	0.75	0.53	0.62	0.82	0.59	0.69	0.84	0.57	0.68	0.78	0.57	0.66	0.82	0.55	0.65
Short Mention	497	0.44	0.16	0.23	0.37	0.24	0.29	0.54	0.44	0.48	0.5	0.30	0.37	0.50	0.36	0.42	0.39	0.28	0.33
Extended Mention	9	1.00	0.56	0.71	0.83	0.56	0.67	1.00	0.44	0.62	1.00	0.44	0.62	1.00	0.44	0.62	0.80	0.44	0.57
Alias	112	0.56	0.16	0.25	0.33	0.21	0.25	0.52	0.32	0.40	0.67	0.38	0.48	0.60	0.29	0.40	0.55	0.29	0.38
Numeric/Temporal	404	0.45	0.01	0.02	0.82	0.24	0.37	0.14	0.03	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Common Form	2,452	0.21	0.00	0.01	0.66	0.33	0.44	0.49	0.28	0.35	0.88	0.04	0.08	0.43	0.00	0.00	0.56	0.00	0.01
Pro-form	153	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Singular Noun	2,623	0.79	0.17	0.28	0.73	0.45	0.56	0.62	0.38	0.47	0.87	0.24	0.38	0.79	0.20	0.32	0.74	0.19	0.31
Plural Noun	746	0.33	0.01	0.02	0.61	0.33	0.43	0.56	0.28	0.37	0.83	0.03	0.06	0.70	0.03	0.07	0.66	0.04	0.07
Adjective	516	0.77	0.02	0.04	0.26	0.07	0.11	0.56	0.24	0.34	0.65	0.14	0.23	0.72	0.21	0.32	0.60	0.14	0.22
Verb	334	0.00	0.00	0.00	0.86	0.02	0.04	0.37	0.17	0.23	1.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Adverb	12	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.42	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non-Overlapping	2,871	0.75	0.12	0.20	0.67	0.33	0.45	0.58	0.38	0.46	0.84	0.19	0.32	0.78	0.19	0.30	0.71	0.17	0.27
Maximal Overlap	464	0.87	0.17	0.29	0.85	0.36	0.50	0.73	0.34	0.46	0.89	0.19	0.32	0.84	0.08	0.15	0.84	0.12	0.22
Intermediate Overlap	71	0.76	0.18	0.30	0.71	0.52	0.60	0.57	0.30	0.39	0.56	0.13	0.21	0.54	0.10	0.17	0.78	0.10	0.17
Minimal Overlap	825	0.82	0.04	0.09	0.61	0.37	0.46	0.50	0.15	0.23	0.80	0.09	0.17	0.72	0.09	0.16	0.66	0.06	0.12
Direct	3,106	0.79	0.13	0.23	0.71	0.43	0.53	0.63	0.38	0.47	0.83	0.21	0.33	0.76	0.19	0.30	0.70	0.17	0.27
Anaphoric	153	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Metaphoric	69	0.00	0.00	0.00	0.57	0.29	0.38	0.43	0.35	0.38	0.91	0.14	0.25	0.00	0.00	0.00	0.00	0.00	0.00
Metonymic	73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Related	829	0.64	0.06	0.11	0.36	0.14	0.20	0.39	0.24	0.30	0.76	0.10	0.18	0.81	0.08	0.15	0.83	0.09	0.16
Descriptive	189	0.33	0.01	0.01	0.44	0.02	0.04	0.16	0.02	0.03	0.60	0.02	0.03	0.00	0.00	0.00	0.6	0.02	0.03
All	4231	0.77	0.11	0.19	0.67	0.35	0.46	0.59	0.33	0.42	0.84	0.17	0.29	0.77	0.16	0.26	0.72	0.14	0.24

Results per category for Babelfy (strict/relaxed), TagME, DBpedia Spotlight, AIDA and FRENTE

Outline

- Introduction
- Problem
- Hypothesis
- Consensus about Entity Linking
- Multilingualism
- Fine-Grained Entity Linking
- Fine-Grained Entity Linking Systems
- Conclusions

