Linking WordNet Verb Classes to Semantic Interpretation

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Abstract

An analysis that defines predicates for Wordnet verb classes and links them to semantic interpretation is presented. The selectional restrictions for the thematic roles defining the predicates are WordNet ontological categories. Thematic roles are also linked to the syntactic relations that realize them. The paper illustrates the methodology by providing a detailed analysis of some major WordNet verb classes.

1 Introduction

We present an analysis [1] of some WordNet verb classes (Miller et al., 1993; Fellbaum, 1993). Its purpose is to offer a detailed analysis of some verb classes so that the reader may grasp the main ideas guiding our methodology for constructing verb predicates using the WordNet lexicon. We plan to publish a complete listing of all our predicates and subpredicates for all WordNet verb classes, once they have been fully tested. In (Gomez, 1998), the reader can find a detailed description and evaluation of the semantic interpreter algorithm that uses the lexical entries defined here. This paper complements (Gomez, 1998) in which, for space reasons, only one predicate could be analyzed.

The hierarchical decomposition of predicates plays a central role in our methodology. A generic predicate subsumes all its subpredicates in a similar way in which the generic concept "book" subsumes all its subconcepts. A subpredicate inherits thematic roles and inferences from its super-predicate. From the point of view of the lexicographer, inheritance comes with an added bonus because it allows her/him to handle a large number of verbs by just defaulting their lexical entry to its super-predicate. In a subsequent analysis, the lexical entries can be refined by mapping some verbs which were just defaulted to a superpredicate into their own subpredicates. This top down approach and the WordNet lexicon makes possible to define predicates for every English verb in a "reasonable" amount of time. The mapping of WordNet verb classes into generic predicates has required to define new classes and to reclassify and/or redefine some WordNet classes and subclasses. The WordNet ontology for nouns also has been reorganized and redefined in some respects in order to conform with the entries in the thematic roles of the predicates. (See (Gomez, 1998) for some details.) Two major consequences derive from anchoring verb classes in abstract semantic predicates: coalescing several WordNet synsets into a predicate, and mapping the same WordNet synset into distinct predicates. The *differentia* between a generic predicate and its subpredicates are given by one or more of the following: a) specific selectional restrictions for the thematic roles, b) different syntactic realizations of the thematic roles, and c) specific sets of inferences associated with the subpredicates.

The semantic interpreter algorithm, which is an extension of the one reported in (Gomez et al., 1997), is based on the idea that the meaning of the verb depends not only on its selectional restrictions, but also on the syntactic relations that realize them. A similar view has been presented in (Pustejovsky, 1995). Semantic interpretation is delayed until the end of a clause. For every verb in a clause, WordNet provides a list of verb synsets for which we have defined predicates. These predicates are contenders for the meaning of the verb. For every syntactic relation in the clause, the interpreter checks each predicate in order to see if the predicate has a thematic role which is realized by the syntactic relation. The interpreter records this fact and gets the next syntactic relation. The predicate that realizes the most syntactic relations in the sentence is selected as the meaning of the verb. In case of ties, the predicate that has more thematic roles realized is selected.

2 The syntax of roles

The syntax of roles in the predicates that will be defined below is given by the cfg grammar on the next page. Each thematic role is followed by any number of list pairs. The first list contains the selectional restrictions, a subset of the ontological categories in WordNet, in order of preference (Wilks, 1975) for

[1] This paper contains some material published as report UCF-CS-TR-97-03 January-4-1997 with the same title.

the thematic role, and the second list contains the syntactic relations (henceforth, SRs) that may realize the thematic role. For any given sentence, only one of the SRs in the list realizes the role. An ontological category preceded by the sign "-" in a selectional restriction means that any noun sense that is subsumed by the semantic category preceded by "-" does not realize that thematic role.

```
S -> (ROLE L); ROLE -> agent|theme|..
L -> (SM) (SR) L| (SM) (SR)
SM -> ONTOLOGICAL-CAT SM|ONTOLOGICAL-CAT
SM -> -ONTOLOGICAL-CAT SM|-ONTOLOGICAL-CAT
SR -> SYNTACTIC-REL SR|SYNTACTIC-REL
SYNTACTIC-REL -> (prep PREP)|subj|
  |obj|obj2|subj-if-obj|subj-if-no-obj|
  |obj-if-obj2|predicate-complement|
  |complement-phrase|adjective-phrase
PREP -> ANY-PREP PREP| ANY-PREP
ONTOLOGICAL-CAT ->thing|physical-thing|...
ANY-PREP ->  on|in|....
```

The entry obj refers to the first postverbal NP, obj2 to the second postverbal NP. Subj-if-obj refers to the subject of a sentence that also has an object (the verb is used transitively), and subj-if-no-obj refers to the subject of a sentence containing no object (the verb is used intransitively). Obj-if-obj2 refers to the obj of a sentence having also an obj2 (the verb is used ditransitively). Thus, subj refers to the subject of a sentence without expressing any context about the transitivity or intransitivity of the verb.

