On Hidden Semantic Relations between Nouns in WordNet

Tsvetana Dimitrova, Valentina Stefanova
Institute for Bulgarian Language "Prof. Lyubomir Andreychin",
Bulgarian Academy of Sciences
52 Shipchenski Prohod Blvd., bldg. 17
cvetana,valentina@dcl.bas.bg

Abstract

The paper presents an effort on transferability of noun – verb and noun – adjective derivative and semantic relations to noun – noun relations. The approach relies on information from semantic classes and existing inter-POS derivative and (morpho)semantic relations between noun and verb, and noun and adjective synsets. We have added semantic relations between nouns in WordNet that are indirectly linked via verbs and adjectives. Observations on the combination between the relations and semantic classes of nouns they link, may facilitate further efforts in assigning semantic properties to nouns pointing to their abilities to participate in predicate-argument structures.

1 Introduction

The present work aims at revealing hidden (indirect) semantic relations between nouns in WordNet by using information that is already available from the inter-POS derivative and (morpho)semantic relations between noun – verb, and noun – adjective synsets, and the semantic class of lexical concepts expressed by the members of a noun–noun pair.

The main relation among words in WordNet is synonymy (or near-synonymy; synonyms are defined as words which denote the same concept and are interchangeable in many (but not all) contexts). The synonyms (called ’literals’) are grouped into unordered sets (synsets) which are linked via the so-called ’conceptual relations’. Most relations between synsets connect words of the same part-of-speech (POS). Noun synsets are linked via hypernymy / hyponymy (superordinate) relation, and meronymy (part-whole) relation. Verb synsets are arranged into hierarchies via hypernymy / hyponymy relation. Adjectives are organised in terms of antonymy and similarity, and relational adjectives (pertainyms) are linked to the nouns they are derived from. Adverbs are linked to each other via similarity and antonymy relations.

Thus, WordNet consists of four sub-nets, with few cross-POS relations – the so-called ’(morpho)semantic’ relations between semantically similar words that share a stem with the same meaning (e.g., writer is an Agent of write, see (Fellbaum et al., 2009)); pertainym relations: noun – adjective (e.g., pope – papal); adjective – adverb (e.g., bad – badly); derivative relations: noun – verb (e.g., write – writer); adjective – verb (e.g., writing – write); noun – adjective (e.g., pope – papal).

Lexical concepts expressed by the synsets are further semantically classified by assigning the so-called ’semantic primitives’ (or ’semantic primes’ or ’semantic classes’) to each synset ((Fellbaum et al., 2009); (Miller et al., 1993)). Noun and verb synsets are subjected to elaborate semantic classifications – nouns are organised into 25 semantic classes such as noun.person, noun.animal, noun.plant, noun.process, noun.act, noun.location, etc., and verbs – into 15 classes – verb.stative, verb.communication, verb.cognition, verb.perception, etc. Only three labels are applied to the adjective synsets – adj.all (mainly) for descriptive adjectives, adj.pert for pertainyms, and adj.ppl for adjectival participles, but there are efforts on more detailed classifications of adjectives in wordnets for other languages (the...
WordNet for German (GermaNet), see (Hamp and Feldeg, 1997); WordNet for Russian (RussNet), see (Azarova and Sinopalnikova, 2004); the Polish WordNet (plWordNet), see (Maziarz et al., 1997); and the Bulgarian wordnet (BulNet), see (Stefanova and Dimitrova, 2017), (Dimitrova and Stefanova, 2018).

2 Nouns in WordNet

Nouns in WordNet are organised within the superordinate / subordinate (hyponymy / hyponym) hierarchy. The hierarchical semantic organisation is limited in depth, and distinguishing features are added to create lexical inheritance system where each word inherits the distinguishing features (attributes (modification), parts (meronymy), functions (predication) from its superordinates ((Miller 1990, 1990)). An example would be {diarist:1} [10011486-n] which, as a hyponym of {writer:2} [10801291-n], is classified as noun.person and could be an Agent of the verb synsets {write:1} [00993014-v], {write:3} [01007027-v], write:4 [01031966-v], and {write:5} [01691057-v] just like its hyponym.

