Distinguishing between Instances and Classes in the Wikipedia Taxonomy

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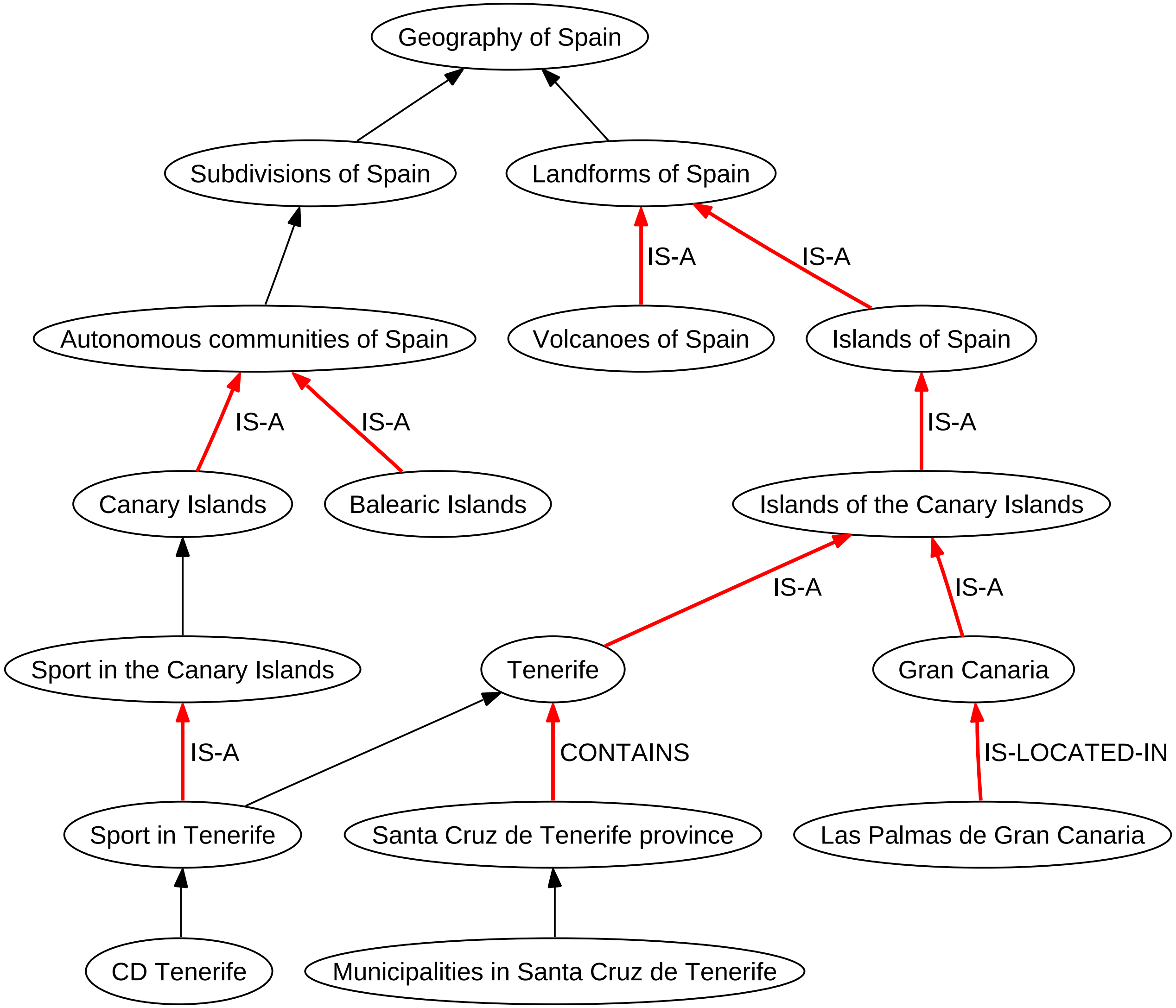
A Wikipedia Ontology?



Wikipedia Ontology

The big goal:

