

Encoding information on adjectives in a lexical-semantic net for computational applications

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Abstract

The goal of this paper is to describe how the EuroWordNet framework for representing lexical meaning is being modified within an Italian National Project in order to include information on adjectives. The focus is on the 'new' semantic relations being encoded and on the revisions we have made to the EuroWordNet Top Ontology structure. We also briefly discuss the utility of the information which is being encoded for computational applications.

Introduction

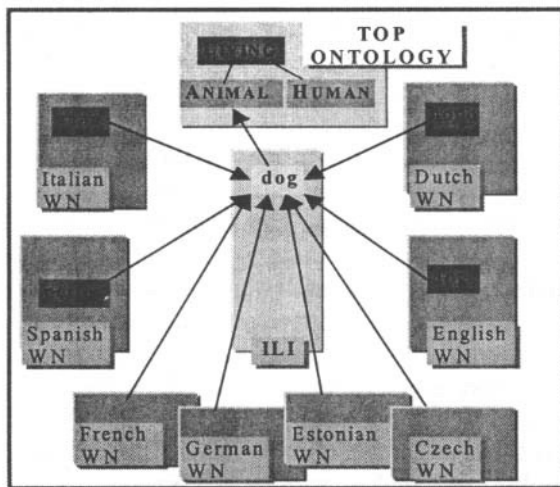
The Princeton *WordNet* (henceforth WN) is a lexical semantic network in which the meanings of words are represented in terms of their conceptual and lexical relations to other words. The basic notion around which it is developed is that of a *synset* (synonyms set), i.e. a set of words with the same Part-of-Speech (PoS) that can be interchanged in a certain context. Various conceptual and lexical relations are then encoded between synsets of the same PoS: e.g., hyponymy, antonymy, meronymy, etc. (Miller et al. 1990; Fellbaum 1998b).

Within the *EuroWordNet* (henceforth EWN) project¹ a similar (multilingual) lexical resource was developed, retaining the basic underlying design of WN, but enriching the set of lexical-semantic relations to be encoded for nouns and verbs in various ways², in order to obtain a maximally re-usable resource for computational applications. Thus, a) cross-PoS (XPOS) relations were added so that different surface realizations of similar concepts within and across languages could be matched (e.g., the noun *research* and the verb *to research* could be linked as

¹ EWN was a project in the EC Language Engineering (LE-4003 and LE-8328) programme. In a first phase, the partners involved were the University of Amsterdam (coordinator); the Istituto di Linguistica Computazionale, CNR, Pisa; the Fundacion Universidad Empresa (a cooperation of UNED, Madrid, Politecnica de Catalunya, Barcelona, and the University of Barcelona); the University of Sheffield; and Novell Linguistic Development (Antwerp), changed to Lernout & Hauspie during the project. In a further phase, the database was extended with German, French, Estonian and Czech. Complete information on EWN can be found at its web site: <http://www.hum.uva.nl/~ewn/>.

² Adjectives and adverbs were encoded in EWN only as targets of relations from nouns and verbs.

'XPOS_NEAR_SYNONYMS' in EWN); b) some relations were identified which provide detailed information on semantic components lexicalized within word roots (e.g., *to hammer* could be linked to the noun *hammer* by means of an 'INVOLVED_INSTRUMENT' relation); c) some labels were distinguished which could be added to relations to make their semantic entailments more explicit and precise (cf. Alonge et al. 1998). The links among the wordnets of different languages were realized by means of an Interlingual-Index (ILI), constituted by an unstructured list of the Princeton WN (version 1.5) synsets. In addition, a hierarchy of language-independent concepts, reflecting fundamental semantic distinctions (e.g., *Object* and *Substance*, *Dynamic* and *Static*, *Cause*, *Manner*, etc.), was built: the Top Ontology (TO). The TO consists of language-independent features which may (or may not) be lexicalized in various ways, or according to different patterns, in different languages (Rodriguez et al. 1998). Via the ILI, all the concepts in the monolingual wordnets are directly or indirectly linked to the TO. The following picture shows the EWN data structure (see also Vossen 1999):



While in WN all PoSs are represented, in EWN detailed information was encoded only for nouns and verbs and no analysis was carried out with respect to lexical-semantic relations which could be used to describe the semantics of adjectives and adverbs. In an Italian National Project we are building a large wordnet, *ItalWordNet*

(henceforth IWN)³, by extending the network built for Italian in EWN. Thus, we are both increasing the coverage for nouns and verbs and adding adjectives and some adverbs⁴. To be able to encode information on adjectives we have enriched the set of the EWN lexical-semantic relations, aiming at encoding data which can be useful for computational applications. Moreover, we have revised the TO in order to account for the semantics of the new lexical categories being encoded.

