Enriching the Integration of Semantic Resources based on WordNet

Enriqueciendo la Integración de Recursos Semánticos basados en WordNet

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Abstract: In this paper we present the enrichment of the Integration of Semantic Resources based in WordNet (ISR-WN Enriched). This new proposal improves the previous one where several semantic resources such as SUMO, WordNet Domains and WordNet Affects were related, adding other semantic resources such as Semantic Classes and SentiWordNet. Firstly, the paper describes the architecture of this proposal explaining the particularities of each integrated resource. After that, we analyze some problems related to the mappings of different versions and how we solve them. Moreover, we show the advantages that this kind of tool can provide to different applications of Natural Language Processing. Related to that question, we can demonstrate that the integration of semantic resources allows acquiring a multidimensional vision in the analysis of natural language.

Keywords: WordNet, WordNet Domains, SUMO, WordNet Affects, Semantic Classes, SentiWordNet.

Resumen: En este artículo se presenta el enriquecimiento de la herramienta Integración de recursos Semánticos basados en WordNet (ISR-WN Enriquecido). Esta nueva propuesta mejora la anterior, introduciendo nuevos recursos tales como Semantic Classes y SentiWordNet a los anteriormente relacionados: SUMO, WordNet Domains y WordNet Affects. Previamente a la introducción de nuevos recursos se describe la arquitectura de esta propuesta explicando las particularidades de cada recurso integrado. Tras la descripción de la arquitectura se analizan los problemas surgidos tras el mapeo de diferentes versiones y cómo se han solucionado. Además, se muestran las ventajas que la introducción de este tipo de herramientas pueden proporcionar a diferentes aplicaciones de Procesamiento del Lenguaje Natural. Relacionado con esta cuestión también se demuestra que la integración de recursos semánticos permite adquirir una visión multidimensional en el análisis del lenguaje natural.

Palabras Clave: WordNet, WordNet Domains, SUMO, WordNet Affects, Semantic Classes, SentiWordNet.

1   Introducction

Most of Natural Language Processing (NLP) tasks use external resources. Usually, these resources are dictionaries, thesaurus, ontologies, etc. However, one of the most used on its different versions is WordNet (WN) (Fellbaum, 1998). WN is a lexical dictionary where words are annotated with senses (synsets) and it is structured as a semantic network. Due to the large usage of this resource it has been harvested and linked with different lexical resources such as WordNet Domains (WND) (Magnini and Cavaglia, 2000) a domain ontology, SUMO (Niles, 2001) an upper ontology, WordNet Affects (WNA) an extension of WND for emotion, SentiWordNet (SWN) (Esuli and Sebastiani, 2006) a lexical resource providing the polarity of senses, Semantic Classes (SC) (Izquierdo, Suárez and Rigau, 2007) a label set created from WN taxonomy with an important semantic value, etc.

In order to obtain additional information to solve different NLP problems, a variety of semantic resources have been used. However, one of the main problems of using semantic resources is their decentralization. Despite WN serves as kernel to develop different resources and aplications there are few tools that integrate them together. We can mention some works focused on the idea of building semantic networks with the same interface like MultiWordNet (MWN) (Pianta, Bentivogli and Girardi, 2002) which is able to align the Italian and English lexical dictionaries conceptualized by Domain labels, EuroWordNet (EWN) (Dorr and Castellón, 1997) which was developed to align Basque, Catalan, English, Italian and Spanish lexical dictionaries, Multilingual Central Repository (MCR) (Atserias *et al.*, 2004) which integrates into the EWN framework an upgraded version of the EWN Top Concept ontology, the MWN Domains, the Suggested Upper Merged Ontology (SUMO) (Niles and Pease, 2001) and hundreds of thousands of new semantic relations and properties automatically acquired from corpora, Integration of Semantic Resources based in WN (ISR-WN) (Gutiérrez *et al.*, 2010a) resource that takes into account different kinds of labels linked to WN: Level Upper Concepts (SUMO), Domains and Emotion labels.