Deriving an ontology from Wikipedia automatically

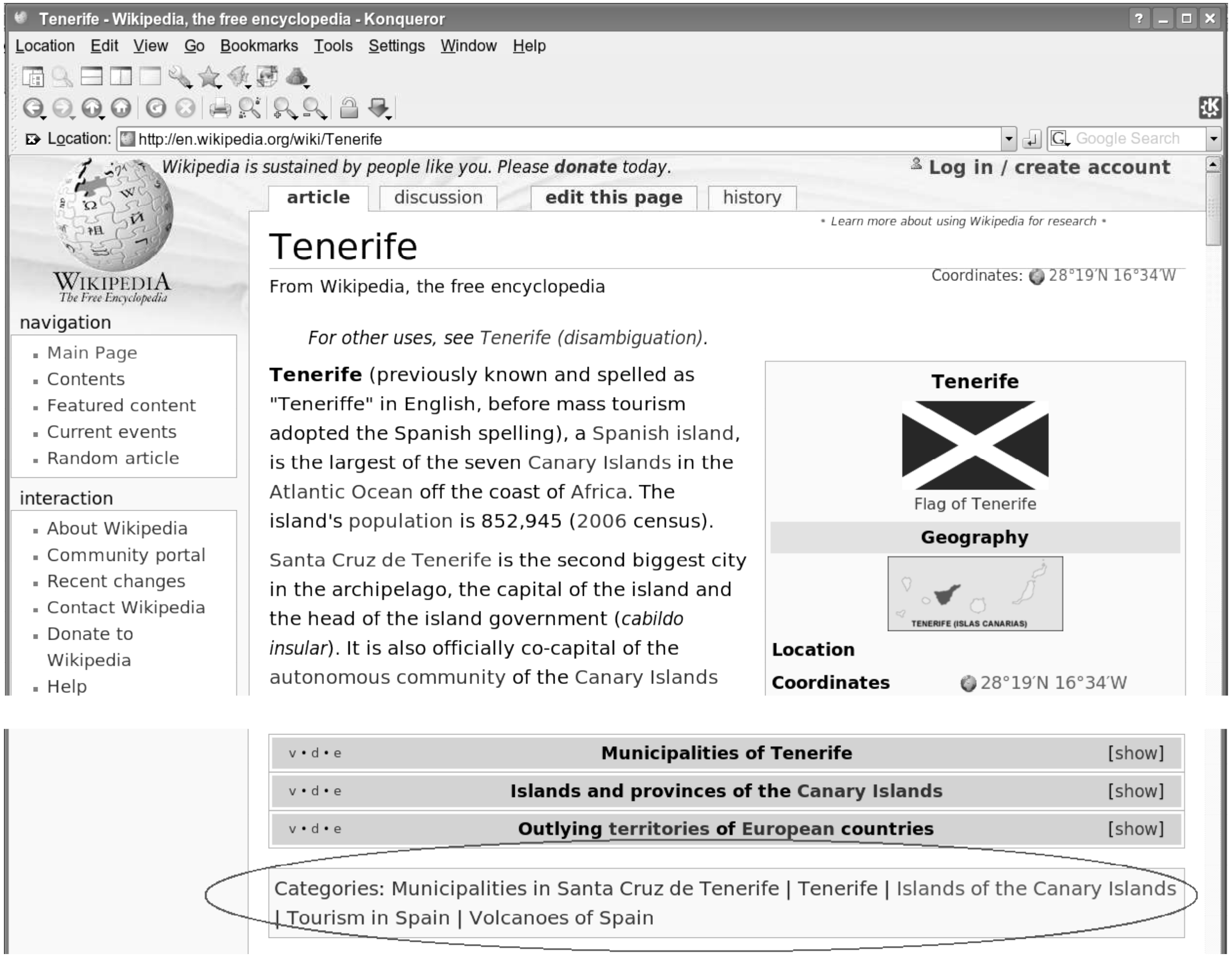
Necessary steps:

1. derive a **taxonomy** from Wikipedia (identify ISA relations), Ponzetto & Strube (AAAI 2007)
2. distinguish between **instances** and **classes** (work presented now)
3. interpret remaining **relations**, Nastase & Strube (AAAI 2008)

Outline

1. Deriving a taxonomy from Wikipedia
2. Instances and classes
3. Methods
4. Evaluation
5. Conclusions

Prerequisites: Category Network



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Tenerife

From Wikipedia, the free encyclopedia

Coordinates: 28°19′N 16°34′W

For other uses, see Tenerife (disambiguation).

Tenerife (previously known and spelled as "Teneriffe" in English, before mass tourism adopted the Spanish spelling), a Spanish island, is the largest of the seven Canary Islands in the Atlantic Ocean off the coast of Africa. The island's population is 852,945 (2006 census).

Santa Cruz de Tenerife is the second biggest city in the archipelago, the capital of the island and the head of the island government (*cabildo insular*). It is also officially co-capital of the autonomous community of the Canary Islands