In this paper we describe the main changes made to the EWN framework in order to encode information on adjectives in IWN. Firstly, we provide a brief overview of the WN treatment of adjectives. Then, we discuss the set of relations being encoded for this category in IWN. Finally, we show the integration made to the EWN TO. We then conclude the paper by adding some remarks on the utility of the data being encoded for computational applications.

1 Adjectives in WN

In WN adjectives are divided into two major classes: descriptive adjectives and relational adjectives. A descriptive adjective is "one that ascribes a value of an attribute to a noun" (Fellbaum et al. 1993:27). Descriptive adjectives combine with nouns to express some qualities of the thing, person or concept they designate. Typically, in this group we find adjectives that designate the physical dimension of an object, its weight, abstract values etc. Besides these *referent-modifying* adjectives, we also find *reference-modifying* adjectives (cf. Bolinger 1967; Chierchia & McConnel-Ginet 1990 name them *intensional adjectives*). Typical examples of the latter are *former*, *future*, *present*.

³ *ItalWordNet* will be the reference lexical resource among various integrated language resources and software tools for the automatic treatment of the Italian written and spoken language which are being developed within the SI-TAL ('Integrated System for the Automatic Treatment of Language') National Project.

⁴ Actually, we shall only encode adverbs derived from adjectives by adding the suffix *-mente*, for which a derivation relation with an adjective will be encoded.

Relational adjectives, on the other hand, mean something like “relating/pertaining to, associated with”, and usually have a morphologically strong link with a noun. Typical examples are *musical*, *atomic*, *chemical*⁵.

Synonymy is the basic relation encoded for all the PoSs (since it is used to build synsets). While in WN the noun and verb networks are then mainly developed around the superordinate (hyper/hyponymy) relationship, the organization of descriptive adjectives can “be visualized in terms of barbell-like structures, with a direct antonym in the centre of each disk surrounded by its semantically similar adjectives (which constitute the indirect antonyms of the adjectives in the opposed disk)” (Fellbaum 1998a: 212). The main relation encoded for these adjective synsets is antonymy, claimed to be the most prominent relation, both from a psycholinguistic point of view and from a more strictly lexical-semantic one, in the definition of the semantics of descriptive adjectives. Hyponymy is substituted by a ‘similarity’ relation.

Relational adjectives, on the contrary, are not organized in this way, because their semantics cannot be described by using these relations. Indeed, they only point to the noun to which they pertain (e.g. *atomic* is linked to *atom*).

Finally, information on the selectional preferences of both descriptive and relational adjectives is sometimes encoded (e.g., between *high* and *degree*), by using an ‘is_attribute_of’ relation.

2 The IWN relations for adjectives

As for the other lexical categories, also in IWN the basic relation encoded for adjectives is synonymy, on the basis of which synsets are built. Following EWN, we also encode a NEAR_SYNONYMY relation when two synsets are very close in meaning but their members cannot be put in the same synset (and no other relation results appropriate to link them; see Alonge et

⁵ Note that some adjectives have both a descriptive sense and a relational one. For example, *musicale* (musical) can modify the noun *voce* (voice) when we want to say that a voice is sweet-sounding and melodious, but can also be combined with the noun *strumento* (instrument) when we want to indicate that an instrument can be used to produce music.

al. 1998 for a discussion of this relation, and Alonge et al., in prep., for a complete and detailed discussion of the linguistic design of IWN). Then, we encode a number of additional relations, which have been identified by taking into consideration i) theoretical works; ii) the EAGLES recommendations on semantic encoding (cf. Sanfilippo et al. 1999); iii) the data available in our sources; iv) possible use of data encoded in computational applications.

2.1 Hyponymy

Together with synonymy, the hyponymy relation constitutes the ‘bone structure’ of both WN and EWN. However, as we have seen, in WN the possibility of encoding hyponymy for adjectives is denied and the basic relation encoded for adjectives is antonymy, while EWN did not really deal with adjectives and a complete network for them was not built.