As we can observe, each resource provides different semantic relations. Our proposal consists on building only one application to integrate the maximum number of semantic resources. In order to carry out this task we have extended the previously developed resource ISR-WN (which included WN, SUMO, WND and WNA) enriching it with Semantic Classes (SC) (Izquierdo, Suárez and Rigau, 2007) and SentiWordNet (SWN) (Esuli and Sebastiani, 2006). Our purpose is to prove that the integration of semantic resources offers very useful information for NLP tasks and could lead us to achieve better results.

The paper is organized as follows: in Section 2 we present a brief motivation and contribution. Section 3 describes WN mappings in order to understand how our proposal integrates several resources based on WN. Next, Section 4 describes the characteristics of the model used to obtain the integration. In Section 5 we evaluate the results obtained and also some NLP approaches that use ISR-WN Enriched as knowledge base. Finally, the conclusion and further works are in Section 6.

2   Motivation and Contribution

Authors as (Gliozzo, Strapparava and Dagan, 2004; Magnini *et al.*, July 2002; Magnini *et al.*, 2002; Vázquez, Montoyo and Rigau, 2004; Zubaryeva and Savoy, 2010) among others, have developed approaches that use some enrichments of WN. These works have introduced improvements on tasks such as Information Extraction, Summarization, Document Classification, Sentiment Analysis and Word Sense Disambiguation. However, these authors only take into account one resource at once. This is motivated by the lack of tools that provide the integration of several semantic resources mapped to WN, as we propose in this paper.

Over the previously mentioned resources, only ISR-WN is able to take into account a higher quantity of semantic dimensions. So, we propose to increase this resource with another two dimensions: Semantic Classes and SentiWordNet.

Figure 1 shows how the logical model is represented. As we can see, each dimension (resource) is connected to WN (the core of the network) through their internal relations. As we will explain in the next sections, there are different versions of WN so, it is necessary to

adequate the mappings of each version to each resource.

Our proposal includes six resources: WND, WNA, SUMO, SWN, SC and WN. In the next sections, all of the resources that are used to obtain the interrelations from WN will be described in detail.
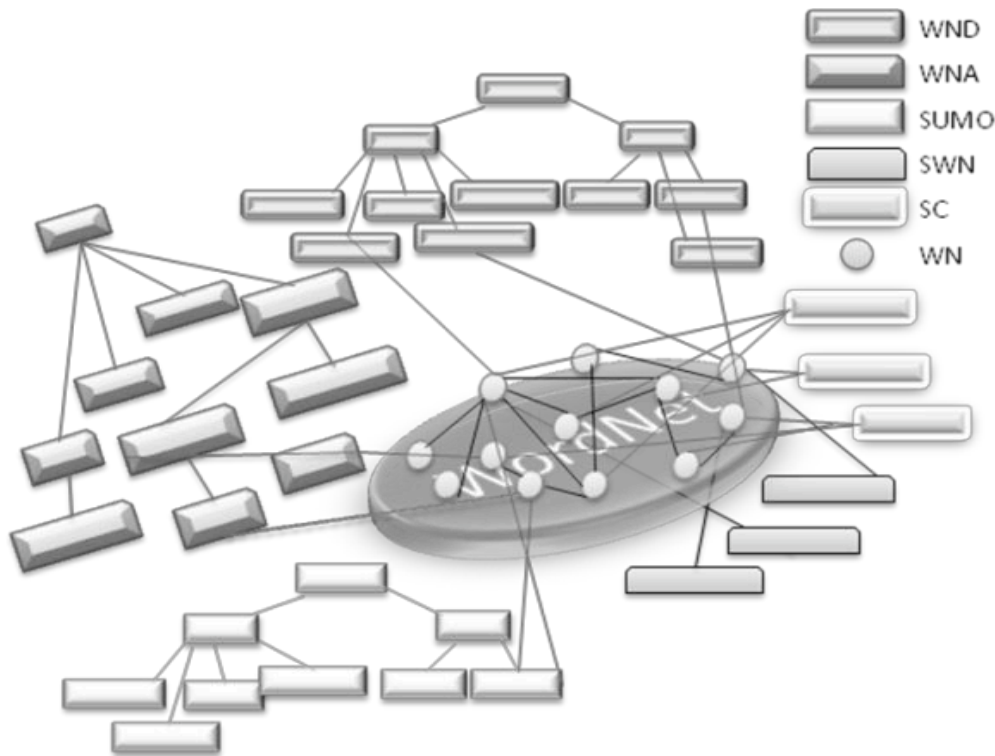