Nouns are further related to verb synsets via derivative and/or (morpho)semantic relations – (morpho)semantic relations are applied to derivationally related noun – verb pairs, but not vice versa – not every derivationally related pair is (morpho)semantically linked, and to adjectives – via derivative and pertainym relations (pertainym relations are usually applied to adj.pert adjectives, and nouns and adjectives are derivationally linked but not every derivationally linked pair noun – adjective is in pertainym relation).

Some nouns linked via a verb have an explicit link through hyponym/hyponym relation: (1) they can be two hyponyms of the same hypernym, e.g., the nouns {exhibition:1} [eng-30-00522145-n] and {exposure:3} [eng-30-00522537-n] are derivationally linked via the verb {expose:9; exhibit:3} [eng-30-02140033-v], and are co-hyponyms of the noun synset {presentation:1; demonstration:1} [eng-30-00521562-n]; (2) One can be a hyponym of the other, as with {relish:2; flavour:2} [eng-30-05715864-n] which is a hyponym of {taste:9; taste sensation:1; taste perception:1} [eng-30-05715283-n], and the two are derivationally and morphosemantically (as Event) related to {taste:6; savor:4; savour:4} [eng-30-02194286-v].

In the next section 2., we will discuss the relations between these nouns by taking into account the semantic class of the nouns and the 'linking verb', and the (morpho)semantic relations between the two (if available).

3 Nouns linked via verb synsets

In WordNet, verb and noun synsets are related via derivative and (morpho)semantic relations that link semantically similar verbs and nouns that share a stem with the same meaning. Verbs impose selectional restrictions on the entities selected for their argument positions, particularly on characteristics of the nouns taking specific semantic roles. For example, the Agent of cognitive verbs is expected to be animate and human (but not animal) while that of consumption verbs is animate but can be both human and animal. Selectional restrictions also apply to complements – for example, motion verbs may have as their Instrument nouns referring to vehicles and artifacts while their Location or Direction complement can be location, object or artifact.

Previous studies have further differentiated nouns which are linked via (morpho)semantic relations to different verb classes. (Paiva et al., 2014) and (Real and Rademaker, 2015) offer extension of the classification of deverbal nominals in Portuguese drawing upon work on Portuguese nominalisations (Real, 2014) where eight possible classes of eventive nominalisation have been proposed: action of, result of, physical result of, iteration of the act of, resulting state from, abstract result of, locative, collectivisation of.

In previous work on the Bulgarian wordnet, (morpho)semantic relations Agent and Undergoer were subdivided by taking into account the information about: verb and noun semantic classes, sentence frames encoding predicate-argument structure of the simple sentences that verbs can form, and noun suffixes, to formulate additional (morpho)semantic relations, such as Experiencer, Actor, Recipient ((Dimitrova, 2018)), (Leseva et al., 2018) have proposed subcategorisation...
of nouns by taking into account information from WordNet, VerbNet, and FrameNet, which resulted in formulating subcategories such as: Agent_communicator, Agent_effector, Agent_experiencer, Agent_undergoer, Artifact_undergoer, etc.

Our proposal on introducing noun–noun semantic relations is based on the assumption that selectional restrictions are imposed not only by verbs but also by nouns derived from verbs such as nominalisations (e.g., writing), agentive nouns (e.g., writer), resultative nouns (e.g., written), etc. They are related to the source verb (e.g., write) not only via (morpho)semantic but also via derivative relations. We additionally take into account the relations between the semantic classes of the nouns linked through derivative relations via verb synsets.

Some – but not all – derivationally linked nouns are linked also via (morpho)semantic relations, as in (1) where \{writing:2\} and \{writer:1\} are Event and Agent, respectively, of \{write:7\}. Other derivationally related nouns, however, such as \{pen:3\} below, are only derivationally (but not (morpho)semantically) linked:

Ex.

\{write:7; compose:3; pen:1\} [01698271-v] verb.creation 'produce a literary work'

\has_Event: \{writing:2; authorship:2; penning:1\} [00929718-n] noun.act

\has_Agent: \{writer:1; author:3\} [10794014-n] noun.person

\derivative: \{pen:3\} [03906997-n] noun.artifact

We assume that in many cases, the (morpho)semantic relations between the nouns may reflect the (morpho)semantic relations between the respective nouns and the verb, i.e., \{writing:2\} is an event nominal which has an Agent \{writer:1\}. This assumption, however sketchy, can be tentatively extended to other derivationally related nouns; thus, we can add a semantic relation Instrument to \{pen:3\}, which can be additionally related as an Instrument for \{writing:2; penning:1\} and an Instrument of \{writer:1\}:

Ex.