Tenerife

Flag of Tenerife

Geography

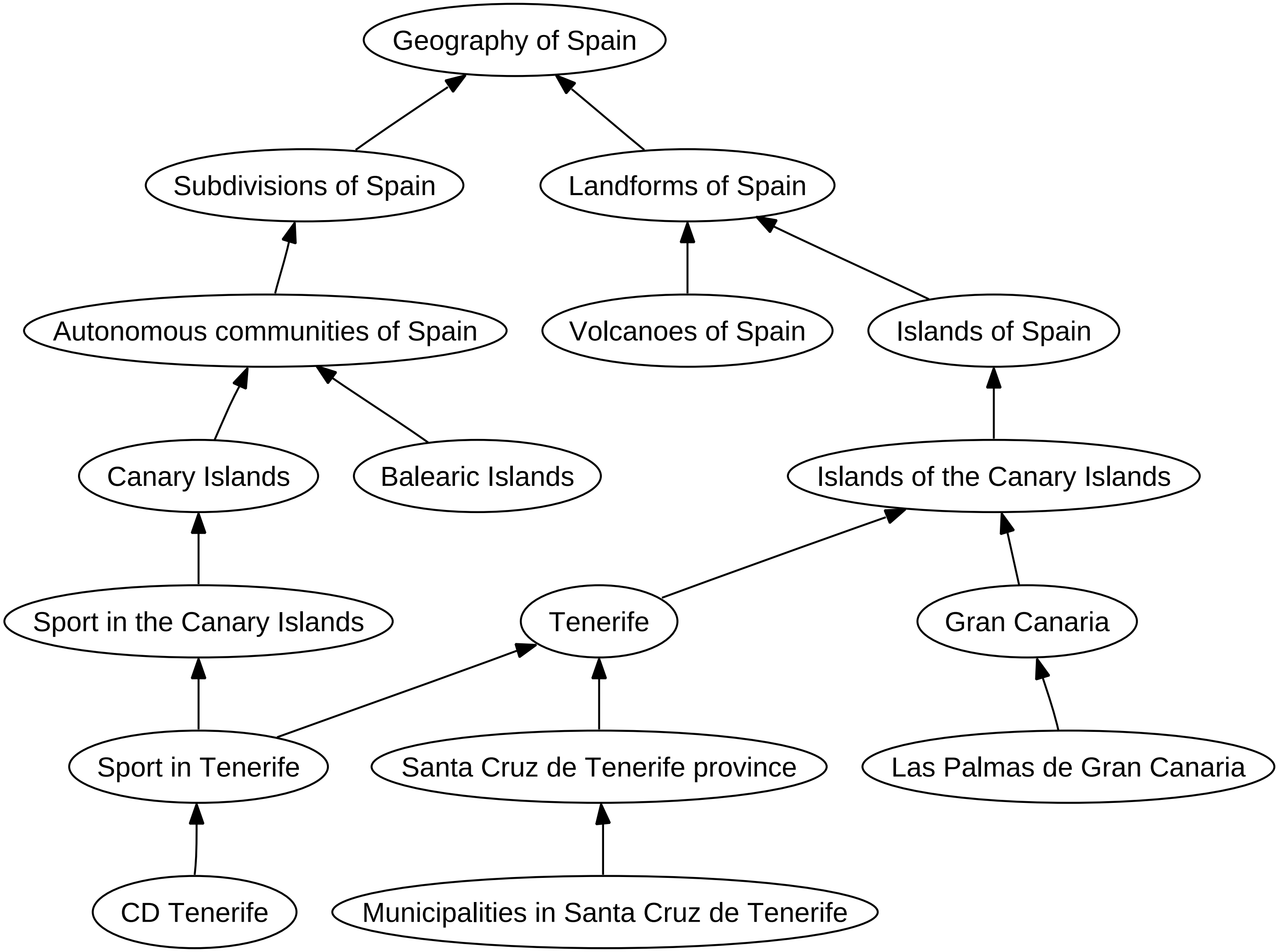
TENERIFE (ISLAS CANARIAS)

Location	
Coordinates	28°19′N 16°34′W

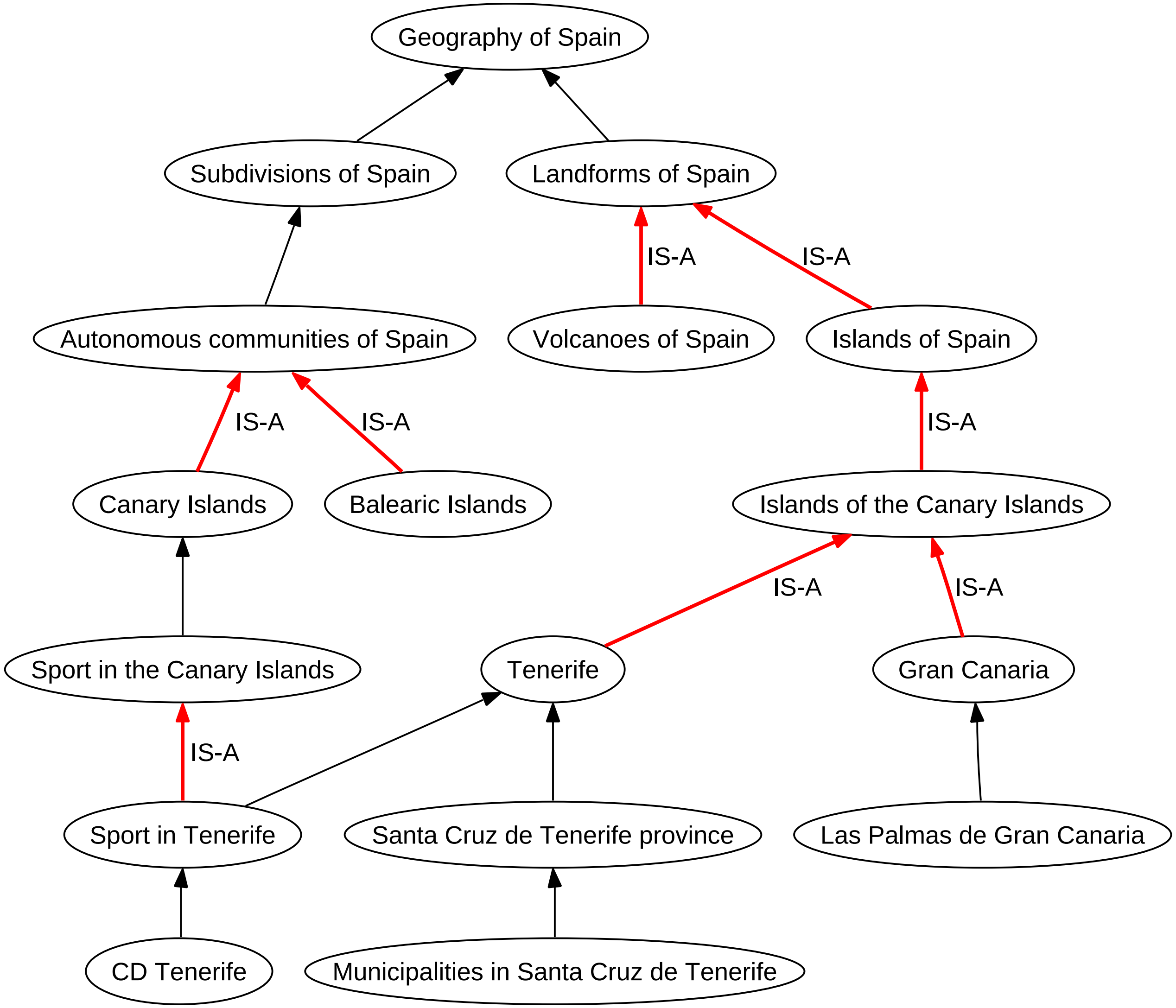
v • d • e	**Municipalities of Tenerife**	[show]
v • d • e	**Islands and provinces of the Canary Islands**	[show]
v • d • e	**Outlying territories of European countries**	[show]

