A Bottom-up Comparative Study of EuroWordNet and WordNet 3.0 Lexical and Semantic Relations

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Abstract

The paper presents a comparative study of semantic and lexical relations defined and adopted in WordNet and EuroWordNet. This document describes the experimental observations achieved through the analysis of data from different WordNet versions and EuroWordNet distributions for different languages, during the development of JMWNL (Java Multilingual WordNet Library), an extensible multilingual library for accessing WordNet-like resources in different languages and formats. The goal of this work was to realize an operative mapping between the relations defined in the two lexical resources and to unify library access and content navigation methods for both WordNet and EuroWordNet. The analysis focused on similarities, differences, semantic overlaps or inclusions, factual misinterpretations and inconsistencies between the intended and practical use of each single relation defined in these two linguistic resources. The paper details with examples the produced mapping, discussing required operations which implied merging, extending or simply keeping separate the examined relations.

1. Introduction

We introduce a comparative study of semantic and lexical relations defined and adopted in two renowned lexical databases: WordNet (Miller, Beckwith, Fellbaum, Gross, & Miller, 1993; Fellbaum, 1998) and EuroWordNet (Vossen, 1998). The study was conducted during the development of the Java Multi WordNet Library (JMWNL), an extensible multilingual library for accessing WordNet-like resources in different languages and formats, based on John Didion's JWNL library (http://sourceforge.net/projects/jwordnet). The analysis and comparison between the two resources was carried out in the pre-design stage of development of the above library. The aim was to realize an operative mapping between the relations defined in the two lexical resources and to unify library access and content navigation methods for both WordNet and EuroWordNet. The work was conducted bottom-up by analyzing the raw data and several examples either from English WordNet and different language EuroWordNet (EWN from now on) resources. The analysis focused on similarities, differences, semantic overlaps or inclusions, factual misinterpretations and inconsistencies between the intended and practical use of each single relation defined in these two linguistic resources.

The mapping between the relations defined in the two resources required a two layered investigation. In most cases it sufficed to establish a *template level* mapping like telling that has_hyperonym is equivalent – at least in the *intentions* of the lexicographers – to hypernym. This way, in theory, all instantiated relationships based on these two relations could be interchangeable. In other cases, (even partial) mappings between apparently different relations emerged by looking at a vast quantity of sample data and studying cross-linguistic similarities.

This document describes the experimental observations achieved through the analysis of data from different WordNet versions and EuroWordNet distributions for different languages, during the development of JMWNL. The paper focuses on relations mapping, cross part-of-speech relations and the partial mapping of Fuzzynym relations like Derivationally Related Form.

2. WordNet and EuroWordNet

WordNet is a large lexical database of English. Nouns, verbs, adjectives and adverbs are grouped into sets of cognitive synonyms (synsets), each expressing a distinct concept. WordNet "Synsets are interlinked by means of conceptual-semantic and lexical relations" (About WordNet, 2006). Its European counterpart, EuroWordNet, is a multilingual database with wordnets for several European languages (Dutch, Italian, Spanish, German, French, Czech and Estonian). The wordnets are structured in the same way as the American wordnet for English in terms of synsets with basic semantic relations between them (Vossen, EuroWordNet Web Abstract, 2001).

EuroWordNet is based on the 1998 WordNet version 1.5 (Fellbaum, 1998) and contains more (and different) relations than current English WordNet (version 3.0 - 2007), so a one- to-one relations mapping is not achievable.

Although the structure of various wordnets is similar and consistent, the relations defined in each version are not identical and moreover some wordnets are richer in relations than others.

3. Overall Mapping Statistics

Our analysis revealed that only some EuroWordNet relations could be mapped directly with WordNet relations. Other EuroWordNet relations had to be added.