Within IWN we have reconsidered the possibility of encoding hyponymy for adjectives. By analysing data coming from machine-readable dictionaries we find subsets of adjectives which have a *genus + differentia* definition, like nouns or verbs. That is, these adjectives seem to be organised into classes sharing a superordinate. This is the case, e.g., of adjectives indicating a ‘containing’ property (*acquoso* - watery; *alcalino* - alkaline), or a ‘suitable-for’ property (*difensivo* - defensive; *educativo* - educational), etc. In IWN we have decided, therefore, to encode hyponymy also for these sets of adjectives. The taxonomies which can be built on the basis of this relation are different from those built for nouns or verbs, since they are generally very flat, consisting almost always of two levels only (an exception is the color adjectives taxonomy). However, by encoding a hyponymy relation for these adjectives, we obtain classes for which it will be possible to make various inferences. For instance, it will be possible to infer semantic preferences of certain classes: e.g., all the adjectives occurring in the taxonomy of *contenente* (containing) will occur as attributes of concrete nouns; adjectives found in the taxonomy of *affetto* (affected by an illness) will never be predicated of nouns referring to objects, etc. Furthermore, it will also be possible to infer information on syntactic characteristics

of adjectives found in the same taxonomy: e.g., the hyponyms of *atto* (suitable for) are always found in predicative position (and do not accept any complements); the hyponyms of *privo* (lacking) may occur both in attributive and in predicative position (and may take certain prepositional complements), etc.

As it was done for all the relations identified in EWN, we have built substitution tests or diagnostic frames based on normality judgements (cf. Cruse 1986). Inserting two words in the test sentences built evokes a ‘normality’/ ‘abnormality’ judgement on the basis of which each relation can be determined. These tests are used by encoders both to verify the existence of relations between synsets and to encode them in a consistent way (for a complete lists of the tests built see Alonge et al., in prep.)

2.2 Antonymy

As in WN, also in IWN the antonymy relation remains an important relation to describe the semantics of various adjectives. Following theoretical work (Lyons 1977; Cruse 1986), we have further distinguished between `COMPLEMENTARY_ANTONYMY` and `GRADABLE_ANTONYMY`⁶. The former relation links adjectives referring to opposing properties/concepts: when one holds the other is excluded (*alive/dead*). The latter relation is used for those antonym pairs which refer to gradable properties (*long/short*). In case it is not clear if two opposing adjectives refer to complementary or gradable properties, we can still use an underspecified `ANTONYMY` relation. Also this information can be useful for computational applications since word pairs presenting one of the two kinds of opposition may occur in different contexts (cf. Cruse 1986).

2.3 Other relations

In WN a relation between adjectives and nouns is encoded for relational adjectives which point to a noun to which they ‘pertain’: *atomic/atom*,

industriall/industry, etc. This relation will be encoded also in IWN, by using the label `PERTAINS_TO`.

Another relation ‘inherited’ from WN can be useful to distinguish both adjective senses and their semantic preferences⁷:

alto ₁ (tall)	<code>IS_A_VALUE_OF</code>	statura (stature)
alto ₂ (high)	<code>IS_A_VALUE_OF</code>	altezza (height).

Other relations are then being encoded which are not in WN, but are encoded for nouns and verbs in EWN. In WN each PoS forms a separate system of language-internal relations and conceptually close concepts are totally separated only because they differ in PoS. In EWN, instead of using as main classificatory criterion the traditional distinction among PoSs, drawn upon heterogeneous criteria, a purely semantic distinction was adopted (following Lyons 1977). Thus, a distinction was drawn among *1st order entities* (1oes - referred to by concrete nouns), *2nd order entities* (2oes - referred to by verbs, adjectives or nouns indicating properties, states, processes or events), and *3rd order entities* (3oes - referred to by abstract nouns indicating propositions existing independently of time and space). By drawing this distinction it was possible to relate lexical items that, either within a language or across different languages, refer to close concepts, although they belong to different PoSs. Thus, as said above, the possibility to encode ‘near-synonymy’ between synsets of the same order (but different PoSs) was provided. Furthermore, other cross-PoS relations were identified which allow to obtain a better description of word meanings. In IWN we maintain the same distinction among semantic orders and encode for adjectives some relations which can be encoded for the other 2oes. In particular, we encode the ‘INVOLVED’ and ‘CAUSE’ relations.