Categories: Municipalities in Santa Cruz de Tenerife | Tenerife | Islands of the Canary Islands | Tourism in Spain | Volcanoes of Spain

Deriving a taxonomy


Geography of Spain
Subdivisions of Spain
Landforms of Spain
Autonomous communities of Spain
Volcanoes of Spain
Islands of Spain
Canary Islands
Balearic Islands
Islands of the Canary Islands
Sport in the Canary Islands
Tenerife
Gran Canaria
Sport in Tenerife
Santa Cruz de Tenerife province
Las Palmas de Gran Canaria
CD Tenerife
Municipalities in Santa Cruz de Tenerife

Deriving a taxonomy



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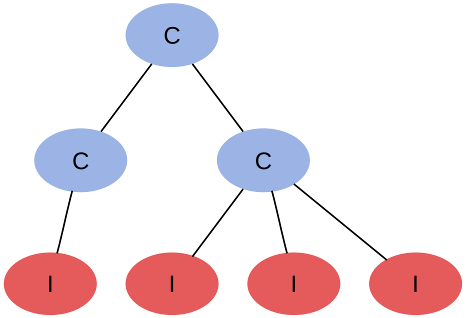
Instances and Classes

Instances



Tenerife, Teide, 2008

- are unique entities in the world
- in reasoning, they are mapped to objects

Classes

Municipalities in Santa Cruz de Tenerife, Volcanoes of Spain

- concepts that subsume classes or individuals
- in reasoning, they are mapped to predicates

Distinction between instances and classes...

can be found in WordNet and Cyc

was done manually there

agreement coefficient on this task
on WordNet data $\kappa = 0.75$
(Miller & Hristea, Computational Linguistics 2006)

⇒ high cost!

Distinction between instances and classes...

can be found in WordNet and Cyc

was done manually there

agreement coefficient on this task
on WordNet data $\kappa = 0.75$
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➠ high cost!

develop heuristics to distinguish between
instances and classes **fully automatically**

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Methods

- development of 5 methods
  - Structure-based method
  - NER (Named entity recognition)
  - Capitalization
  - Plural
  - Page
- all are **heuristics**
- use NLP techniques
- based on category network

Methods

- development of 5 methods
  - Structure-based method
  - NER (Named entity recognition)
  - Capitalization
  - Plural
  - Page

Structure-based method (1)

Only classes can have instances and classes.

TENERIFE, TENERIFE NORTH AIRPORT

Structure-based method (1)

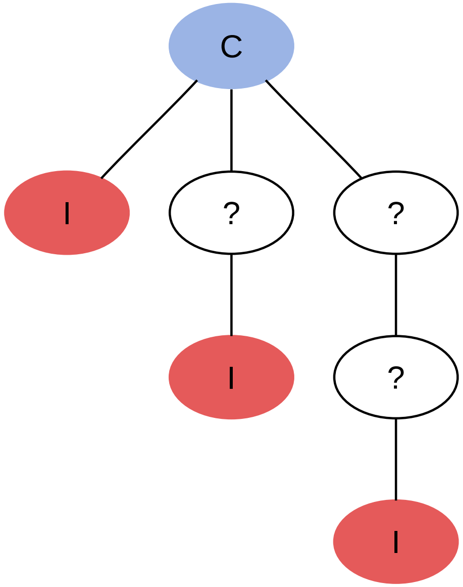
Only classes can have instances and classes.

TENERIFE, TENERIFE NORTH AIRPORT

- if a category has hyponyms, it has to be a class
- count hyponyms (incoming ISA-links)

Structure-based method (2)

- If a category has **more than one** hyponym:
  ➠ the Category is labeled as **Class**
- If a category has **no** hyponym:
  ➠ the Category is labeled as **Instance**



Structure-based method (3)

Only classes can have instances and classes.

Tenerife, Tenerife North Airport

Structure-based method (3)

Only classes can have instances and classes.