\{writing:2; authorship:2; penning:1\} noun.act

\has_Agent: \{writer:1; author:3\} noun.person

\has_Instrument: \{pen:3\} noun.artifact

\{writer:1; author:3\} noun.person

\has_Instrument: \{pen:3\} noun.artifact

Some noun synsets have been already linked via hypernym/hyponym relations, f.ex. \{squandering:1\} is_hyponym_of \{waste:5; wastefulness:1\}, and \{wastrel:1; waster:2\} is_hyponym_of \{prodigal:2; profligate:3; squanderer:1\}, and all of them are linked to the verb \{consume:4; squander:1; waste:6\}. Thus, the relation between them is overtly exposed though it can be categorised further.

In the following section, we propose a set of semantic relations that can be applied to the noun–noun pairs\(^4\).

3.1 Noun–noun relations through verbs

As already stated, noun synsets that are derivationally related to a verb synset, can be linked through semantic relations that mirror (or are inherited from) the (morpho)semantic relations between noun and verb synsets on the basis of the assumption that a deverbal noun may inherit the argument structure of the source verb. Some noun–verb relations in WordNet are derivative only, but (morpho)semantic ones can be additionally formulated (see Stoyanova et al., 2013).

Nouns of all semantic classes can be derivationally related to verbs, as in: cook: cooking (noun.act) is done by using a cooker (noun.artifact) as an Instrument by a cook (noun.person) as an Agent; toast: toasting (noun.act) is done by using a toaster (noun.artifact) as an Instrument to produce a toast (noun.food) as a Result. Further, a cook (noun.person) uses a cooker (noun.artifact) as an Instrument for cooking (noun.act); a toaster (noun.artifact) produces a toast (noun.food) as a Result when toasting (noun.act); etc. We have formulated a number of noun–noun relations, some of which such as Agent, Instrument, Result, Property, Location, mirror or are inherited from noun–verb (morpho)semantic relations; in some cases the type of relation was changed (Event can become Result) or additionally specified as with Resulting_State. There are also newly formulated relations such as Actor, Causator, Patient, Possessor, Experiencer, Cause, Time, etc. Relations are inverse, asymmetric and intransitive, e.g., is_Agent_of / has_Agent; is_Subevent_of / has_Subevent, etc.

The new relations assigned to nouns, may allow us to further assign semantic subclasses (re-

\(^4\)The set is to be extended further but for now we cover only the main relations.
fecting their properties) to the nouns at hand. Thus, if a noun classified as noun.person is related via Experiencer relation, we may assume that it lacks properties like agentity and control. Moreover, these properties would restrict the noun’s properties that enable its participation in certain predicate-argument structures (if a noun is classified as noun.object or noun.artifact and is linked to other noun(s) via a Location relation, we may assume that it may also participate in Location relations with other verbs selecting a Location relation.

3.1.1 Noun – noun relations: an overview

We have manually assigned the semantic relations to 2,303 noun – noun pairs.

Persons

A noun labeled as noun.person can express a variety of relations to verbs and deverbal nouns such as Agent, Causator, Experiencer, Recipient, etc. Other semantic classes here are noun.group and noun.animal.

The Agent relation (513) is inherited from noun – verb relations and links nouns mostly classified as noun.person related via verbs of semantic classes such as verb.creation, verb.motion, verb.change, verb.competition. Nouns classified as noun.person have conscious and active referents, while the other noun in the pair refers to explicitly active predicates such as noun.act, noun.event, noun.process, noun.communication.

Ex.: {etcher:1} [10064977-n] is_Agent_of {etching:1} [09938791-n].

The Actor relation (174) links a noun which cannot be considered an active participant in the situation but refers to an entity who has abilities to perform the action referred to by the other noun (noun.animals linked to verbs via Agent relation are marked as Actors). Ex.: {inhabitant:1} [09620078-n] is_Actor_of {inhabitation:1} [01054545-n].