3 Verbs in which the agent causes a change of location of something else

In (Gomez, 1998), we provide an analysis of verbs in which an animate agent changes location. We start explaining the predicate *cause-to-change-location* depicted on top of the next column. The primary event expressed by this predicate is a cause of change of location of something other than the agent; although the agent may have also changed location. In "Kelly carried the flowers to the table" and in "Kelly drove John to school," the agent has also been moved, but the primary event is the fact that Kelly causes a change of location of the flowers and John, respectively. The WordNet synset "move2, displace, make move - (cause to move)" is coalesced, in principle, into this predicate. But, also many of the subclasses of "move3, change position" are mapped into subpredicates of this predicate. (Physical-thing has been abbreviated to phy-thing in some entries for space reasons.) The *wn-map* entry means that all verb forms under the synset move2 are in principle coalesced into the concept *cause-to-change-location*. However, subpredicates of this predicate will be recognized as explained below. The category *human-agent* subsumes *human* and *social-group*. The role *inanimate-cause* stands for an agent that is not an animate being or an organization. The syntactic realization of this role is always a subj-if-obj. Because the *agent* of this predicate is also realized by subj-if-obj, and the ontological category *animal* and *human-agent* are subsumed by *physical-thing*, then in "Beth put the books on the table," both the *agent* and the *inanimate-cause* will match. The impasse is solved by preferring the *agent* over the *inanimate-cause*. The *theme* is realized by obj, and is also realized by a subj if the verb is used intransitively. Thus, for "The wind has knocked down many apples from the tree," "the wind" is the *inanimate-cause*, "many apples" is the *theme* and "from the tree" is the *source*. In "The leaves have moved," the "leaves" is the *theme*, and the *agent*, or *inanimate-cause* is unknown. In "The tractor has pulled the tree" "the tractor" is the *instrument*, and the *agent* is unknown. The different ways of expressing a path, namely *toward-goal*, *near-goal*, etc. have been collapsed here into *goal* for space reasons. Actually, there is one role for each preposition that expresses a different spatial relationship.

```
[cause-to-change-location(is-a (action))
(wn-map(move2))
(agent(human-agent animal)(subj-if-obj))
(theme(phy-thing) (obj subj-if-no-obj))
(source(location phy-thing) ((prep from)))
(goal(location phy-thing)((prep to towards
 toward in through into back-to along over
 beside above by on under below throughout
  beyond past across near up)))
(instrument(instrumentality animal-body-part)
          (subj-if-obj((prep with on in)))
          (animal) ((prep on)))
(distance(distance linear-measure)
                        ((prep for)))
(inanimate-cause(phenomenon physical-thing)
                        (subj-if-obj))]
```

The first subclasses of move2 analyzed by WordNet are the senses of "transport." The subclasses formed by the synsets "transport1 (move something or somebody around; usually over long distances)," "transport2, carry (move while supporting, either in a vehicle or in one's hands or on one's body)," "transport3, send, ship - (transport commercially)" and "transmit, transfer, conduct, transport5, channel, channelize" are mapped into subpredicates of the predicate *transport* which is:

```
[transport(is-a(cause-to-change-location))
(theme (physical-thing)(obj obj2))
(goal(human-agent animal)
           (obj-if-obj2 (prep for)))
     (location phy-thing)((prep to towards ...
           same as cause-to-change-location)))]
```

```
[transport-over-long-distances
(is-a(transport)) (wn-map(transport1))]
<other transport predicates here>
```

The *goal*, besides being realized by the same prepositions as those for *cause-to-change-location*, is also syntactically realized by an indirect object (obj-if-obj2), e.g., (1)"Susan brought her children a book from Harvard." Thus, the *theme* can be realized by an obj2 or by an obj, e.g., "Mary brought her children from school." This is the analysis that this work provides for all double object verbs. Because the semantic interpreter delays commitment until the end of the clause, the interpreter does not have to reanalyze.