EuroWordNet Has Holo Madeof Relation

```
0 @2817@ WORD_MEANING
  1 PART_OF_SPEECH "n"
  1 VARIANTS
    2 LITERAL "seta"
      3 SENSE 2
      3 STATUS new
      3 EXTERNAL_INFO
        4 SOURCE_ID 1
          5 TEXT_KEY "0-0b"
  1 INTERNAL_LINKS
    2 RELATION "has_hyperonym"
      3 TARGET_CONCEPT
        4 PART_OF_SPEECH "n"
        4 LITERAL "tessuto"
          5 SENSE 1
    2 RELATION "has_holo_madeof"
      3 TARGET_CONCEPT
        4 PART_OF_SPEECH "n"
        4 LITERAL "abito"
          5 SENSE 1
```

EuroWordNet Has Mero Madeof Relation

```
0 @4493@ WORD_MEANING
  1 PART_OF_SPEECH "n"
  1 VARIANTS
    2 LITERAL "steccato"
      3 SENSE 1
      3 STATUS new
      3 EXTERNAL_INFO
        4 SOURCE_ID 1
          5 TEXT_KEY "0-1a"
  1 INTERNAL_LINKS
    2 RELATION "has_mero_madeof"
      3 TARGET_CONCEPT
        4 PART_OF_SPEECH "n"
        4 LITERAL "palo"
          5 SENSE 1
  1 EQ_LINKS
    2 EQ_RELATION "eq_synonym"
      3 TARGET_ILI
        4 PART_OF_SPEECH "n"
        4 WORDNET_OFFSET 2963587
```

Figure 1: EuroWordNet Has_Holo_Madeof and Has_Mero_Madeof Relations

English WordNet has in total 46 relations defined on all parts of speech while EuroWordNet has more than one hundred relations. During our integration for building the JMWNL library we could map directly 32 EuroWordNet relations and we had to add 17 new relations that were present in EuroWordNet from which 10 are defined across multiple parts of speech (XPOS). We created these 10 new relations using the defined WordNet relation pointer symbols adding an "x" character as prefix to express the cross relationship.
We found in total 21 WordNet relations that are not present in EuroWordNet and that couldn't be mapped even partially.

4. Comparative results and observations

As previously mentioned, it is not possible to build a complete 1-to-1 mapping between WordNet and EuroWordNet lexical and semantic relations. However a correct and complete record of all lexical and semantic relations is indispensable for building multilingual applications that use available wordnets as their lexical databases. Moreover, it is necessary to establish relationships between their models to create the grounds for working consistently across different languages.
This section will show the differences between WordNet and EuroWordNet identifications of lexical and semantic relations focusing on the most important EuroWordNet relations and their correspondent WordNet ones.

4.1. Synonymy and Antonymy

Unlike in WordNet, EuroWordNet distinguishes between tight and loose synonymy and antonymy relationships, introducing two relations respectively called *NEAR SYNONYM* and *NEAR ANTONYM*: for example, in Italian EuroWordNet the word "nemico" ("enemy", in English) is *NEAR_ANTONYM* of "alleato" (Eng. "allay"), while in original WordNet "enemy" is only direct *ANTONYM* of "friend".
These two relations can be mapped directly as *SIMILAR TO* and *ANTONYM* in WordNet. The tight version of synonymy is implicit in the WordNet definition of synset (words appearing in the same synset are, by definition, synonyms), while, in the case of antonymy, EWN tight and loose antonyms both collapse in the *ANTONYM* definition in WordNet (see section 4.4).

4.2. Meronymy and Holonymy

In EuroWordNet *HAS_MERO/HAS_HOLO* with all their variants express respectively *HOLONYM/MERONYM* relations.
More specifically, in EuroWordNet, *HAS MERO MADEOF* and *HAS HOLO MADEOF* relations have a partial overlap with both *SUBSTANCE MERONYM/HOLONYM* and *PART MERONYM/HOLONYM*.
In Figure 1 are shown two examples of *HAS MERO MADEOF* and *HAS HOLO MADEOF* relations. The first example is the overlap with *SUBSTANCE HOLONYM: "abito" (suit) is made of "seta" (silk).* The second example shows the overlap of *HAS MERO MADEOF* with *PART MERONYM: "palo" (pole) is part meronym of "steccato" (wooden fence).*
In Table 1 are presented both *HAS MERO PART* and *HAS HOLO MEMBER* relations in parallel starting from the same base concept: "tree". Looking at this example we could conclude that there are not big differences between definitions of the relations for such base concepts.