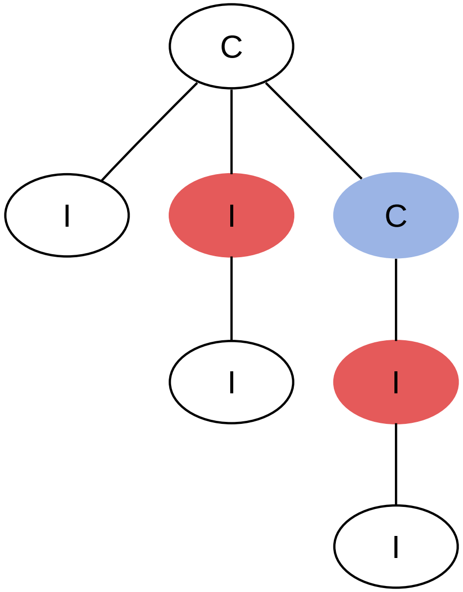
TENERIFE, TENERIFE NORTH AIRPORT

- labeling of the ISA-links has been done automatically
- possible that links are classified erroneously

➠ tolerate one erroneous link

Structure-based method (4)

- If a category has **exactly one** hyponym:
  - If the hyponym **has a hyponym** itself:
    ➠ the Category is labeled as **Class**
  - If the hyponym **has no hyponym**:
    ➠ the Category is labeled as **Instance**



Methods

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Method: NER (1)

Instances correspond to unique entities in the world and are therefore named entities.

TENERIFE, CD TENERIFE

Method: NER (1)

Instances correspond to unique entities in the world and are therefore named entities.

TENERIFE, CD TENERIFE

➠ Idea: use a named entity recognizer

Utility: Named Entity Recognizer

- input: noun phrase
- output: named entity tags
  - *Person, Location, Organization* for named entities
  - *Other* for the rest
- we use CRFClassifier (Stanford)

Method: NER (2)

Instances correspond to unique entities in the world and are therefore named entities.

TENERIFE, CD TENERIFE

Method: NER (2)

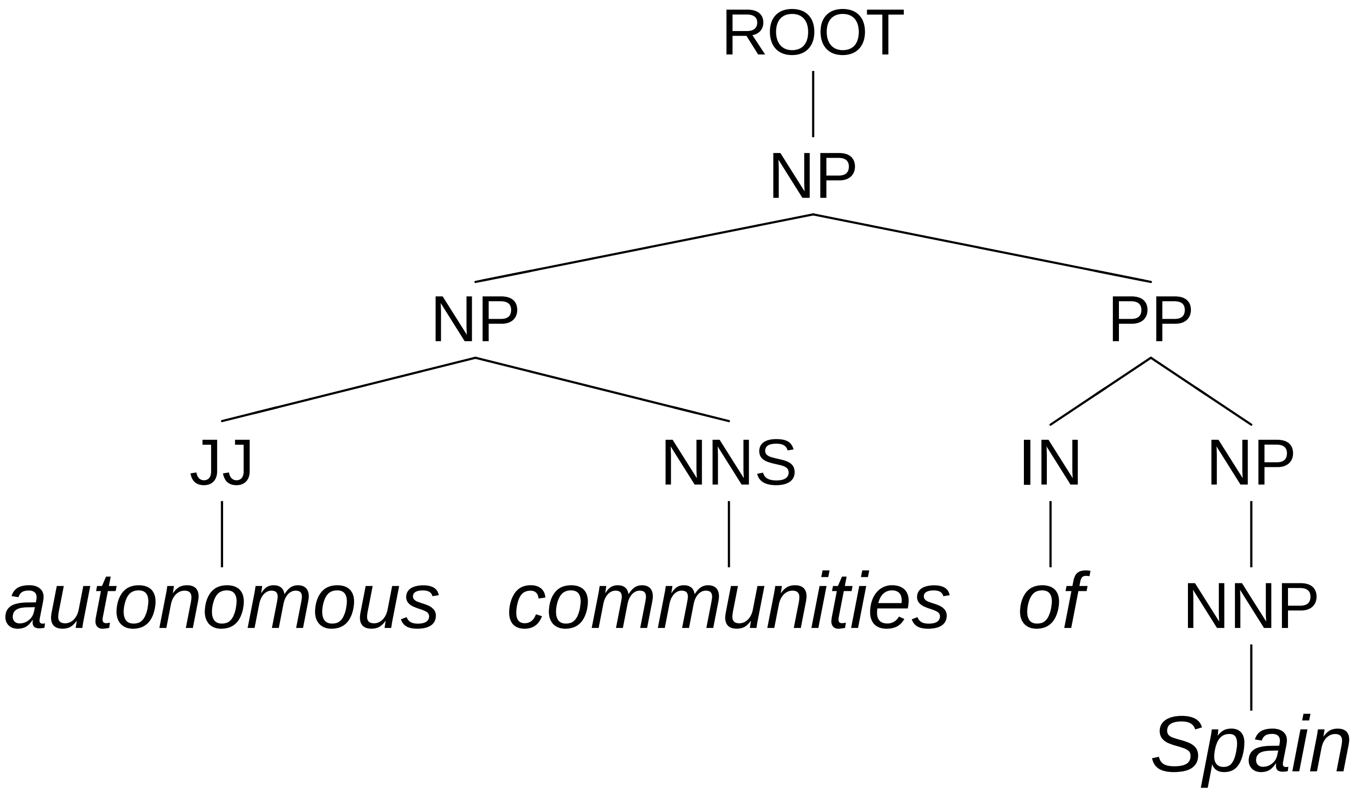
Instances correspond to unique entities in the world and are therefore named entities.