Outline

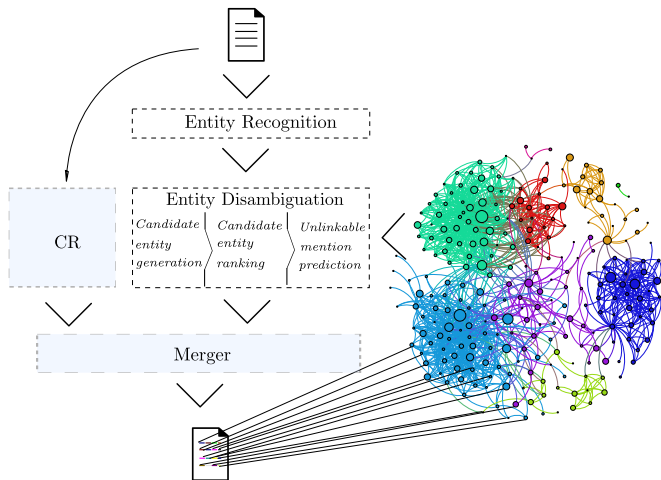
- Introduction
- Problem
- Hypothesis
- Consensus about Entity Linking
- Multilingualism
- Fine-Grained Entity Linking
- Fine-Grained Entity Linking Systems
- Conclusions

Fine-Grained Entity Linking Systems

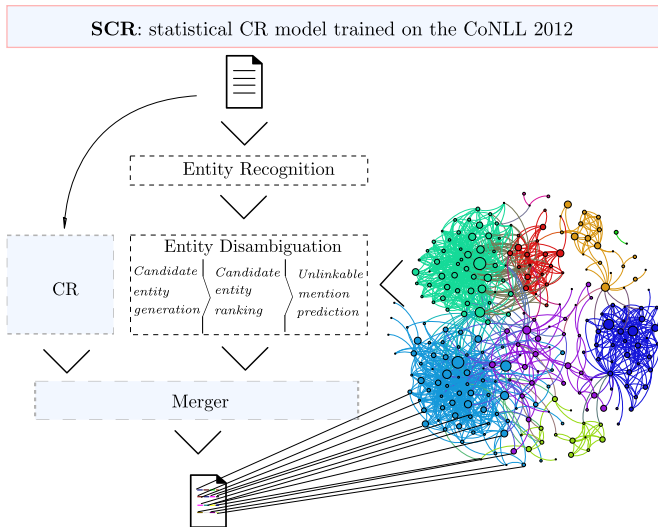
Adding Coreference Resolution

- Could we combine EL and CR to improve the quality of linking *Pro-Form* mentions?