Base Word	*Relation*	*Italian*	*French*	**English Translation**
Albero (It) Arbre (Fr) Tree (En)	***Has mero part***	*frutto*	*N/A*	**fruit**
		corteccia	*souche*	**bark**
		foglia	*N/A*	**leaf**
		ramo	*branche d'arbre*	**branch**
		tronco	*tronc*	**trunk**
		cima	*cime*	**flower**
		radice	*N/A*	**root**
	Has holo member	*bosco*	*bois*	**wood**

Table 1: Multilingual Holonymy and Meronymy Relations

EuroWordNet Fuzzynym Relation

```
0 @317@ WORD_MEANING
  1 PART_OF_SPEECH "a"
  1 VARIANTS
    2 LITERAL "classico"
      3 SENSE 1
      3 DEFINITION "attinente al classicismo
(mondo)"
      3 EXTERNAL_INFO
        4 SOURCE_ID 2
  1 INTERNAL_LINKS
    2 RELATION "xpos_near_synonym"
      3 TARGET_CONCEPT
        4 PART_OF_SPEECH "n"
        4 LITERAL "classicismo"
          5 SENSE 1
    2 RELATION "xpos_fuzzynym"
      3 TARGET_CONCEPT
        4 PART_OF_SPEECH "n"
        4 LITERAL "classicismo"
          5 SENSE 2
    2 RELATION "has_hyperonym"
      3 TARGET_CONCEPT
        4 PART_OF_SPEECH "a"
        4 LITERAL "relativo"
          5 SENSE 3
  1 EQ_LINKS
    2 EQ_RELATION "eq_synonym"
      3 TARGET_ILI
        4 PART_OF_SPEECH "a"
```

WordNet Derivationally Related From Relation

```
00151567 00 a 01 classico 1 003 @ 00049003 a 0000 x+ 01005210 n 0000 & 00292627 n 0000 |
attinente al classicismo (mondo)
```

Figure 2: EuroWordNet Fuzzynym relation transformed into WordNet Derivationally Related Form

For less specific concepts instead meronymy and holonymy relations are loosely defined.
E.g. "Football américain" (american football) "has_mero_part" "match de football" (football game); "fasciatura" "has_mero_member" "fascia"; "bowling" "has_mero_part" "roll" (the act of rolling something (as the ball in bowling).
These differences in the definition meronymy and holonymy relations are mostly attributable to human interpretation and language particularities but also to the grade of the maturity of concepts. Concepts present in modern vocabulary tend to have more loosely defined relations than those present in the base vocabulary of a language.

4.3. Fuzzynym

Two interesting EuroWordNet relations that we explored are *FUZZYNYM* (X has some strong relation to Y, same POS) and *XPOS FUZZYNYM* (X has some strong relation to Y, different POS). *FUZZYNYM* and *XPOS FUZZYNYM* are mostly semantic relations that are not belonging to other categories. As underlined by Morris & Hirst (2004), NLP applications need to explore such not perfectly structured and context dependent relations.
These relations can't be mapped directly to any WordNet relation but a part of their instantiations may be considered as members of the *DERIVATIONALLY RELATED FORM* found in WordNet.
During the integration process we found that using an algorithmic multilingual stemmer (e.g. Snowball - http://snowball.tartarus.org/) it is possible to extract most of standard WordNet *DERIVATIONALLY RELATED FORM* relations from EuroWordNet *FUZZYNYM* relation. This process would need only a fast human validation to properly import the correct relation instances.
The initial check of this process was done using a small portion of the English EuroWordNet resource, automatically comparing the results with original WordNet.
More tests were performed on other languages present in EuroWordNet (e.g. Italian and French) with a manual validation (since the original WordNet resource is only in English). With proper stemmer settings and word similarity measure (Cohen, Ravikumar, & Fienberg, 2003), we got high precision ratings ranging from 80% to 90%, thus requiring a light, but careful, filtering work by a human supervisor.
In Figure 2 is shown an example of transformation of a *FUZZYNYM* relation instance into an original WordNet *DERIVATIONALLY RELATED FORM*.