TENERIFE, CD TENERIFE

- Some names consist of complex noun structures: AUTONOMOUS COMMUNITIES OF SPAIN
  - only lexical heads are passed to named entity recognizer
  - lexical heads are extracted using Stanford Parser

Utility: Parser

- analyzes the grammatical structure of the input
- outputs a parse tree



ROOT

NP

NP PP

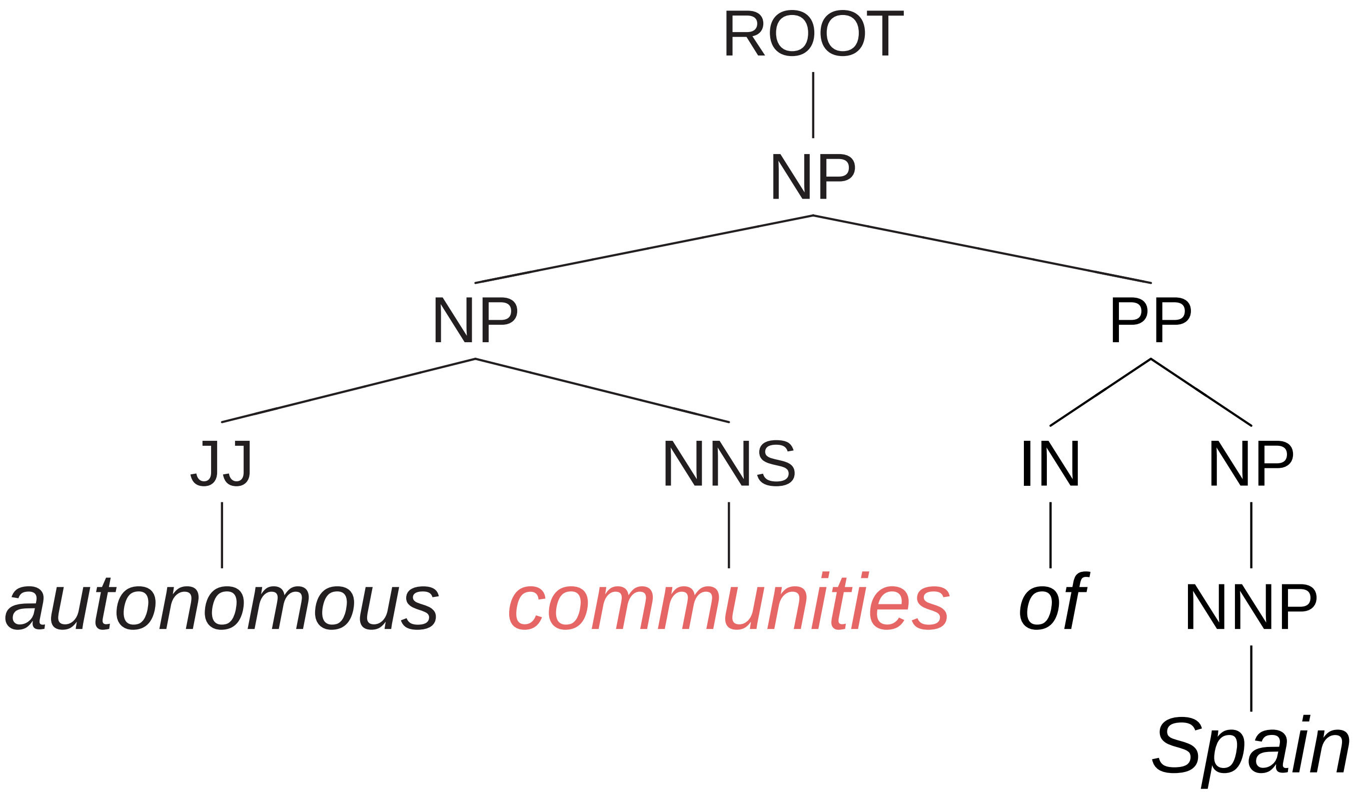
JJ NNS IN NP

autonomous *communities* *of* NNP

Spain

Utility: Lexical head finder

- lexical heads: determine the syntactic properties of a phrase
- in a noun phrase: the noun



Method: NER (3)

- If the named entity recognizer returns one of the labels: *Person, Location, Organization*:
  ➠ the Category is labeled as **Instance**
- If the named entity recognizer returns the label *Other*
  ➠ the Category is labeled as **Class**

Method: NER (3)

- If the named entity recognizer returns one of the labels: *Person, Location, Organization*:
  - ➠ the Category is labeled as **Instance**
- If the named entity recognizer returns the label *Other*
  - ➠ the Category is labeled as **Class**

the parser sometimes returns several heads

- If the majority of returned labels is *Other* :
  - ➠ the Category is labeled as **Class**
- otherwise
  - ➠ the Category is labeled as **Instance**

Methods

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Method: Capitalization (1)

Content words belonging to a named entity are capitalized.

Convention for Wikipedia titles.

Tenerife Ladies Open

and

Autonomous communities of Spain

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Content words belonging to a named entity are capitalized.

Convention for Wikipedia titles.