Figure 1: Logical model of the integration of WN-based resources

3   WordNet

WordNet (WN) (Miller, G. A. 1995) is a lexical data base. It represents a structured semantic conceptual network. WN defines nouns, verbs, adjectives and adverbs. The basic unit of information in WN is the *synset* (*synonym sets*). A *synset* represents a concept of lexical form (word senses) (Ševčenko, 2003) and it is encoded like a unique number of eight digits called *offset*. Within the data base, each *synset* represents a different concept and it has connections that express semantic, conceptual or lexical relations among other synsets. The result of this set of connections is an extensive navigable network that provides a huge quantity of interrelations among different words. Due to its characteristics it is suitable of being applied in NLP, WN provides the base for other resources that extend its relations. Using some of these extensions we have built the new ISR-WN resource.

Next sections describe each one of the resources used in ISR-WN.

3.1   Resources mapped to WordNet

As we have mentioned above we work with resources mapped to WN. In the next sections we present each of these resources.

3.1.1   WordNet Domains

WordNet Domains extends the information provided by WN, by means of the inclusion of relevant word sets for a specific domain (*Subject Field Codes* (SFC)) (Magnini and Cavaglia, 2000). As a result, each synset is annotated with one or more labels.

This new extension allows to group together several synsets according to their common labels. Therefore, WND is useful to solve one problem of WN, its fine granularity. Due to the fact that in WN senses are semantically very close, the distinction among them is often a hard work. So, with WND we can reduce this fine granularity.

In WND, WN *synsets* have been tagged using a semi-automatic process with one or several labels, selected among a set of 200 candidates labels hierarchically organized (our

proposal uses 170 labels). This helps to reduce the level of polysemous senses, grouping those that belong to the same domains or labels (Magnini *et al.*, July 2002).

3.1.2 WordNet Affect (WNAffect)

It is an extension of WND (*WordNet Domain*, 2009; Magnini and Cavaglia, 2000). It is constituted by subsets of affective concepts that group *synsets* denoting emotional statuses. Labels have been tagged with a process similar to WND annotation. Some of the represented concepts are moods, situations eliciting emotions or emotional responses.

This resource has been extended with a set of additional labels so-called *emotional categories.* In order to establish the relations among different concepts it uses hypernyms relations of WN (since version 1.1) (Valitutti, Strapparava and Stock, 2004).

In a second revision some modifications were made to distinguish which senses were further in agreement with emotional labels and also new labels like: *Positive, negative, ambiguous* and *neutral* were included*.* We have selected the combination of WNA1.0 and WNA1.1.

WNA1.0 does not add labels related to a structured tree, this resource only links *synsets* to emotion labels.

WNA1.1 adds emotion labels related to a structured tree assuming the majority of labels from WNA1.0 and including others.

3.1.3 SUMO

SUMO (*Suggested Upper Merged Ontology*) (Niles and Pease, 2001) is considered a superior level ontology. It provides definitions for terms of general purpose and it can act as a base for ontologies of more specific domains. It was built from the combination of different ontological contents into a cohesive structure.

At present it contains around 1000 terms and 4000 assertions (Niles and Pease, 2003). Our proposal takes into account 559 categories provided by the Ontological Portal[1]

3.1.4 Semantic Classes (SC)

The Semantic Classes resource (Izquierdo *et al.*, 2007) consists of a set of Base Level Concepts (BLC) obtained from WN applying a bottom-up process using the chain of hypernym relations. For each *synset* in WN, the procedure selects as

its Base Level Concept the first local maximum according to the relative number of relations. As a result, the Semantic Classes have a set of BLCs that are semantically linked to several *synsets*.