The `INVOLVED` relation links a 2oes with a 1oe or 3oe referring to a concept *incorporated* within

⁶ A similar distinction is also made within the SIMPLE EC project (LE-8346), whose goal is adding semantic information to the set of harmonized lexicons built within the PAROLE project for twelve European languages. Of course, the sub-classification of antonymy can also be used for nouns and verbs.

⁷ Furthermore, these relations being encoded between an adjectival synset and a nominal or verbal one are also useful to distinguish adjective classes as described by Dixon (1991), and reported in Sanfilippo et al. (1999). Indeed, such classes are often indicated by the nouns linked to adjectives.

the meaning of the 2oe⁸. Examples for adjectives are given in the following:

filoso (= pieno di fili) (thready, filamentous)
 HAS_HYPERONYM pieno (full)
 INVOLVED filo (thread)

imberbe (= privo di barba) (beardless)
 HAS_HYPERONYM privo (lacking)
 INVOLVED barba (beard).

Another relation which can be encoded is the CAUSE relation:

depuratorio (= atto a depurare) (depurative, purifying)
 HAS_HYPERONYM atto, adatto (suitable for)
 CAUSES *non-factive*⁹ depurare (to purify)

compensativo (= che serve a compensare) (compensatory)
 HAS_HYPERONYM atto, adatto (suitable for)
 CAUSES *non-factive* compensare (to compensate)

A new relation, not present either in WN or in EWN, will be encoded for a class of adjectives indicating the possibility of some events occurring:

giudicabile (= che può essere giudicato) (triable)
 LIABLE_TO giudicare (to judge)

inaccostabile, inavvicinabile (= che non può essere avvicinato) (which cannot be approached)
 LIABLE_TO avvicinare, accostare (to approach) *negative*.

⁸ E.g., *to lapidate* has as INVOLVED_INSTRUMENT *stone*; *to work* has as INVOLVED_AGENT *worker* (see Alonge et al. 1998).

⁹ As said above, in EWN various features were encoded to make implications of relations explicit: *conjunction* and *disjunction* (for multiple relations of the same kind encoded for a synset); *non-factivity* (to indicate that a causal relation does not necessarily apply); *intention* (added to a cause relation to indicate intention to cause a certain result); *negation* (to explicitly encode the impossibility of a relation occurring). These features are also used in IWN.

The table below gives an overview of the main relations being encoded for adjectives in IWN (for the other relations being encoded for adjectives see Alonge et al., in prep.):

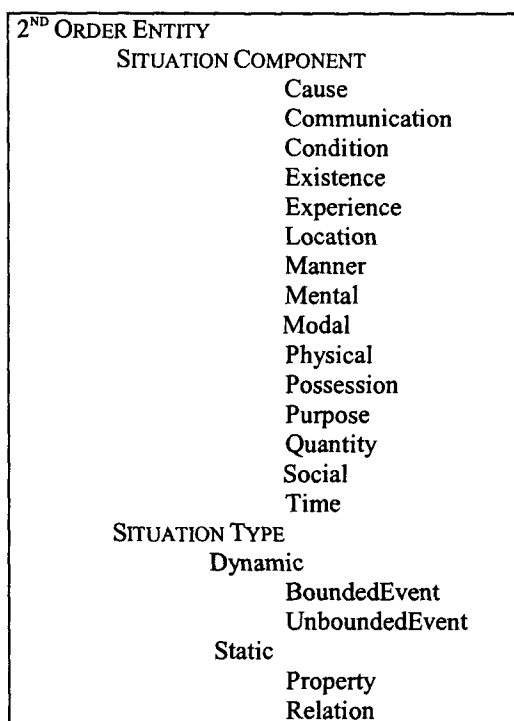
Relation	PoS linked	Example
ANTONYMY	adj/adj	happy/unhappy
GRAD_ ANTONYMY	adj/adj	beautiful/ugly
COMP_ ANTONYMY	adj/adj	alive/dead
HYPONYMY	adj/adj	watery/containing
PERTAINS_TO	adj/noun	chemical/chemistry
IS_A_VALUE_OF	adj/noun	tall/stature
INVOLVED	adj/noun	dental/tooth
CAUSE	adj/verb; adj/noun	depurative/ to depurate
LIABLE_TO	adj/verb; adj/noun	triable/to judge

3 The IWN Top Ontology

In the EWN TO all the entities belonging to the 2nd order have been organized into two different classification schemes, which represent the first division below 2nd Order Entity:

- *Situation Type*: the event-structure or *Aktionsart* (or lexical aspect) of a situation;
- *Situation Components*: the most salient semantic components that characterize situations.