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- Bunescu & Paşca (2006) developed heuristic to process Wikipedia **page** titles:
  “If all content words of a page title are capitalized, it corresponds to a named entity”

➠ We apply this heuristic to **category** titles

Method: Capitalization (2)

1. preprocess first word
    - first word is always capitalized
    - ➡ pass it to CRFClassifier
    - if it is not recognized as a named entity: lowercase the word
2. filter out function words
3. analyze remaining words:
    - If all words are capitalized
        - ➡ the Category is labeled as **Instance**
    - otherwise
        - ➡ the Category is labeled as **Class**

Methods

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Method: Plural (1)

Instances are unique ➡ generally used in singular form.

TENERIFE, SPAIN

and

AUTONOMOUS COMMUNITIES OF SPAIN

Method: Plural (1)

Instances are unique ➠ generally used in singular form.

TENERIFE, SPAIN

and

AUTONOMOUS COMMUNITIES OF SPAIN

- Exceptions: *“The Millers are coming to our party”* not to be expected in Wikipedia category titles

Method: Plural (2)

Instances are unique → generally used in singular form.

Tenerife, Spain

and

Autonomous communities of Spain

Method: Plural (2)

Instances are unique ➠ generally used in singular form.

TENERIFE, SPAIN

and

AUTONOMOUS COMMUNITIES OF SPAIN

- the grammatical number of the lexical head is the same as the number of the category title

➠ we parse the category title with the Stanford Parser, obtaining:

  - the lexical head(s)
  - the part-of-speech tags

Utility: Part-of-speech tagging

- assigns each word its part of speech
- tags of interest:
  - NNPS = noun, proper, plural
  - NNS = noun, common, plural

Autonomous/JJ communities/NNS of/IN Spain/NNP

Method: Plural (3)

- If the lexical head of a phrase is tagged as plural noun (NNS, NNPS)
  - ➡ the Category is labeled as **Class**
- otherwise
  - ➡ the Category is labeled as **Instance**

Methods

- development of 5 methods
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  - Plural
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Method: Page (1)

> Articles should be placed in categories
> with the same name.

Advice for authors in Wikipedia.

SPAIN, TENERIFE

Method: Page (1)

> Articles should be placed in categories
> with the same name.

Advice for authors in Wikipedia.

SPAIN, TENERIFE

- a number of articles have homonymous categories
- most articles refer to unique entities

➠ Heuristic: a category containing a page with the same name is an instance

Method: Page (2)

- If a page with homonymous title exists
  - ➠ the Category is labeled as **Instance**
- otherwise
  - ➠ the Category is labeled as **Class**

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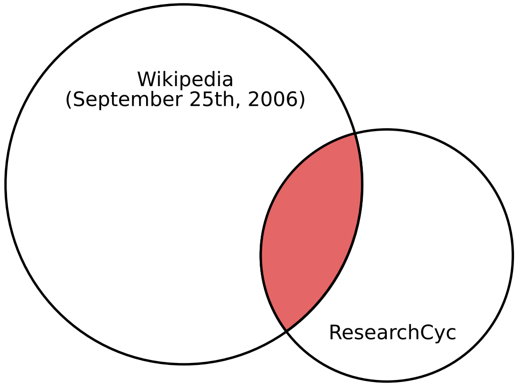
Data (1)

Use ResearchCyc as **gold standard**.



ResearchCyc

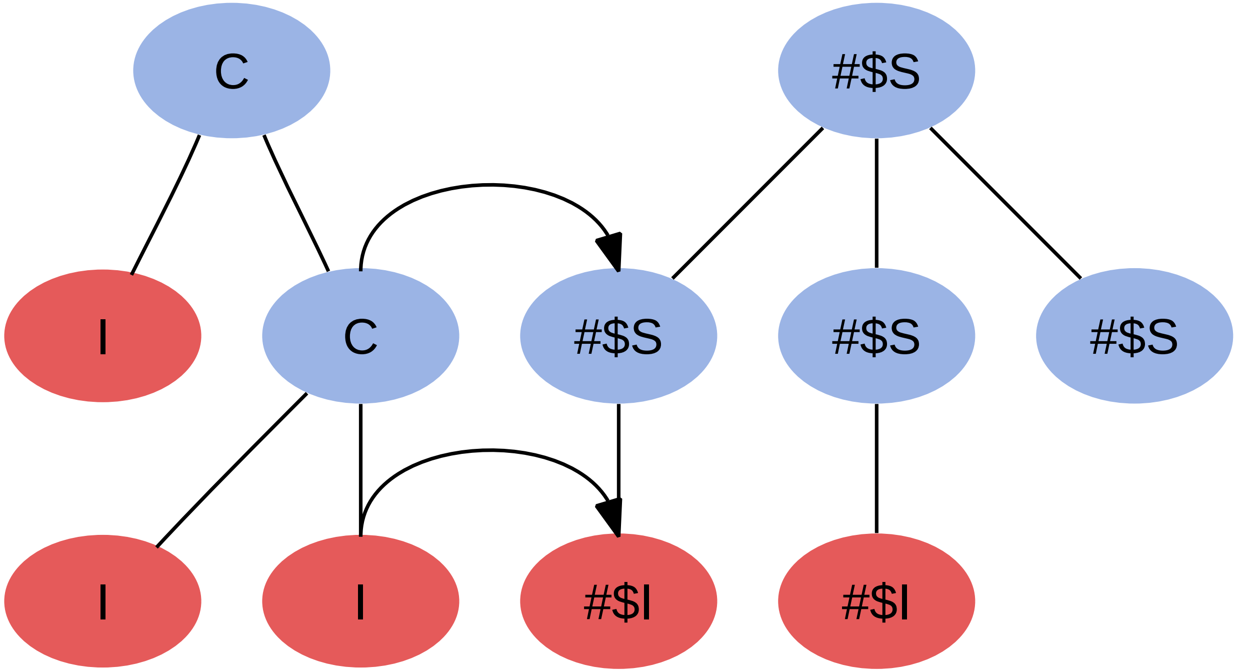
- distinguishes between #$Individual and #$SetOrCollection
- distinction is done manually

overlap Wikipedia / ResearchCyc:

- 7860 concepts
  - 44.35%(3486)#$Individual
  - 55.65%(4374)#$SetOrCollection

Data (2)

Use ResearchCyc as **gold standard**.



Measures (1)

$T_{instances}$	$F_{classes}$
$F_{instances}$	$T_{classes}$

$$\text{Prec}_{instances} = \frac{T_{instances}}{T_{instances}+F_{instances}}$$

$T_{instances}$: Instance in Wiki & individual in Cyc

$F_{instances}$: Instance in Wiki but **not** individual Cyc

$T_{classes}$: Class in Wiki & SetOrCollection Cyc

$F_{classes}$: Class in Wiki but **not** SetOrCollection in Cyc

Measures (2)

$T_{instances}$	$F_{classes}$
$F_{instances}$	$T_{classes}$

$$\text{Prec}_{classes} = \frac{T_{classes}}{T_{classes}+F_{classes}}$$

$T_{instances}$:	Instance in Wiki & Individual in Cyc
$F_{instances}$:	Instance in Wiki but **not** Individual in Cyc
$T_{classes}$:	Class in Wiki & SetOrCollection in Cyc
$F_{classes}$:	Class in Wiki but **not** SetOrCollection in Cyc

Measures (3)

$T_{instances}$	$F_{classes}$
$F_{instances}$	$T_{classes}$

$$\text{Accuracy} = \frac{T_{instances}+T_{classes}}{T_{instances}+F_{instances}+T_{classes}+F_{classes}}$$

$T_{instances}$: Instance in Wiki & individual in Cyc

$F_{instances}$: Instance in Wiki but **not** individual Cyc

$T_{classes}$: Class in Wiki & SetOrCollection Cyc

$F_{classes}$: Class in Wiki but **not** SetOrCollection in Cyc

Evaluate every method separately

Method	Prec$_{instances}$	Prec$_{classes}$
NER	**85.23**	76.84
page	66.1	**91.5**
capitalization	**85.99**	82.44
plural	66.44	**87.99**
structure	56.17	**87.21**

Evaluate every method separately

Method	Prec$_{instances}$	Prec$_{classes}$	Accuracy
NER	**85.23**	76.84	79.69
page	66.1	**91.5**	75.74
capitalization	**85.99**	82.44	83.82
plural	66.44	**87.99**	75.24
structure	56.17	**87.21**	64.71

Final setting

Classification schemes

A) Accuracy scheme

- method with best accuracy: **capitalization**
- (regard method as baseline)

Final setting

Classification schemes

B) Precision scheme

- order methods according to their precision ($\text{Prec}_{instances}$ or $\text{Prec}_{classes}$)

1.	page	➡	class
2.	plural	➡	class
3.	structure	➡	class
4.	capitalization	➡	instance
5.	remaining categories	➡	class

Final setting

Classification schemes

C) Voting scheme

1. page & plural ➠ class
2. capitalization & NER ➠ instance
3. remaining categories ➠ precision scheme

Final setting

Classification schemes

A) Accuracy scheme
B) Precision scheme
C) Voting scheme

Special form of cross-validation:

- 5 rounds of binary random splits
- maintain the #$Individual / #$SetOrCollection distribution
- evaluate on the resulting 10 data sets

Final results

Method	Precision$_{instances}$	Precision$_{classes}$	Accuracy
A) *Accuracy sc.*	85.99±0.54	**82.44±0.63**	82.82±0.5
B) *Precision sc.*	**90.92±0.41**	77.36±0.52	81.64±0.42
C) *Voting sc.*	89.21±0.46	81.82±0.52	**84.52±0.34**

Discussion

- Preprocessing errors, e.g. wrong parsing results (…AND YOU WILL KNOW US BY THE TRAIL OF DEAD ALBUMS)
- Recognizing named entities:
  BEE TRAIN
  If components of a named entity are not named entities, it is not recognized
- Concepts in Cyc:
  Inter-agreement between judges is not 100%
  ➡ different possible judgements

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Conclusions

- automatic distinction between instances and classes is possible with a high accuracy (84.52%)
- combining the methods with machine learning could improve performance even more
- next step: introducing distinction between instances and classes to Wikipedia articles
- methods can easily be applied to other languages

Thanks!

Acknowledgements

- Simone Ponzetto for his work in deriving the taxonomy
- Klaus Tschira Foundation

Check out

... the results (RDF Schema)

`www.eml-research.de/nlp/download/wikitaxonomy.php`

... more papers on Wikipedia

`www.eml-research.de/∼strube`