In the Causator relation (34), the other noun refers to a resultative phenomenon such as noun.event, noun.phenomenon, noun.motive, etc.

Ex.: {bell ringer:3; ringer:4} [10714851-n] is_Causator_of {ring:12; ringing:3} [07391863-n].

Three relations are labeled according to a semantic role differentiated on the basis of the verb class, (morpho)semantic relations and the class of the other noun in a pair. The Experiencer relation (98) holds between a noun.person and a noun classified mostly as noun.seeing or noun.state via verb.emotion, verb.perception, verb.body.

Ex.: {lover:1} [09622302-n] is_Experiencer_of {love:8} [07543288-n]

Nouns that are linked via Patient relation (85) are related to the verb via an Undergoer relation and can be noun.person or noun.animal, and the other noun in the pair is noun.seeing, noun.possession, noun.cognition, etc.

Ex.: {beloved:2; love:9} [09849598-n] is_Patient_of {love:8} [07543288-n].

The Recipient relation (17) holds between a noun related to the verb via an Agent relation, and a noun labeled as noun.food, noun.competition, noun.possession, noun.communication, noun.artifact, etc., as in: {luncher:1} [10277132-n] is_Recipient_of {lunch:3; luncheon:1} [07575076-n].

The Possessor relation (17) involves a noun labeled noun.attribute, and more rarely a noun.possession, as in: {economiser:1} [10044470-n] is_Possessor_of {economy:2} [05644727-n].

In a previous effort (Dimitrova, 2018), (morpho)semantic relations Agent and Undergoer were subdivided to formulate additional (morpho)semantic relations between nouns and verbs such as Experiencer, Actor, Recipient to be applied to the Bulgarian wordnet. Inthere, the relation Experiencer surpasses the relation Agent with two verb classes – verb.perception and verb.emotion. However, observations on the data about noun – noun relations show that if a noun.person is related to noun.seeing and noun.state, it is most likely to be Experiencer (53) or Causator (21) especially if linked via verb.emotion and verb.body. If a noun.person is linked to noun.state, it can be also Patient, Possessor, and Actor (e.g., {suspect:6} [10681383-n] is_Patient_of {suspicion:4} [13982839-n].

The Agent relation, however, still holds between noun.person and noun.act disregarding the class of the verb: a noun.person which is linked to a noun.act via verb.cognition is most likely to be Agent as referring to a person in professional function.

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5 For the resource, see: https://dlcl.bas.bg/semantichnimrezhi/, with any further additions and changes.

6 Due to space limitation, only the total number of relations added is given in brackets here.
A noun labeled as *noun.person* is most likely a *Possessor* or a *Recipient* in relation to *noun.possession* (esp. when linked via *verb.possession*).

Thus, one may assume that if a *noun.person* is related to other nouns of classes such as *noun.feeling* and *noun.state* via Experiencer relation, it may lack properties such as agentivity and control (a sleeper may snore (just like a snorer) but cannot read or drive a car).

In addition, there are nouns classified as *noun.group* which are linked via *Agent* or *Patient* relation, as in: {mover:1; moving company:1} [08478482-n] is *Agent_of* {move:16} [01850315-v]. Here, we may assume that the group and/or its members have properties characteristic of a person.

**Artifacts**

A *noun.artifact* refers to non-animate nouns and is linked with *Instrument* (166) relation to nouns of all other classes but mostly predicative ones, as in:

Ex.: {printer:2} [-04004767-n] is *Instrument_of* {printing:4; printing process:1} [06677302-n] {machine:1; mechanic:3} [10279018-n] has *Instrument* {machine:4} [03699975-n]

The *noun.instrument* is usually linked to the verb synset via *Instrument* or *Means* (morpho)semantic relations.