3.1.5 Senti WN

SentiWordNet is a lexical resource where each *synset* of WN is associated to three numerical scores Obj(s), Pos(s) and Neg(s). Each score describes how Objective, Positive, and Negative the terms contained in the synset are respectively.

Each one of the three scores moves from 0.0 to 1.0, and their sum is 1.0 for each *synset.* This means that a *synset* could have nonzero scores for all the three categories. That means that one synset would have three opinion-related properties with a certain degree (e.g. *atrocious#3* [Pos: 0|Neg: 0.625 |Obj: 0.375]).

4   Integrative Model

This section describes the characteristics of the model used to obtain the integration of the different resources. As we have mentioned previously, the integration model takes WN as nucleus and links each resource: SUMO, WND and WNA, SC and SWN. We have taken into account each one of their peculiarities and have added each one of them using different versions. Due to the fact that all the resources are tagged in English the integration only has been done in English.

From the model presented in Figure 1, a new model has been obtained. It includes not only the integration of all the above-mentioned resources, but also the possibility to access each one of them in an individual way.

Figure 2 shows how the *synsets* are represented by words and at the same time their relations with several hierarchies (SUMO, WND and WNA) and also labels of SC and SWN through different mappings files.

These relations permit to link distinct versions in which the resources were tagged, getting as a result a useful semantic-graph for NLP applications.

As we can observe on Figure 2 all the mentioned resources (taxonomies of SUMO, WordNet-Domains and WordNet-Affect; Semantic Class labels and SentiWordNet descriptions) are linked to WN senses.