4.4. Collapsed Relations

Some relations that belong either to WordNet or EuroWordNet are collapsed in one relation. E.g. WordNet *ANTONYM* relation groups EuroWordNet *NEAR ANTONYM* and *ANTONYM* while EuroWordNet *IS DERIVED FROM* in WordNet becomes either *PERTAYNYM* (A\N), *PARTICIPLE OF VERB* (A<V). At the same time *IS DERIVED FROM* (as relation is not mappable for nouns.
E.g. "generalmente" (generally) is derived from "generale" (general).
In Figure 3 is presented the mapping of EuroWordNet *NEAR ANTONYM* relation with WordNet *ANTONYM* Relation. E.g. "piccolo" (little, small) is near antonym of "grande" (big). In English WordNet the same relation is defined as antonym.

4.5. Extended relations and cross part of speech relations

In EuroWordNet are defined some relations between different parts of speech that are not present in WordNet. We introduced them in order to preserve all EuroWordNet relations. These relations are marked as *XPOS* (*cross POS*), like *HAS XPOS HYPERONYM*, *XPOS NEAR ANTONYM*, *XPOS NEAR SYNONYM*, *HAS_XPOS_HYPONYM* and *XPOS FUZZYNYM*.
In our mapping, to express cross relations we have chosen to maintain WordNet pointer symbols whenever possible, adding only one "x" as prefix.

EuroWordNet Near Antonym Relation

```
0 @548@ WORD_MEANING
  1 PART_OF_SPEECH "a"
  1 VARIANTS
    2 LITERAL "grande"
      3 SENSE 1
      3 DEFINITION "Superiore a misura ordinaria
per dimensioni, quantit , durata e simili"
      3 EXTERNAL_INFO
        4 SOURCE_ID 2
  1 INTERNAL_LINKS
    2 RELATION "near_synonym"
      3 TARGET_CONCEPT
        4 PART_OF_SPEECH "a"
        4 LITERAL "forte"
          5 SENSE 3
    2 RELATION "near_antonym"
      3 TARGET_CONCEPT
        4 PART_OF_SPEECH "a"
        4 LITERAL "piccolo"
          5 SENSE 1
```

```
2 RELATION "state_of"
      3 TARGET_CONCEPT
        4 PART_OF_SPEECH "n"
        4 LITERAL "grande"
          5 SENSE 2
      3 FEATURES
        4 REVERSED
  1 EQ_LINKS
    2 EQ_RELATION "eq_synonym"
      3 TARGET_ILI
        4 PART_OF_SPEECH "a"
        4 WORDNET_OFFSET 1052939
```

WordNet Antonym Relation

```
01443454 00 a 02 small 0 little 1 026 ! 01434452 a 0202 ! 01434452 a 0101 (…) | limited or below
average in number or quantity or magnitude or extent; "a little dining room"; "a little house";
"a small car"; "a little (or small) group"
01434452 00 a 02 large 0 big 1 052 (…) | above average in size or number or quantity or
magnitude or extent; "a large city"; (…)
```

Figure 3: EuroWordNet Near Antonym relation mapped to WordNet Antonym Relation

4.6. WordNet relations non present in EuroWordNet

A number of English current WordNet relations are not defined in the first Fellbaum version. These relations are: *INSTANCE HYPERNYM*, *ATTRIBUTE*, *ALSO SEE*, *VERB GROUP*, *TOPIC*, *DOMAIN* and *USAGE* relations with all their versions.

4.7. Notes on equivalent relations

In WordNet are present some equivalent relations (EQ) linked to the ILI (Inter-Lingual-Index). Although the ILI does not cover all language internal relations, it can be used to aid in cross language mapping.

Such equivalent relations are: *EQ SYNONYM*, *EQ NEAR SYNONYM*, *HAS EQ HYPERONYM*, *HAS EQ HYPONYM*, *EQ HAS HOLONYM*, *EQ IN MANNER*, *EQ BE IN STATE*, *EQ HAS MERONYM*, *EQ CAUSES*, *EQ IS STATE OF*, *EQ INVOLVED*, *EQ IS CAUSED BY*, *EQ RULE*, *EQ HAS SUBEVENT*, *EQ CO ROLE*, *EQ IS SUBEVENT OF*.

The most important relation is `EQ SYNONYM` that expresses a one to one mapping between synsets in different languages. If one synset in one language matches more synsets in the other language, than the `EQ NEAR SYNONYM` relation is preferred.