*noun.artifact* can also be Result of a *noun.act*, as in:

excavation:3 [03302121-n] is *Result_of* excavation:2; digging:1 [00941974-n]

Another relation that can link a *noun.artifact* and a *noun.act* is Theme (306) as in:

{piece:9} [03932203-n] is *Theme_of* {patching:1} [00267349-n]

The *Theme* relation often links non-animate nouns related to the verb via an *Undergoer* relation (and *Uses*) which was subdivided into *Theme* and *Patient* depending on the characteristics of the noun’s referent (a non-animate noun such as *noun.food*, *noun.plant*, etc. would be *Theme*, while animate and human nouns would be *Patient*), as in:

Ex.: {draft:12; tipple:2} [07883980-n] is *Theme_of* {tippler:1; social drinker:1} [10712690-n]

{plant:1; flora:1} [00017222-n] is *Theme_of* {planting:1} [00919513-n]

Most noun – noun pairs linked via *Instrument* relation contain a noun classified as *noun.artifact* – these nouns are related to verbs via *Instrument* and *Vehicle* (morpho)semantic relations. Nouns classified as *noun.substance* are linked to verbs via *Material* and *Uses* relations. In these cases, a *noun.substance* refers to a man-made entity.

If a noun is classified as *noun.object* and is linked to *noun.act*, *noun.event* or *noun.state*, it may be Theme (21) and Result (25) but also Location (11) and Uses (9); if it is linked to *noun.act* and *noun.state* via the same verb, it is Result of *noun.act* and Theme of *noun.state*.

One may also assume that *noun.artifact* can be argument of various predicates (a cooker can be an Instrument of cooking (but also, indirectly, of frying or boiling) but also a Location of putting, or a Theme of repair, or a Result of producing, etc.).

**Events**

A noun – noun relation that is mostly inherited from the noun – verb relation is Result (219) which holds between a noun labeled as *noun.artifact*, *noun.food*, *noun.object*, etc. (linked to the verb synset via the (morpho)semantic relation Result) and a *noun.act*.

Ex.: {toast:3} [07686873-n] is *Result_of* {toasting:1} [00246552-n]

The subcategorised relation Resulting state (89) holds between a noun classified as *noun.state* or *noun.feeling* and nouns of various classes such as *noun.state*, *noun.feeling*, *noun.event* via *verb.perception*, *verb.emotion*, *verb.change*, *verb.body* classes.

Ex.: {disturbance:7; upset:17} [14403282-n] is *Resulting_state_of* {upset:4} [00554850-n]

The type of the relation can be changed, as in: {snap:23} [07394236-n] is *Result_of* {snap:4} [00344699-n] (the noun – verb relation was *Event*).

A new relation that encodes the relation between two predicative nouns is Subevent (144) – it mostly holds between a noun referring to the act as such and a noun which may refer to the beginning, the end or any moment in-between the starting and ending point. This relation often holds between *noun.act* and *noun.event*, with the former referring to an event within the act, and between *noun.process* and *noun.act* assuming that a process consists of a series of acts. An example here is: {start:20} [07325190-n] is *Subevent_of* {beginning:1; start:1} [00235435-n]. The as-
sumption that the lexical inheritance condition is valid here, would mean that any Subevent may have Agent or Instrument of the main event, e.g., if \{ barrage:2; bombardment:3\} [00987863-n] has_Agent blaster:1; chargeman:1 [09859557-n], and has_Instrument \{ shell:12\} [04190464-n], its Subevent blast:15 [07408171-n] would inherit these relations, and any of the verbal predicates related to the verb \{ blast:6; shell:4\} [01135922-v] such as its hyponym \{ crump:2\} [01136393-v] and its hypernym \{ bombard:3; bomb:1\} [01113902-v], may select for arguments the nouns at hand (i.e., the person blaster as an Agent, the artifact shell as an Instrument, and the event blast as a Subevent).

Others
The relation Location (121) links nouns classified as noun.location, noun.object, and noun.artifact with noun.process, noun.act, noun.state via verb.stative, verb.motion, verb.body through Location and Event (morpho)semantic relations: \{ hatchery:1\} [08581299-n] is_Location_for \{ hatch:8; hatching:2\} [13491464-n]
Nouns labeled noun.object or noun.artifact can be linked not only to verbs but to other noun(s) via Location relation prompting an assumption that the noun classified as noun.artifact may also participate in Location relations with other verbs selecting a Location relation (a person can be hospitalised in a hospital as a Location but can also live or dance (however unusual it may seem) in a hospital as a Location).