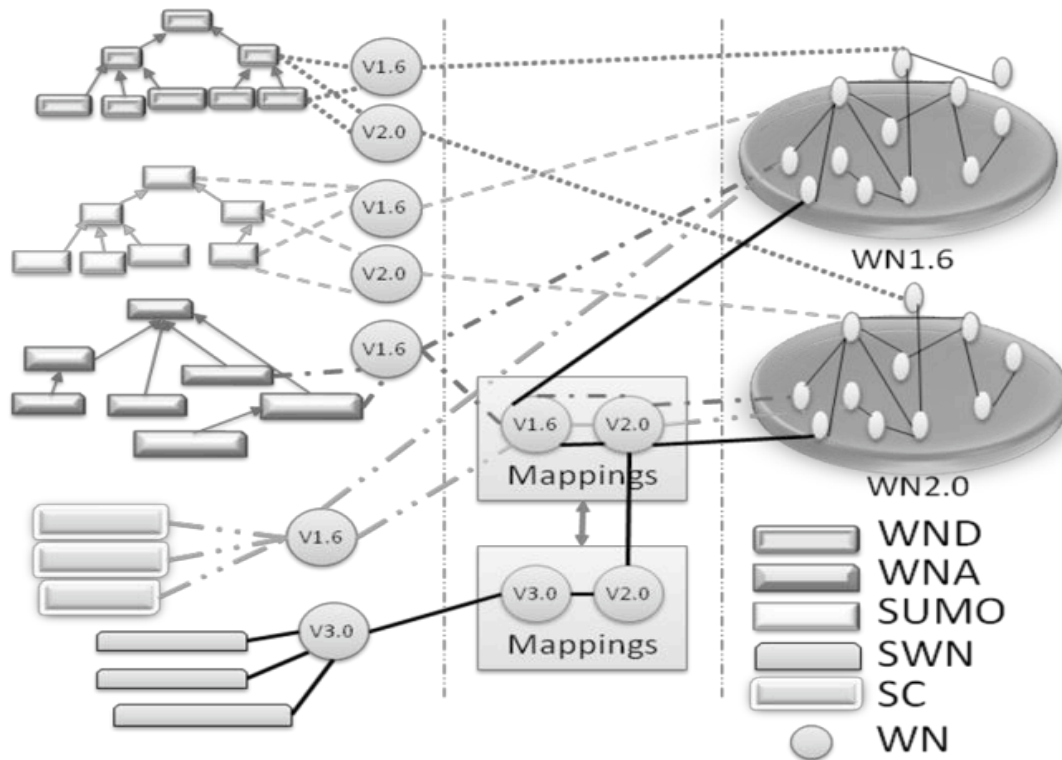
[1] http://www.ontologyportal.org/

Figure 2: Architecture of our proposal

In order to integrate a wide knowledge network from several conceptual dimensions, we use WN mappings of different versions. In some cases, there are relations that are not contemplated in all existing versions. In order to solve this problem we propose to navigate through as many versions as possible until getting all the necessary data. For example: WNA is linked with WN 2.0, SWN is linked with both versions of WN 1.6 and 2.0, and Semantic Classes is linked with WN 2.0.

The model presented in Figure 2 can take as core WN 1.6 or 2.0 depending on our objective. This decision does not limit the usage of other WN versions in future implementations.

As a result, the integrative model respects the existent relations among WN *synsets.* Besides, the concepts of SUMO preserve the relations of WN mappings (SUO, 2001). Moreover, the relations that are established in WND and WNAffect are those related to the hyponym and hypernym sets, but the relations of *synsets* with WND and WNA come from membership. It is important to remark that WNA1.1 harvests WN with new relationships among *synsets* (e.g. entailment, cause) which allow linking verbs, adjectives and adverbs to nouns. These considerations are taken into account to develop our proposal.

The connections of the obtained knowledge network permit navigating through all the relations of the integrated resources.

For example, taking into consideration the word *"atrocious" and* using version 1.6 of WN we can obtain the following information:

- Sense: *alarming#1*
  Relation: Similar-To
- WNDomain: *Psychological_Feature*
  Relation: Pertainym
- SUMO: *SubjetiveAssessmentAttribute*
  Relation: Hyponym
- WNAffect: *Emotion*
  Relation: Pertainym
- WNAffect*: Horror*
  Relation: Pertainym
- SentiWN: *atrocious#3*
  Pos: 0|Neg: 0.625 |Obj: 0.375
  Relation: SentiWN-Description
- Sense: *horror#1*
  Relation: Cause

As we can see, apart from offset, pos, list of lemmas or glosses, information can be extracted from the integrated resources. In this case, using WN 1.6 we can obtain all the different senses of the word *"atrocious"*.

Moreover, if this input word coincides with a label of some WN mappings, the label is

obtained too. Therefore, for each given label we can also obtain all labels from any resource that are related to it. It is important to emphasize that, originally, the affect "*Horror*" did not link directly to *atrocious#3,* but we can assume that if the *atrocious#3* sense is linked to the noun *horror* with the affective relations obtained from WNA1.1, then this sense will be linked too. In this case the sense*"horror#1"* is the sense that is linked to "*Horror*" directly.

5 Results and discussion

After developing the integrative resource, we have conducted an analysis to study the quantity of *synsets* that should have been mapped from the data sources against the quantity of *synsets* that our integrative resource maps in fact. This analysis is shown in Table 1. Also, the quantities of labels that are involved on the integrator resource using WN 1.6 as core are indicated. In addition the totality of *synsets* to map and the finally mapped synsets are shown too.

	WND2.0	SUMO	WNA_1.0-1.1	SC	SWN_30
# Labels	170	569	309	1231	117659
Synsets to map					
n	86901	67923	1256	66025	82114
a	19322	18531	2418	-	18157
v	12843	12469	801	12127	13767
r	3735	3627	614	-	3621
Total *synsets* to map	122801	102550	5089	78152	117659
Synsets mapped					
n	86901	67923	1096	66025	56563
a	19322	18531	2125		8757
v	12901	12469	474	12127	9223
r	3735	3627	549		2101
Total *synsets* mapped	122801	102550	4244	78152	76644
Difference	0	0	845	0	41015
% mapped	100.00	100.00	83.40	100.00	65.14

Table 1: *Synsets* linked to each resource using WN1.6 as core

As we can see WND, SUMO and SC were 100% mapped. This is possible because the sources used on these resources were built over WN 1.6.