The `HAS EQ HYPERONYM` and `HAS EQ HYPONYM` relations are typically used if a meaning is more specific than any available ILI-record.

5. Relations mapping

Table 2 presents a complete list of JMWNL relations including full and partial mapping, also non mapped relations and pointer symbols. Based on this table were generated the resource files for English WordNet 3.0 and EuroWordNet. For other lexical resources is just necessary to generate the adequate resource file using one of the provided templates.

6. Conclusion and Future Work

This paper presented an empirical study on mapping lexical and semantic relations between WordNet 1.6/EuroWordNet and the Princeton English WordNet version 3.0.

This paper described our study on relations mapping, cross part of speech relations and the partial mapping of Fuzzynym relations like Derivationally Related From.

We also showed the evolution of relations from EuroWordNet (mostly similar to WordNet 1.5) to WordNet 3.0. The modern WordNet has the tendency to have fewer relations for a better computability but looses a little linguistic expressivity.

Some relations could be mapped directly but others could not. A large number of EuroWordNet relations can be grouped to define one modern relation.

This study was a necessary step during the development of JMWNL, to properly include EuroWordNet data in a coherent way, and to help build multilingual applications based on WordNet/EuroWordNet.

7. References

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8. Appendix: Mapping Table

WordNet 1.6 / EuroWordNet Relations		WordNet 3.0 Relations
1. Nouns relations	***Relation Symbol***	
ANTONYM	!	ANTONYM
NEAR_ANTONYM	!	ANTONYM*
NEAR_SYNONYM	&	SIMILAR TO*
HAS_HYPERONYM	@	HYPERNYM
HAS_HYPONYM	~	HYPONYM
HAS_INSTANCE	~i	INSTANCE HYPONYM
HAS_HOLO_MEMBER	%m	MEMBER MERONYM**
HAS_HOLO_PART	%p	PART MERONYM**
HAS_HOLO_PORTION	%s	SUBSTANCE MERONYM**
HAS_MERO_MEMBER	#m	MEMBER HOLONYM**
HAS_MERO_PART	#p	PART HOLONYM**
HAS_MERO_PORTION	#s	SUBSTANCE HOLONYM**
HAS_XPOS_HYPERONYM	x@	HYPERNYM (X POS)***
XPOS_NEAR_ANTONYM	x!	ANTONYM (X POS)***
XPOS_NEAR_SYNONYM	x&	SIMILAR TO (X POS)***
FUZZYNYM	+	DERIVATIONALLY RELATED FORM
XPOS_FUZZYNYM	x+	DERIVATIONALLY RELATED FORM (X POS)
CAUSES	>	CAUSE
HAS_HOLONYM	%	
HAS_HOLO_MADEOF	%mo	
HAS_HOLO_LOCATION	%ml	
HAS_MERONYM	#	
HAS_MERO_MADEOF	#mo	
HAS_MERO_LOCATION	#ml	
INVOLVED	i	
INVOLVED_AGENT	ia	
INVOLVED_INSTRUMENT	ii	
INVOLVED_LOCATION	il	
INVOLVED_PATIENT	ip	
INVOLVED_RESULT	ir	
INVOLVED_SOURCE_DIRECTION	isd	
ROLE	r	
ROLE_AGENT	ra	
ROLE_DIRECTION	rd	
ROLE_INSTRUMENT	ri	
ROLE_LOCATION	rl	
ROLE_PATIENT	rp	
ROLE_RESULT	rr	
ROLE_SOURCE_DIRECTION	rsd	
ROLE_TARGET_DIRECTION	rtd	
CO_AGENT_INSTRUMENT	cai	
CO_INSTRUMENT_AGENT	cia	
CO_ROLE	cr	
DERIVATION	d	
IS_DERIVED_FROM	<-	
STATE_OF	st	
BE_IN_STATE	ist	