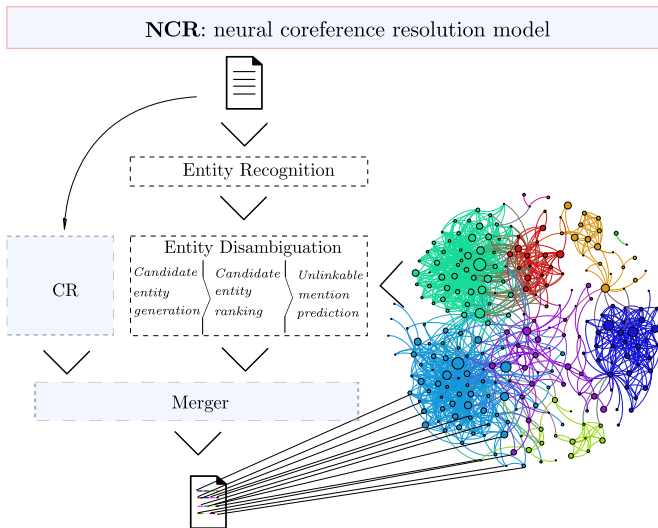
CR + FEL experiment



CR + FEL experiment



CR + FEL experiment



SCR + FEL experiment

	A	B _s			B _r			T			D			A			F		
		P	R	F ₁	P	R	F ₁	P	R	F ₁	P	R	F ₁	P	R	F ₁	P	R	F ₁
Pro-form	153	0.44	0.18	0.26	0.55	0.24	0.33	0.52	0.27	0.36	0.60	0.24	0.34	0.55	0.27	0.36	0.44	0.22	0.30
Singular Noun	2623	0.77	0.18	0.29	0.72	0.45	0.56	0.62	0.39	0.48	0.86	0.25	0.39	0.78	0.21	0.33	0.73	0.20	0.31
Adjective	518	0.49	0.05	0.09	0.33	0.12	0.17	0.55	0.29	0.38	0.64	0.18	0.28	0.67	0.25	0.37	0.54	0.18	0.27
Non-Overlapping	2871	0.71	0.13	0.21	0.67	0.34	0.45	0.58	0.40	0.47	0.82	0.20	0.33	0.76	0.20	0.32	0.68	0.18	0.28
Minimal Overlap	826	0.78	0.05	0.09	0.62	0.38	0.47	0.51	0.15	0.24	0.81	0.10	0.18	0.72	0.10	0.17	0.66	0.07	0.13
Anaphoric	153	0.44	0.18	0.26	0.55	0.24	0.33	0.52	0.27	0.36	0.60	0.24	0.34	0.55	0.27	0.36	0.44	0.22	0.30
All	4231	0.74	0.12	0.20	0.67	0.36	0.46	0.59	0.34	0.43	0.82	0.18	0.30	0.76	0.17	0.27	0.69	0.15	0.25

Results per category for Babelfy, TagME, DBpedia Spotlight, AIDA and FRED extended with SCR

NCR + FEL experiment

	A	B _s			B _r			T			D			A			F		
		P	R	F ₁	P	R	F ₁	P	R	F ₁	P	R	F ₁	P	R	F ₁	P	R	F ₁
Short Mention	497	0.46	0.17	0.25	0.37	0.25	0.30	0.54	0.44	0.49	0.50	0.31	0.38	0.50	0.37	0.42	0.39	0.29	0.34
Common Form	2452	0.21	0.00	0.01	0.66	0.34	0.44	0.49	0.28	0.36	0.88	0.04	0.08	0.69	0.00	0.01	0.67	0.01	0.01
Pro-form	153	0.39	0.15	0.22	0.39	0.16	0.23	0.47	0.22	0.30	0.55	0.20	0.30	0.51	0.23	0.32	0.42	0.18	0.25
Singular Noun	2623	0.77	0.18	0.29	0.72	0.46	0.56	0.62	0.39	0.48	0.86	0.25	0.39	0.78	0.21	0.33	0.73	0.20	0.32
Adjective	518	0.48	0.04	0.07	0.29	0.10	0.15	0.55	0.28	0.37	0.63	0.17	0.27	0.66	0.24	0.36	0.55	0.17	0.26
Non-Overlapping	2871	0.72	0.13	0.22	0.66	0.34	0.45	0.58	0.40	0.47	0.83	0.21	0.33	0.76	0.20	0.32	0.69	0.18	0.29
Maximal Overlap	464	0.83	0.17	0.29	0.83	0.36	0.50	0.73	0.35	0.47	0.90	0.20	0.33	0.86	0.09	0.17	0.85	0.14	0.23
Intermediate Overlap	71	0.78	0.20	0.31	0.72	0.54	0.61	0.57	0.30	0.39	0.59	0.14	0.23	0.57	0.11	0.19	0.80	0.11	0.20
Minimal Overlap	826	0.72	0.05	0.09	0.60	0.38	0.46	0.50	0.15	0.24	0.77	0.10	0.18	0.68	0.09	0.16	0.63	0.07	0.12
Anaphoric	153	0.39	0.15	0.22	0.39	0.16	0.23	0.47	0.22	0.30	0.55	0.20	0.30	0.51	0.23	0.32	0.42	0.18	0.25
Descriptive	189	0.25	0.01	0.02	0.40	0.03	0.06	0.32	0.04	0.07	0.82	0.05	0.09	1.00	0.03	0.06	0.82	0.05	0.09
All	4231	0.73	0.12	0.20	0.67	0.35	0.46	0.59	0.34	0.43	0.82	0.18	0.30	0.76	0.17	0.27	0.70	0.15	0.25

Results per category for Babelfy, TagME, DBpedia Spotlight, AIDA and FRED extended with SCR