The difference of 845 in Table 1 between WNA 1.0 and WNA 1.1 (according to the mapped *synsets* and the ones that should have been mapped) is due to we have used the emotional labels from WNA 1.1. In this special case, the majority of labels in WNA 1.0 are maintained in version 1.1, but several of them disappear in this version. The *synsets* in the source files of WNA 1.0 mapped to the disappeared labels are not taken into account.

For example, the next labels disappear on the WNA 1.1's tree structure: "attitude", "emotional response", "psy", "man", "sympathy", "sta", "softheartedness", "joy-pride", "identification", "levity-gaiety", "general-gaiety", "empathy", "positive-concern", "compatibility", "kindheartedness" and "buck-fever". Therefore, our resource does

not include the links among these labels and the *synsets*.

It is important to remark that we have used the hierarchy tree of the most recent version of WND and WNA (e.g. WND 3.2, WNA 1.1) and then some labels could not be included.

We have added the WNA mapping sources trying to assign the biggest quantity of emotion labels to *synsets*. WNA 1.1 has the peculiarity that only nouns are linked to the emotion labels. But notice that WNA 1.1 harvest WN with new relationships among *synsets* (e.g. entailment, cause), indicating that we can obtain new relations with verbs, adjectives and adverbs according to the nouns.

The main difference among the mapped *synsets* pertains to SWN. This resource was built based on WN 3.0. Therefore, many senses of the existent word in WN 3.0 do not exist in WN1.6.

Table 2 shows the quantity of labels that are involved on the integrative resource using WN 2.0 as core.

	WND 3.2	SUMO	WNA_1.0-1.1	SC	SWN_30
# Labels	170	569	309	1231	117659
Synsets to map					
n	103504	79688	1256	66025	82114
a	19398	18564	2418	-	18157
v	19398	13507	801	12127	13767
r	3835	3663	614	-	3621
Total *synsets* to map	146135	115422	5089	78152	117659
Synsets mapped					
n	103504	79688	1089	65904	78061
a	19398	18564	2118		11052
v	19398	13507	473	12064	13207
r	3835	3663	580		3428
Total *synsets* mapped	146135	115422	4260	77968	105748
Difference	0	0	829	184	11911
% mapped	100.00	100.00	83.71	99.76	89.88

Table 2: *Synsets* linked to each resource using WN2.0 as core

As we can see SC has lost a few links, this is due to the fact that SC is built with WN1.6 and some *synsets* do not exist exactly on WN 2.0.

On the other hand, we can observe that SWN increases the quantity of *synsets* linked with WN 2.0 as core of the integrative resource. In both tables we have not analyzed WNA1.0 and WNA1.1 separately. We have joined both resources because we have proposed a fusion version. In this fusion all labels that remain in the WNA1.1 hierarchy are linked to all *synsets* of WNA1.0 and all labels from WNA1.1 are linked at the same time. Using this special linking we enable the coexistence of both versions.

5.1 Usefulness of the integrative module in different NLP tasks

One of the main purposes of the integrative resource is to help different NLP tasks from a multidimensional view. In this section we present how the previous proposal has been used in different works. Specifically, it has been used in Word Sense Disambiguation obtaining promising results.

For example, we can mention the system presented on the SemEval-2010 task number 17 (All-words Word Sense Disambiguation on Specific Domain), which identifies Relevant Semantic Trees from sentences in order to solve the ambiguity (Gutiérrez *et al.*, 2010b). This work proposed a method that obtained the appropriate senses from a multidimensional analysis (using Relevant Semantic Trees combined with ISR-WN). Moreover, in order to achieve better results, other approaches were made using different information sources: ISR-WN (WordNet, WordNet Domains, WordNet-Affects and SUMO) and combining the results with Sense Frequencies obtained from SemCor.