IS_CAUSED_BY	<	
HAS_SUBEVENT	hse	
IS_SUBEVENT_OF	ise	
	@i	Instance Hypernym
	=	Attribute
	;c	Domain of synset - TOPIC
	-c	Member of this domain - TOPIC
	;r	Domain of synset - REGION
	-r	Member of this domain - REGION
	;u	Domain of synset - USAGE
	-u	Member of this domain - USAGE
2. Private Nouns Relations		
HAS_HOLO_MEMBER	%m	MEMBER MERONYM
HAS_MERO_MEMBER	#m	MEMBER HOLONYM
BELONGS_TO_CLASS	)c	
3. Verb Relations		
CAUSES	>	CAUSE
HAS_HYPERONYM	@	HYPERNYM
HAS_HYPONYM	~	HYPONYM
NEAR_ANTONYM	!	ANTONYM*
IS_SUBEVENT_OF	*	ENTAILMENT
HAS_XPOS_HYPONYM	x~	HYPONYM (XPOS)***
NEAR_SYNONYM	&	SIMILAR TO*
XPOS_NEAR_ANTONYM	x!	ANTONYM (X POS)***
XPOS_NEAR_SYNONYM	x&	SIMILAR TO (X POS)***
XPOS_FUZZYNYM	x+	DERIVATIONALLY RELATED FORM (X POS)
IN_MANNER	im	
INVOLVED	i	
INVOLVED_DIRECTION	id	
INVOLVED_AGENT	ia	
INVOLVED_INSTRUMENT	ii	
INVOLVED_LOCATION	il	
INVOLVED_PATIENT	ip	
INVOLVED_RESULT	ir	
INVOLVED_SOURCE_DIRECTION	isd	
INVOLVED_TARGET_DIRECTION	itd	
BE_IN_STATE	ist	
IS_CAUSED_BY	<	
HAS_SUBEVENT	hse	
	^	Also see
	$	Verb Group
	;c	Domain of synset - TOPIC
	;r	Domain of synset - REGION
	;u	Domain of synset - USAGE
4. Adjective Relations		
IS_DERIVED_FROM	\	PERTAYNYM (A\N)
IS_DERIVED_FROM	<	PARTICIPLE OF VERB (A<V)
NEAR_ANTONYM	!	ANTONYM
NEAR_SYNONYM	&	SIMILAR TO
HAS_HYPERONYM	@	HYPERNYM
HAS_HYPONYM	~	HYPONYM
XPOS_NEAR_SYNONYM	x&	SIMILAR TO (X POS)***
FUZZYNYM	+	DERIVATIONALLY RELATED FORM
XPOS_FUZZYNYM	x+	DERIVATIONALLY RELATED FORM (X POS)
DERIVATION	d	
HAS_DERIVED	->	
IS_DERIVED_FROM	<-	
IS_CAUSED_BY	<	
MANNER_OF	mo	
STATE_OF	st	
	=	Attribute
	^	Also see
	;c	Domain of synset - TOPIC
	;r	Domain of synset - REGION
	;u	Domain of synset - USAGE

5. Adverb Relations		
DERIVED_FROM	\	DERIVED FROM ADJECTIVE(ADV\A)
NEAR_ANTONYM	!	ANTONYM
NEAR_SYNONYM	&	SIMILAR TO
XPOS_FUZZYNYM	x+	DERIVATIONALLY RELATED FORM (X POS)
IS_DERIVED_FROM	<-	
MANNER_OF	mo	
ROLE_DIRECTION	rd	
ROLE_LOCATION	rl	
ROLE_SOURCE_DIRECTION	rsd	
ROLE_TARGET_DIRECTION	rtd	
ROLE	r	
ROLE_AGENT	ra	
ROLE_INSTRUMENT	ri	
ROLE_PATIENT	rp	
ROLE_RESULT	rr	
	;c	Domain of synset - TOPIC
	;r	Domain of synset - REGION
	;u	Domain of synset – USAGE

Table 2: EuroWordNet and WordNet relations correspondence; In black are the relations that could be directly mapped, in blue the new defined relations and in red the relations that didn't have a correspondent either in EuroWordNet or WordNet.

* In EuroWordNet is preferred a loose synonymy and antonymy relation

** In EuroWordNet *HAS_MERO/HOLO* express respectively *HOLONYM/MERONYM* relations

*** *XPOS* Relations – In WordNet this relations are not present. We introduced them in order to preserve all EuroWordNet relations.