WSD + FEL experiment

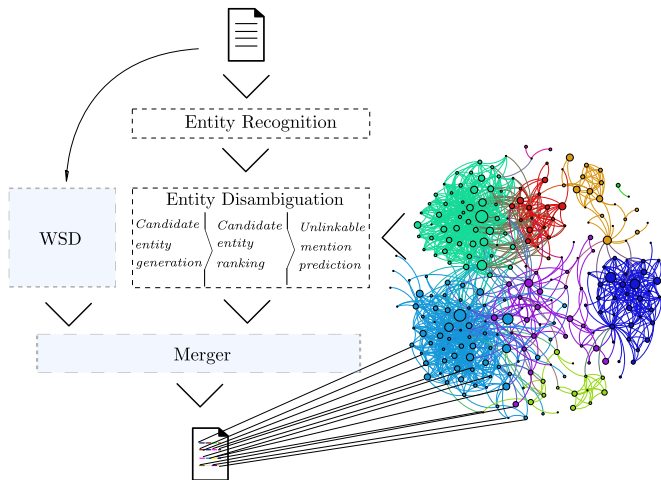
	A	B _s			B _r			T			D			A			F		
		P	R	F ₁	P	R	F ₁	P	R	F ₁	P	R	F ₁	P	R	F ₁	P	R	F ₁
Full Mention	766	0.93	0.46	0.61	0.75	0.53	0.62	0.82	0.59	0.69	0.84	0.57	0.68	0.78	0.57	0.66	0.82	0.55	0.65
Short Mention	497	0.44	0.16	0.23	0.37	0.24	0.29	0.54	0.44	0.48	0.5	0.30	0.37	0.50	0.36	0.42	0.39	0.28	0.33
Extended Mention	9	1.00	0.56	0.71	0.83	0.56	0.67	1.00	0.44	0.62	1.00	0.44	0.62	1.00	0.44	0.62	0.80	0.44	0.57
Alias	112	0.56	0.16	0.25	0.33	0.21	0.25	0.52	0.32	0.40	0.67	0.38	0.48	0.60	0.29	0.40	0.55	0.29	0.38
Numeric/Temporal	404	0.45	0.01	0.02	0.82	0.24	0.37	0.14	0.03	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Common Form	2,452	0.21	0.00	0.01	0.66	0.33	0.44	0.49	0.28	0.35	0.88	0.04	0.08	0.43	0.00	0.00	0.56	0.00	0.01
Pro-form	153	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Singular Noun	2,623	0.79	0.17	0.28	0.73	0.45	0.56	0.62	0.38	0.47	0.87	0.24	0.38	0.79	0.20	0.32	0.74	0.19	0.31
Plural Noun	746	0.33	0.01	0.02	0.61	0.33	0.43	0.56	0.28	0.37	0.83	0.03	0.06	0.70	0.03	0.07	0.66	0.04	0.07
Adjective	516	0.77	0.02	0.04	0.26	0.07	0.11	0.56	0.24	0.34	0.65	0.14	0.23	0.72	0.21	0.32	0.60	0.14	0.22
Verb	334	0.00	0.00	0.00	0.86	0.02	0.04	0.37	0.17	0.23	1.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Adverb	12	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.42	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non-Overlapping	2,871	0.75	0.12	0.20	0.67	0.33	0.45	0.58	0.38	0.46	0.84	0.19	0.32	0.78	0.19	0.30	0.71	0.17	0.27
Maximal Overlap	464	0.87	0.17	0.29	0.85	0.36	0.50	0.73	0.34	0.46	0.89	0.19	0.32	0.84	0.08	0.15	0.84	0.12	0.22
Intermediate Overlap	71	0.76	0.18	0.30	0.71	0.52	0.60	0.57	0.30	0.39	0.56	0.13	0.21	0.54	0.10	0.17	0.78	0.10	0.17
Minimal Overlap	825	0.82	0.04	0.09	0.61	0.37	0.46	0.50	0.15	0.23	0.80	0.09	0.17	0.72	0.09	0.16	0.66	0.06	0.12
Direct	3,106	0.79	0.13	0.23	0.71	0.43	0.53	0.63	0.38	0.47	0.83	0.21	0.33	0.76	0.19	0.30	0.70	0.17	0.27
Anaphoric	153	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Metaphoric	69	0.00	0.00	0.00	0.57	0.29	0.38	0.43	0.35	0.38	0.91	0.14	0.25	0.00	0.00	0.00	0.00	0.00	0.00
Metonymic	73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Related	829	0.64	0.06	0.11	0.36	0.14	0.20	0.39	0.24	0.30	0.76	0.10	0.18	0.81	0.08	0.15	0.83	0.09	0.16
Descriptive	189	0.33	0.01	0.01	0.44	0.02	0.04	0.16	0.02	0.03	0.60	0.02	0.03	0.00	0.00	0.00	0.6	0.02	0.03
All	4231	0.77	0.11	0.19	0.67	0.35	0.46	0.59	0.33	0.42	0.84	0.17	0.29	0.77	0.16	0.26	0.72	0.14	0.24