The Situation Types provide a classification of 2oes in terms of the event-structure (or *Aktionsart*) of the situation they refer to: a basic distinction was drawn between *Static* and *Dynamic*. The Situation Components represent a more conceptual and intuitive classification of word meanings because they can be viewed like the most salient semantic components of a concept. Examples of Situation Components are: *Manner*, *Existence*, *Communication*, *Cause*. Situation Type represents disjoint features that cannot be combined, whereas it is possible to assign any combination of Situation Components to a word meaning. Here below the Top Concepts identified for 2oes are shown:



In order to be able to draw generalizations on adjective meanings by using the TO, we partially modified this scheme. First of all, we moved the PROPERTY and RELATION nodes under the SITUATION COMPONENT node. This was done for two interconnected reasons: first of all, because this distinction is not directly linked to *Aktionsart* (lexical aspect), while the distinctions under SITUATION TYPE are *Aktionsart* distinctions, i.e. they are connected with the “the procedural characteristics (i.e. the ‘phasal structure’, ‘time extension’ and ‘manner of development’) ascribed to any given situation referred to by a verb phrase” (Bache 1982: 70)¹⁰. Secondly, adjectives may refer to PROPERTIES or RELATIONS, but they may be either stative or not (cfr. e.g. Lakoff 1966; Quirk et al. 1985; Peters et al. 1999). Thus, in our system it has to be possible to specify that an adjective expresses a PROPERTY while being DYNAMIC. In any case, since many adjectives may have both a DYNAMIC sense and a STATIC one, we have also the possibility to under-specify this information

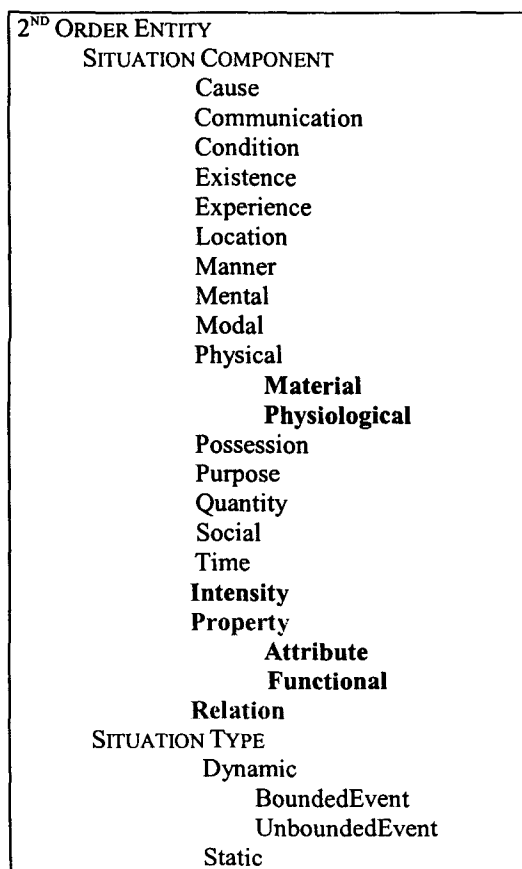
¹⁰ Of course, in EWN all 2oes (and therefore also nouns or adjectives) can be classified according to their *Aktionsart*.

by linking adjectives directly to the SITUATION TYPE node.

Adjectives may indicate many different types of properties: temporal (*passeggiata mattutina* - morning walk), psychological (*canzone triste* - sad song), social (*uomo ricco* - rich man), physical (*superficie legnosa* - wooden surface), physiological (*bambino magro* - thin child), perceptive (*minestra calda* - hot soup), quantitative (*magra ricompensa* - poor reward) and intensity properties (*vino forte* - strong wine). In the EWN TO there are already nodes which may be used to represent these distinctions (TIME, MENTAL, SOCIAL, PHYSICAL, QUANTITY) but we needed to better specify or also add some features. For example, we have added, under the already present node PHYSICAL, the node MATERIAL, to represent, among others, some Italian adjectives ending in *-oso* (for example *legnoso* - wooden, *acquoso* - watery) which indicate the property of containing a certain material. Moreover, we added the node PHYSIOLOGICAL (to classify adjectives corresponding to *tired, hungry, sick, etc.*) under PHYSICAL. For adjectives denoting an intensity, we then added the node INTENSITY directly under the SITUATION COMPONENT node. One of the main problem we had was that no Top Concept in the EWN TO could be used to classify the reference-modifying adjectives (cf. above). These are a very particular kind of adjectives, because they do not indicate a property of the referent of the noun they modify. So, aiming at showing the distinction between referent-modifiers and reference-modifiers, we created two new Top Concepts under the node PROPERTY: ATTRIBUTE and FUNCTIONAL, where the latter can be used for reference-modifying adjectives (according to the definition provided by Chierchia & McConnel-Ginet 1990 for the category referred to by these adjectives: “*a function from properties to properties*”).