The relation Uses (176) holds between nouns that refer to all non-human and non-predicative referents such as noun.substance, noun.artifact, including noun.animal, as in: \{ hawk:1\} [10076604-n] Uses \{ hawk:3\} [01605630-n]
The relation Cause (63) holds between a noun.phenomenon or noun.motive and a noun.act, noun.process, noun.event, etc., as in: \{ soaker:2\} [11502102-n] Causes \{ drenching:1; soaking:2\} [00277811-n]
The relation Property (52) links a noun classified as noun.attribute to a noun of any other class, as in: \{ invalid:5; shut-in:3\} [10214230-n] has_Property \{ disability:1; disablement:1\} [14548343-n], and this property may be characteristic of many other nouns of the same class (a chief executive can has a disability).
The relation Time (29) holds between a noun.time and a noun.act, noun.process, etc., as in: \{ period of play:1; play:52\} [15256915-n] is_Time_for \{ playing:1\} [00041188-n].

### 3.2 Case study

Here, we offer some observations on co-occurrence between the classes of nouns in a pair. We have manually assigned relations on noun – noun pairs linked via verb.perception, verb.competition, and verb.consumption. In Table 1, we give figures on noun.persons.

| noun.person | are often Agents with noun.act, verb.perception |
|-------------|-----------------------------------------------|
| person      | act                                          |
|             | Agent [29], Actor [7], Experiencer [1]       |
| person      | quantity                                     |
|             | Agent [1]                                    |
| person      | cognition                                    |
|             | Experiencer [1]                              |
| person      | feeling                                      |
|             | Experiencer [2], Actor [2]                   |

Table 1: Noun.person linked via verb.perception, verb.competition, and verb.consumption.

and Experiencers with noun.feeling and noun.state, and they Uses (incl. as Instruments) noun.artifacts. Further, with verb.perception and verb.competition, noun.event is Subevent and Result of noun.act, while noun.act is Subevent of noun.process. With verb.consumption, noun.events (4) are much rarer.

Nouns labeled noun.food and noun.artifact are often Themes of noun.act when the two are linked via verb.consumption.
The Location relation links nouns classified as noun.location and noun.artifact with noun.act. (The (morpho)semantic relation Location is rarely found with the three verb classes.)

The observations on noun – noun relations may help us formulate some principles behind combinations between a semantic relation, a verb synset of a particular semantic class, and a set of noun synsets from other classes that are indirectly linked though a verb via derivative and morphosemantic relations. If we assume that the nouns linked to verbs are arguments to a predicate, the features associated with a particular concept in argument position, can be inferred also by observing other nouns linked to the same verb.

4 Nouns linked via adjective synsets

An adjective denotes a property that is permanently inherent for an entity it modifies or refers to and is attributed to it in its entirety. Therefore, an adjective can be defined as part-of-speech whose denotative function is realised through its connection to the noun. Adjectives and nouns in WordNet are linked to each other mostly via derivative relations. Descriptive adjectives (adj.all) are organised into clusters based on similarity of meaning (synonymy) and binary opposition (antonymy). Relational adjectives (adj.pert) are (derivationally) related and linked to the synset which contains their source noun (as a literal). Adjectival participles (adj.ppl) are related via participle relation to verbs they are derived from. Thus, adjectives are organised via a set of relations that encode their properties of attribution, antonymy, similarity, derivation; fuzzynymy and thematic category (in the EuroWordNet (Vossen, 2002).

However, from a derivational point of view, the distinction between descriptive and relational adjectives can be somewhat fuzzy, as descriptive adjectives can be also derived from nouns and refer to an attribute property of the defined entity (expressed by the noun). The property qualifies and characterises the entity expressed by the noun from which they are derived (e.g., pitiful - pity, etc.). Hence, an adjective may express one-sided relationship with the entity denoted by the motivating noun, though adjectives, which are derived from a noun, are motivated by it. In WordNet, an explicit noun – adjective relation with relational adjective (adj.pert) is certainnymy – an antisymmetric (derivative) relation between a relative adjective and the noun from which it is derived. The basic meaning of the relational adjective is determined by the noun from which it is derived, and these adjectives may inherit relations from the noun (Koeva, 2014). Some descriptive adjectives in WordNet may not be linked via certainnymy relation but can be derivationally related to a source noun.