Results per category for Babelfy (strict/relaxed), TagME, DBpedia Spotlight, AIDA and FREME

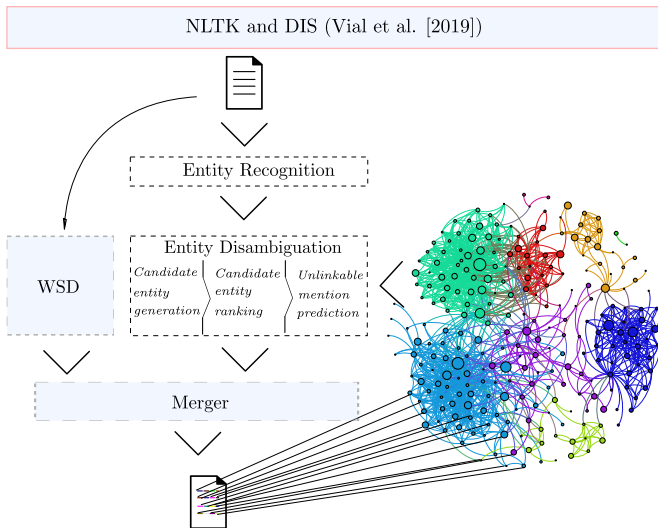
Adding Word Sense Disambiguation

- Could we combine EL and WSD to improve the performance of EL systems?

WSD + FEL experiment



WSD + FEL experiment



NLTK + FEL experiment

	A	B _s			B _r			T			D			A			F		
		P	R	F ₁	P	R	F ₁	P	R	F ₁	P	R	F ₁	P	R	F ₁	P	R	F ₁
Full Mention	766	0.73	0.51	0.60	0.69	0.57	0.62	0.75	0.62	0.68	0.77	0.60	0.67	0.72	0.58	0.65	0.74	0.57	0.64
Short Mention	497	0.31	0.21	0.25	0.35	0.29	0.31	0.53	0.46	0.49	0.43	0.31	0.36	0.46	0.38	0.42	0.36	0.30	0.33
Alias	112	0.39	0.18	0.25	0.32	0.22	0.26	0.49	0.32	0.39	0.63	0.39	0.48	0.57	0.29	0.39	0.54	0.29	0.37
Numeric/Temporal	404	0.56	0.18	0.28	0.68	0.25	0.37	0.34	0.14	0.19	0.59	0.18	0.28	0.59	0.18	0.28	0.59	0.18	0.28
Common Form	2452	0.25	0.13	0.17	0.56	0.36	0.44	0.43	0.32	0.37	0.30	0.16	0.21	0.25	0.12	0.16	0.25	0.13	0.17
Singular Noun	2623	0.46	0.29	0.36	0.64	0.48	0.55	0.56	0.44	0.49	0.53	0.35	0.42	0.48	0.31	0.38	0.47	0.30	0.37
Plural Noun	746	0.25	0.14	0.17	0.51	0.34	0.41	0.45	0.31	0.37	0.29	0.16	0.20	0.28	0.16	0.20	0.28	0.16	0.20
Adjective	518	0.21	0.06	0.09	0.24	0.11	0.15	0.43	0.26	0.33	0.41	0.16	0.23	0.51	0.24	0.32	0.41	0.16	0.23
Verb	334	0.00	0.00	0.00	0.46	0.02	0.03	0.35	0.17	0.23	0.10	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Non-Overlapping	2871	0.43	0.24	0.31	0.56	0.36	0.44	0.54	0.42	0.47	0.51	0.30	0.38	0.49	0.30	0.37	0.46	0.28	0.35
Minimal Overlap	826	0.23	0.15	0.18	0.54	0.41	0.46	0.33	0.23	0.28	0.28	0.19	0.23	0.28	0.19	0.23	0.25	0.17	0.20
Direct	3106	0.45	0.27	0.33	0.64	0.46	0.54	0.55	0.43	0.49	0.52	0.32	0.40	0.49	0.31	0.38	0.46	0.29	0.36
Metaphoric	69	0.14	0.07	0.10	0.42	0.30	0.35	0.40	0.36	0.38	0.42	0.22	0.29	0.16	0.07	0.10	0.16	0.07	0.10
Related	829	0.18	0.08	0.11	0.27	0.16	0.20	0.34	0.25	0.29	0.23	0.11	0.15	0.21	0.10	0.13	0.22	0.10	0.14
Descriptive	189	0.25	0.01	0.01	0.44	0.02	0.04	0.15	0.02	0.03	0.50	0.02	0.03	0.00	0.00	0.00	0.50	0.02	0.03
All	4231	0.40	0.21	0.28	0.58	0.37	0.45	0.52	0.37	0.43	0.48	0.26	0.34	0.45	0.25	0.32	0.43	0.24	0.30