Another new approach in this address was introduced, now using an adaptation of the Cliques Partitioning Technique to *N* distance. This new approach is able to identify sets of strongly related senses using a multidimensional graph based on different resources: WordNet Domains, SUMO and WordNet Affects. As a result, each Clique will contain relevant information used to extract the correct sense of each word (Gutiérrez, Vázquez and Montoyo, 2011b). These proposals obtained good results that could locate them among the 11th best systems on Senseval-2 (Cotton *et al.*, 2001) competition.

Moreover, there are different thematic where the multidimensional analysis can be introduced. For example, the work presented on WASSA'11[2] uses the integrative resource applied on Sentiment Analysis. Related to the topic of evaluating opinions, NTCIR Multilingual Opinion Analysis Task (MOAT) is one of the competitions that set the benchmark for opinion question answering, in a monolingual and cross-lingual setting. The proposal presented in this competition was concentrated on 3 of the tracks proposed in the NTCIR 8 MOAT, concerning the classification of sentences according to their opinionatedness, relevance and polarity. Related to these tasks the paper presented on WASAA'11 provided a method for the detection of opinions, relevance, and polarity classification, based on the integrative resource combining the descriptions of SWN with other dimensions (Gutiérrez,

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[2] http://gplsi.dlsi.ua.es/congresos/wassa2011/

Vázquez and Montoyo, 2011a). This proposal obtained good results positioning on the first places of the rank of this competition.

In conclusion, the usage of WN connected to several resources in a multidimensional network can help NLP systems in different tasks.

6 Conclusions and further works

The main contribution of this article is the development of a module capable to integrate several resources that share a common core (WN). We can observe certain differences when using the integrative resource with WN1.6 or WN2.0. It is because the annotation is different depending on the mapping versions used. It is important to remark that we have introduced new links that have been included in WNA 1.1, not only directly between adjectives, adverbs and verbs with the emotion labels but also through nouns. These new links help to identify quickly the emotion *synsets*. Also the integrated resource has been used in different tasks, offering promising results.

As further works we propose to harvest the resource with other semantic dimensions such as FrameNet[3], a very rich semantic resource that contains descriptions and corpus annotations of English words following the paradigm of Frame Semantics (Fillmore, 1976), Micro-WNOp[4] a Polarity-Tagged corpus composed by 1105 WN *synsets* and other resources that could help us to increase the quantity of dimensions of the actual proposal and then serve to a wide set of NLP tasks.

Aknowledgements

References

Atserias, J., L. Villarejo, G. Rigau, E. Agirre, J. Carroll, B. Magnini and P. Vossen. 2004. The MEANING Multilingual Central Repository. *In Proceedings of the Second International Global WordNet Conference (GWC'04)*. Brno, Czech Republic. ISBN 80-210-3302-9.

Cotton, S., P. Edmonds, A. Kilgarriff and M. Palmer. 2001. English All word. *In SENSEVAL-2: Second International Workshop on Evaluating Word Sense Disambiguation Systems*, Association for Computational Linguistics. Toulouse, France.

Dorr, B. J. and M. A. M. A. I. Castellón. 1997. Spanish EuroWordNet and LCS-Based Interlingual MT. *In AMTA/SIG-IL First Workshop on Interlinguas*. San Diego, CA.

Esuli, A. and F. Sebastiani. 2006. SentiWordNet: A Publicly Available Lexical Resource for Opinion Mining. *In Fifth international conference on Languaje Resources and Evaluation* pages 417-422

Fellbaum, C. 1998. *WordNet. An Electronic Lexical Database*. University of Cambridge. *The MIT Press.*

Fillmore, C. J. 1976. Frame semantics and the nature of language. *In Annals of the New York Academy of Sciences: Conference on the Origin and Development of Language and Speech*. pages 20–32, New York.

Gliozzo, A., C. Strapparava and I. Dagan. 2004. Unsupervised and Supervised Exploitation of Semantic Domains in Lexical Disambiguation. *In Computer Speech and Language*.