Like all descriptive adjectives, also the reference-modifiers classified under the node FUNCTIONAL can be linked to other SITUATION COMPONENTS. Functional adjectives for which the temporal aspect prevails (*ex* - former, *presente* - present) can be classified under the node TIME; adjectives referring to some ‘epistemological’ property (*potenziale* - potential, *necessario* - necessary) can be linked

to MODAL¹¹; etc. A particular case of functional adjectives are the ‘argumental’ ones. They introduce a comparison between different entities (e.g., *simile* - similar, *diverso* - different, etc.). A comparison presupposes a relation between different entities so these adjectives can be linked to both PROPERTY and RELATION. Since in the EWN TO these two Top Concepts were two different kinds of SITUATION TYPE, they were mutually exclusive; now, in the IWN revised TO they can be conjoined. Here below the IWN Top Concepts for 2nd Order Entities are shown:



Concluding remarks

Although the ANTONYMY, PERTAINS_TO, and IS_ATTRIBUTE_OF relations, already encoded in the Princeton WN, are fundamental relations to describe the adjective semantics, and they can be

¹¹ Since this node is used for situations involving the possibility or likelihood of other situations.

useful for computational applications which exploit our resource, we believe that the ‘new’ relations being encoded may provide equally relevant information, especially because many adjectives cannot be defined by means of the WN relations. Let’s take into consideration just a few examples.

The adjective *depresso* is ambiguous in that it has (at least) three readings:

- 1) which has been lowered, flattened (said of a land);
- 2) being in bad physical or moral conditions (said of an area, a country);
- 3) affected by depression (said of a person).

For these three senses of the adjective we would encode different relations, extractable from our sources:

- depresso₁ IS_CAUSED_BY deprimere (to lower)
IS_A_VALUE_OF terreno (land)
- depresso₂ HAS_HYPERONYM colpito (affected)
IS_CAUSED_BY depressione₁
(depression - economic sense)
- depresso₃ HAS_HYPERONYM affetto
(affected, suffering from sthg.)
IS_CAUSED_BY depressione₂
(depression - medical sense)

The relations encoded could, e.g., help disambiguate the occurrences of the adjective in contexts such as: *Gianni era depresso* (Gianni was depressed) or *Quella regione è depressa* (That area is depressed). Indeed, by checking the semantic information encoded for the two senses of *depressione* linked to *depresso*, it’s possible to provide the right interpretation for the sentences under analysis; on the other hand, the first sense of the adjective would be excluded because of the IS_A_VALUE_OF relation encoded. In this case, also the TO links could be helpful: actually, *depresso₂* would be linked to SOCIAL and CONDITION, while *depresso₃* would be linked to MENTAL and EXPERIENCE.

Many adjectives found in our sources do not seem to have (lexicalized) antonyms, nor cannot be defined by using the PERTAINS_TO or IS_A_VALUE_OF relations. These are often linked to nouns or verbs, by various relations:

piumato = coperto di piume (plumed = covered with plumage)

HAS_HYPERONYM	coperto
INVOLVED	piuma

distillabile = che può essere distillato (distillable = which can be distilled)

LIABLE_TO	distillare.
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For these and many other adjectives the ‘new’ relations identified in IWN are necessary, given that we often cannot encode other relations for them. The relations encoded provide fundamental semantic information on them, which can, for instance, be used to infer semantic preferences (e.g., only certain loes can be modified by *piumato*, etc.). The inclusion of this information in a large database which is mainly intended for computational applications can be very useful, mainly because it may help in resolving ambiguities and may be used to draw inferences of different nature.

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