We have extracted noun synsets which are indirectly linked via adjectives – a noun is derivationally related to an adjective which, in its turn, is related via similarity relation to another adjective which is related to another noun. We applied the following scheme of extracted nouns:

Noun derivative Adjective similar_to Adjective derivative Noun.

An example is given below where a noun – noun relation is assumed between \{north wind:1; northerly:4; norther:1\} and \{north:3\}.

Ex.
\{north wind:1; norther:1\} [11487950-n]

noun.phenomenon
derivative: {northerly:2; northern:1}
[01601069-a]
similar_to: {north:2}

has_attribute: {north:3} 08561081-n
noun.location

\{north wind:1; norther:1\} is_Related_to {north:3}

Some of these noun – noun pairs contain literals that are derivationally related (literals have the same root of at least one of the literals in the synset) though the synsets are not explicitly related via derivative relation; with others, only the adjectives are derivationally linked. We have identified only 31 noun – noun pairs that have at least one literal that is derivationally related, as in the example below.

Ex.
\{salinity:1\} [04993604-n]
noun.attribute
derivative: {saline:1} [01074458-a]
similar_to: {salty:1} [01073822-a]
derivative: {salt:7; table salt:1}
[07813107-n] noun.food

We have attempted to explore the dependence between the semantic classes of the nouns that are indirectly related via adjectives linked via similarity relation, to formulate noun – noun relations which were experimentally applied.
4.1 Noun – noun relations through adjectives

The majority of noun – noun pairs here contain literals that are not derivationally related – 1,193 pairs – but noun synsets are otherwise related through derivationally related adjectives, as exemplified below. Ex.:

\{ceremony:1\} [01026897-n] noun.act
derivative: \{ceremonial:1\} [01042491-a]
similar_to: \{formal:2\} [01049116-a]
has_attribute: \{formality:2; formality:1\} [04911420-n] noun.attribute

We have formulated four noun – noun semantic relations mostly drawing upon classes and definitions of the nouns. Here, we exemplify the co-occurrence of noun semantic classes that are most often found in our data. For a cleaner representation of dependencies between semantic classes of nouns we will present them in separate groups acc. to the formulated relations.

Result is a relation referring to a consequence of performing any action, process, event. Here, nouns classified as noun.act can express Result of noun.artifact\[3\]\[7\], noun.attribute [33], noun.cognition [4], noun.feeling [4], etc. For example, \{empiricism:2\} [00635699-n] noun.act, which is derivative of: \{empirical:1; empiric:1\} [00858917-a] – similar_to: \{experiential:1; existential:1\} [00859632-a], has non-explicit relation with \{experience:6\} [05758059-n] noun.cognition. Hence, we can link \{empiricism:2\} with the relation is_Result_of to \{experience:6\} and formulate dependence of the type: act Result cognition, which means that an action can be a Result or can lead to a certain result of knowledge.

Nouns labeled as noun.event can be Result of noun.attributes [11]. For example \{discharge:17; outpouring:3; run:49\} [07407777-n] noun.event is_Result_of \{fluidity:2; fluidness:2; runniness:1\} [04937043-n] noun.attribute.

Property is a relation that links nouns referring to concepts that are considered to be characteristic of another noun mostly classified as noun.attribute (but also noun.state, noun.feeling). Nouns labeled as noun.animal are characterised by properties classified as noun.attribute [9] which

\[\ldots\]are not obligatorily associated with the animal (body part). For example, \{scale:5\} \[01902877-n\] noun.animal has\_Property \{roughness:3\} or animal has\_Property of some attribute.

Nouns classified as noun.attribute are Properties of noun.act [13], noun.artifact [8], noun.cognition [31], noun.communication [7], noun.person [11], noun.state [33], noun.feeling [21]. For example, \{neurotic:3\} [10354898-n] noun.person has\_Property \{obsessiveness:1\} [04626062-n] noun.attribute.

Nouns classified as noun.body has property of nouns labeled as noun.attribute [12], noun.state [3]. So \{fuzz:1\} [05261894-n] noun.body has\_Property \{hairiness:1\} [04683453-n] noun.attribute

Noun.state is property of nouns classified as noun.feeling [3] and noun.person [14]. For example, \{subservience:2; subservientness:1\} [13952466-n] noun.state is\_Property_of \{slave:2\} [10609325-n] noun.person.