Results per category for Babelfy, TagME, DBpedia Spotlight, AIDA and FREME extended with NLTK

NLTK + FEL experiment

	A	B _s			B _r			T			D			A			F		
		P	R	F ₁	P	R	F ₁	P	R	F ₁	P	R	F ₁	P	R	F ₁	P	R	F ₁
Full Mention	766	0.73	0.51	0.60	0.69	0.57	0.62	0.75	0.62	0.68	0.77	0.60	0.67	0.72	0.58	0.65	0.74	0.57	0.64
Short Mention	497	0.31	0.21	0.25	0.35	0.29	0.31	0.53	0.46	0.49	0.43	0.31	0.36	0.46	0.38	0.42	0.36	0.30	0.33
Alias	112	0.39	0.18	0.25	0.32	0.22	0.26	0.49	0.32	0.39	0.63	0.39	0.48	0.57	0.29	0.39	0.54	0.29	0.37
Numeric/Temporal	404	0.56	0.18	0.28	0.68	0.25	0.37	0.34	0.14	0.19	0.59	0.18	0.28	0.59	0.18	0.28	0.59	0.18	0.28
Common Form	2452	0.25	0.13	0.17	0.56	0.36	0.44	0.43	0.32	0.37	0.30	0.16	0.21	0.25	0.12	0.16	0.25	0.13	0.17
Singular Noun	2623	0.46	0.29	0.36	0.64	0.48	0.55	0.56	0.44	0.49	0.53	0.35	0.42	0.48	0.31	0.38	0.47	0.30	0.37
Plural Noun	746	0.25	0.14	0.17	0.51	0.34	0.41	0.45	0.31	0.37	0.29	0.16	0.20	0.28	0.16	0.20	0.28	0.16	0.20
Adjective	518	0.21	0.06	0.09	0.24	0.11	0.15	0.43	0.26	0.33	0.41	0.16	0.23	0.51	0.24	0.32	0.41	0.16	0.23
Verb	334	0.00	0.00	0.00	0.46	0.02	0.03	0.35	0.17	0.23	0.10	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Non-Overlapping	2871	0.43	0.24	0.31	0.56	0.36	0.44	0.54	0.42	0.47	0.51	0.30	0.38	0.49	0.30	0.37	0.46	0.28	0.35
Minimal Overlap	826	0.23	0.15	0.18	0.54	0.41	0.46	0.33	0.23	0.28	0.28	0.19	0.23	0.28	0.19	0.23	0.25	0.17	0.20
Direct	3106	0.45	0.27	0.33	0.64	0.46	0.54	0.55	0.43	0.49	0.52	0.32	0.40	0.49	0.31	0.38	0.46	0.29	0.36
Metaphoric	69	0.14	0.07	0.10	0.42	0.30	0.35	0.40	0.36	0.38	0.42	0.22	0.29	0.16	0.07	0.10	0.16	0.07	0.10
Related	829	0.18	0.08	0.11	0.27	0.16	0.20	0.34	0.25	0.29	0.23	0.11	0.15	0.21	0.10	0.13	0.22	0.10	0.14
Descriptive	189	0.25	0.01	0.01	0.44	0.02	0.04	0.15	0.02	0.03	0.50	0.02	0.03	0.00	0.00	0.00	0.50	0.02	0.03
All	4231	0.40	0.21	0.28	0.58	0.37	0.45	0.52	0.37	0.43	0.48	0.26	0.34	0.45	0.25	0.32	0.43	0.24	0.30

Results per category for Babelfy, TagME, DBpedia Spotlight, AIDA and FREME extended with NLTK