Gutiérrez, Y., A. Fernández, A. Montoyo and S. Vázquez. 2010a. Integration of semantic resources based on WordNet. *In XXVI Congreso de la Sociedad Española para el Procesamiento del Lenguaje Natural*, SEPLN 2010. pages 161-168, Universidad Politécnica de Valencia, Valencia.

Gutiérrez, Y., A. Fernández, A. Montoyo and S. Vázquez. 2010b. UMCC-DLSI: Integrative resource for disambiguation task. *In Proceedings of the 5th International Workshop on Semantic Evaluation*, Association for Computational Linguistics. pages 427-432, Uppsala, Sweden.

Gutiérrez, Y., S. Vázquez and A. Montoyo. 2011a. Sentiment Classification Using Semantic Features Extracted from WordNet-based Resources. *In 2nd Workshop on Computational Approaches to Subjectivity and Sentiment Analysis (WASSA 2.011)*. Association for Computational Linguistics. pages 139-145. Portland, Oregon.

Gutiérrez, Y., S. Vázquez and A. Montoyo. 2011b. Word Sense Disambiguation: a

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[3] http://framenet.icsi.berkeley.edu/
[4] http://www.unipv.it/micrownop

graph-based approach using N-Cliques Partitioning Technique. *In NLDB'11.* pages 112-124 Alicante, Spain.

Izquierdo, R., A. Suárez and G. Rigau. 2007. A Proposal of Automatic Selection of Coarse-grained Semantic Classes for WSD,Procesamiento del Lenguaje Natural, pages 189-196.

Magnini, B. and G. Cavaglia. 2000. Integrating Subject Field Codes into WordNet. *In Proceedings of Third International Conference on Language Resources and Evaluation (LREC-2000).* pages 1413-1418.

Magnini, B., C. Satrapparava, G. Pezzulo and A. Gliozzo. July 2002. The Role of Domains Informations in Word Sense Disambiguatios. Treto. Cambridge University Press.

Magnini, B., C. Strapparava, G. Pezzulo and A. Gliozzo. 2002. Comparing Ontology-Based and Corpus-Based Domain Annotations in WordNet. *In Proceedings of the First International WordNet Conference.* pages 21-25 Mysore, India.

Miller, G. A. 1995. WordNet: A Lexical Database for English. Comunications of the ACM. Vol 38. pages 39-41.

Niles, I. 2001. Mapping WordNet to the SUMO Ontology,Teknowledge Corporation.

Niles, I. and A. Pease. 2003. Linking Lexicons and Ontologies: Mapping WordNet to the Suggested Upper Merged Ontology.

Niles, I. and A. Pease. 2001. Origins of the IEEE Standard Upper Ontology. *In Working Notes of the IJCAI-2001 Workshop on the IEEE Standard Upper Ontology.* Seattle, Washington, USA.

Pianta, E., L. Bentivogli and C. Girardi. 2002. MultiWordNet. Developing an aligned multilingual database. *In Proceedings of the 1st International WordNet Conference.* pages 293-302, Mysore, India.

Ševčenko, M. 2003. *Online Presentation of an Upper Ontology.* CTU Prague, Dept of Computer Science.

SUO. 2001. The IEEE Standard Upper Ontology web site. Available in: http://suo.ieee.org.

Valitutti, A., C. Strapparava and O. Stock, Eds. 2004. *Developing Affective Lexical Resources,*ITC-irst, Trento, Italy, PsychNology Journal.

Vázquez, S., A. Montoyo and G. Rigau. 2004. Using Relevant Domains Resource for Word Sense Disambiguation. *In IC-AI'04. Proceedings of the International Conference on Artificial Intelligence.* pages, Ed: CSREA Press. Las Vegas, E.E.U.U.

WordNet Domain. 2009. FBK-irst The Human Language Technology Research Unit at FBK. Available in: http://wndomains.fbk.eu/.

Zubaryeva, O. and J. Savoy. 2010. Opinion Detection by Combining Machine Learning & Linguistic Tools *In Proceedings of NTCIR-8 Workshop Meeting.* pages 221-227, Tokyo, Japan.