Nouns labeled as noun.plant [7], noun.quantity [4], noun.shape [11] have properties marked as noun.attribute like in the case of the example \{thorn:3; prickle:4\} [13089631-n] noun.plant has\_Property \{sharpness:3; keenness:1\} [04705324-n] noun.attribute

Nouns classified as noun.person is characterised by noun.attribute [37], noun.cognition [4] or noun.state [6], e.g.: \{teenager:1\} [09772029-n] noun.person has\_Property \{youngness:1\} [04928416-n] noun.attribute.

Part_of is a relation which links nouns referring to concepts as constituent elements of other concepts. This is a relation linking a noun referring to an event or entity which are associated with another event or entity. In this case Part_of is more often related to abstract nouns such as event and entity than to nouns having separate components as in the examples: ‘the finger is part of the hand’; ‘this piece is part of the pie’, where the meronymy relation is to be applied.

Nouns labeled as noun.communication can be Part of noun.cognition [4] or noun.attribute [30], as in: \{irony:3\} [07106246-n] noun.communication is\_Part_of \{incongruity:1; incongruousness:1\} [04714847-n] noun.attribute.

\[\ldots\]

\[\text{\footnotesize \[8\]Here. we give only noun – noun pairs due to limitation of space.}\]
Related is a general relationship that shows that there is connectivity between different objects, phenomena, dimensions but it is more of a free association relation that has not been properly defined yet.

Nouns of semantic class noun.cognition are related to noun.attribute [47], noun.person [4], noun.state [5]. For example {insightfulness:1} [05621808-n] noun.cognition is Related_to {perceptiveness:1} [04843875-n] noun.attribute.

Nouns labeled noun.feeling are related to nouns of classified as noun.attribute [8] or noun.state [9], as in: {un easiness:3} [07507329-n] noun.feeling is Related_to {discomfort:2} [14446652-n] noun.state.

Nouns classified as noun.food are related to nouns classified as noun.attribute [14], noun.substance [3], as in: {fizz:2} [07919310-n] noun.food is Related_to {bubb liness:1; frothiness:1} [04733347-n] noun.attribute.

Nouns labeled as noun.object are related to concepts classified as noun.attribute [10]: {reef:5} [09406793-n] noun.object is Related_to {shallowness:2} [05135725-n] noun.attribute noun.substance and noun.time are related to noun.attribute [25, 12] or noun.state [3, 2]: {vapor:2} [15055633-n] noun.substance is Related_to {cloudiness:3} [14524198-n] noun.state.

Considering the observed results, some dependencies have been formulated, which for the moment copy the information from the semantic classes of the related nouns:

act_Result_attribute [31];
attribute_Property_state [33];
attribute_Property_cognition [31];
attribute_Property_act [13];
attribute_Property_feeling [21];
body_Property_attribute [12];
state_Property_person [14];
shape_Property_attribute [11];
person_Property_attribute [37];
cognition_Related_attribute [47];
substance_Related_attribute [25];
time_Related_state [12].

To sum up, nouns, which refer to an attribute may be a result of a certain act, as well as a property of or related to a particular shape, person, physical body, cognition or substance. Further, they may have certain properties of state, cognition, act or feeling. Nouns for state are properties of a person, while nouns that indicate time may be related to a particular state. Some of these relations such as Property and Result can be traced back to noun – noun pairs linked via verbs, hence they may further deepen the lexical-semantic inter-relatedness.

5 Conclusion

The paper offers an approach to identification of semantic relations between nouns in WordNet that are indirectly linked via derivative relations through verbs and adjectives. In many cases, the derivationally related nouns preserve the semantics of the verb and the adjective, though there are some restrictions. We have formulated a basic set of semantic relations which mostly repeat the knowledge encoded on different levels of the network. Noun – noun relations also reflect certain restrictions on nouns that are related to verbs of certain classes. The new relations assigned to nouns, will not only increase the inter-relatedness and density of WordNet relations but would allow us to assign new semantic properties to nouns. The work will continue with extending both the number of related noun – noun pairs and the set of the semantic relations formulated.

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