DIS + FEL experiment

	A	B _s			B _r			T			D			A			F		
		P	R	F ₁	P	R	F ₁	P	R	F ₁	P	R	F ₁	P	R	F ₁	P	R	F ₁
Full Mention	766	0.80	0.48	0.60	0.71	0.54	0.62	0.77	0.60	0.68	0.80	0.58	0.68	0.74	0.57	0.65	0.76	0.55	0.64
Short Mention	497	0.34	0.17	0.23	0.36	0.26	0.30	0.52	0.45	0.48	0.47	0.30	0.37	0.49	0.38	0.43	0.38	0.30	0.34
Extended Mention	9	0.83	0.56	0.67	0.83	0.56	0.67	0.80	0.44	0.57	0.80	0.44	0.57	1.00	0.44	0.62	0.80	0.44	0.57
Alias	112	0.42	0.16	0.23	0.33	0.21	0.25	0.50	0.32	0.39	0.65	0.38	0.47	0.58	0.29	0.39	0.53	0.29	0.37
Numeric/Temporal	404	0.58	0.06	0.12	0.81	0.24	0.37	0.25	0.07	0.11	0.64	0.06	0.10	0.64	0.06	0.10	0.64	0.06	0.10
Common Form	2452	0.21	0.04	0.07	0.62	0.34	0.44	0.46	0.29	0.35	0.34	0.08	0.13	0.21	0.04	0.07	0.22	0.04	0.07
Singular Noun	2623	0.55	0.21	0.30	0.69	0.46	0.55	0.58	0.40	0.47	0.66	0.28	0.39	0.59	0.23	0.33	0.56	0.23	0.32
Plural Noun	746	0.22	0.05	0.08	0.59	0.34	0.43	0.52	0.29	0.37	0.33	0.07	0.11	0.32	0.07	0.11	0.32	0.07	0.12
Adjective	518	0.31	0.04	0.07	0.29	0.09	0.14	0.53	0.26	0.35	0.56	0.15	0.24	0.65	0.22	0.33	0.52	0.15	0.23
Verb	334	0.25	0.00	0.01	0.75	0.02	0.04	0.37	0.17	0.23	0.40	0.01	0.01	0.25	0.00	0.01	0.25	0.00	0.01
Non-Overlapping	2871	0.51	0.15	0.24	0.63	0.34	0.44	0.57	0.40	0.47	0.64	0.23	0.34	0.60	0.22	0.32	0.55	0.20	0.30
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Traditional F1

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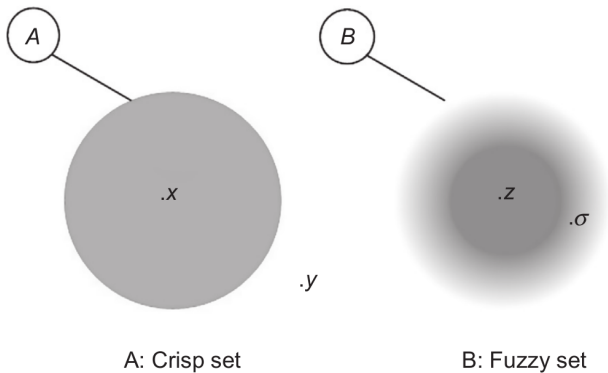
$$R = \frac{|TP|}{|TF| + |FN|}$$

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Traditional F1

- Some EL annotations might be more important in certain application scenarios than others.

Fuzzy set



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Modifications to F1

$$P = \frac{|TP|}{|S|}$$

$$R^* = \frac{\sum_{a \in S} \mu_{G^*}(a)}{\sum_{a \in G} \mu_{G^*}(a)}$$

$$F_1^* = \frac{2 \cdot P \cdot R^*}{P + R^*}$$

- **PROP1:** the values for R^* and F_1^* both range between 0 and 1, inclusive.
- **PROP2:** when $\mu_{G^*} : G \rightarrow \{1\}$ (i.e., when memberships are binary), R^* and F_1^* correspond to R and F_1 .
- **PROP3:** missing annotations with higher membership degree are penalized more in R^* and F_1^* than those with lower degree.

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- Problem
- Hypothesis
- Consensus about Entity Linking
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- Combine CR/WSD with EL helps to fill gaps of some EL systems for specific applications.

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- In our fine-grained EL evaluation, we include the results of two CR systems and two WSD systems.

Towards a Fine-Grained Entity Linking Approach

Henry Rosales-Méndez

Supervisors: Aidan Hogan and Barbara Poblete

Dissertation Defense

June 11th, 2021