The predicate *pull*, which corresponds to the synset "pull1, draw, force," and that contains such forms as "jerk," "twitch," "trail," "drag," etc. is:

```
[pull(is-a (cause-to-change-location))
(wn-map (pull1))
(agent(human-agent animal) (subj-if-obj))
(theme(instrumentality physical-thing)
                         (obj (prep from off)))
(source(location phy-thing)((prep from
                                     off)))]
```

Next, WordNet includes a large class of forms under the synset "put, set, place, pose, position, lay; also with abstract objects and locations." This work differs from WordNet and does not include abstract objects as *themes* of this predicate. The predicate *put* is:

```
[put(is-a (cause-to-change-location))
(wn-map (put1))
(theme (physical-thing) (obj))
(goal(location physical-thing)((prep on
      in towards through into back-to along
      over beside above by under below
      throughout beyond past across near)))
(instrument(instrumentality) ((prep with)))
(source (nil) (nil))]
```

This predicate illustrates two points. First, its *goal* is not expressed with the preposition "to," e.g., **Mary placed/arranged/put/etc the books to the table.* Second, the *source* is not realized by any syntactic relation (Levin, 1993). That is why the *source* entry is nil for the selectional restriction and the syntactic relation in order to indicate that this predicate does not inherit a *goal* from its ancestors. The concern here is not syntactic subcategorization of the verb forms, which is handled by the parser, but attachment of PPs. Any PP whose preposition appears in the entry of a thematic role is going to be attached preferentially to the verb. Thus, in "Connie put the reports from MIT on the shelf," the prepositional attachment algorithm should not consider "from MIT" as a possible complement of "put." WordNet includes several subclasses of put1, all of which have been mapped to subpredicates of *put*. Some verb forms under this predicate, such as "put" and "place," realize their goal with "at" phrases. This fact is represented in the verb forms themselves. The next major subclass of move2 is under the synset "propel1, impel, move forward," which includes the subclasses "hit1 cause to move by striking") and "throw" verbs. The predicate *propel* is depicted on the next column. Most of its thematic roles are inherited from *cause-to-change-location*, illustrating how relatively easy it is to build these entries once the predicates for the main subclasses have been constructed. The *goal* of this predicate is also realized by an indirect object (obj-if-obj2), e.g., "Sue threw the pitcher a ball." This class of verbs has an argument realized by the preposition "against," that has been mapped into the role *contact-goal*, a refinement of the role *goal*, meaning that the *theme* contacted the *goal*.

```
[propel(is-a (cause-to-change-location))
(wn-map (propel1))
(theme (physical-thing) (obj obj2))
(goal(human-agent) (obj-if-obj2)
  (location physical-thing)
   ((prep to on in through towards
     into back-to along over beyond past
      across by near at)))
(contact-goal(physical-thing)(against))]
```

The subclass formed by hit1, not to be confused with "hit3 – (deal a blow to; He hit her hard in the face)," becomes *[cause-to-move-by-hiting* (is-a(propel))(wn-map(hit1))], the one formed by "throw1, project through the air" becomes *[throw(is-a(propel))(wn-map(throw1))]*. A subclass of throw1 is formed by those verbs that Levin (Levin, 1993) calls "pelt" verbs ("buffet," "bombard," "pelt," "shower," "stone") in which the *goal* is realized by obj and the *theme* by a "with" phrase, e.g., "Beth pelted Chris with snowballs." Of these, WordNet does not include "shower" and "stone" as forms under pelt1.

Some classes in move2 and move3 are not mapped into subpredicates of the generic predicate *cause-to-change-location*. The reasons for not mapping a WordNet subclass into a subpredicate of the generic predicate for the WordNet class are any one of the following: a) these predicates do not share the thematic roles of the generic predicate, b) the primary event expressed by these subpredicates is not that of the generic predicate, or c) the ontological categories in the selectional restrictions of the generic predicate do not subsume those in the subpredicates. One major subclass of move2 that clearly is not a subpredicate of *cause-to-change-location* is grouped under the synset "transfer, convey, transmit, communicate, bring," and includes such forms as "relay," "request," "demand," "expect," "require," "beg," and many others. The *theme* of the predicate for this class is not a physical-thing, but an abstract thing, idea or a proposition, which is many times realized by a sentential complement. Two other strongly related subclasses of move2 that are not subpredicates of *cause-to-change-location* are grouped under the synsets "expel, eject, chuck out, exclude, throw out, kick out, turf out, boot out, turn out – (from a place)," and "expel, throw out, kick out – (as from a country)." The first subclass includes such forms as "evict," "exorcise," and the second subclass includes "expatriate," "deport," "disbar," "extradite," "ostracize," and others. The relation between the *theme* and the *agent* in the predicates underlying most of these forms is an abstract relation rather than a physical relation. The analysis provided for these classes has been to create a subpredicate of *action*, called *expel-human-agent*, which coalesces the two synsets discussed above plus a synset of remove, remove2, a class by itself, "remove - (remove from a position or an office)." Remove2 includes such forms as "fire," "lay off," etc. This generic predicate is analyzed into several subpredicates.

Another major subclass of move2 that is not mapped into a subpredicate of *cause-to-change-location* is grouped under the synset "separate2, disunite, force apart, divide, part, take apart, pull apart - He separated the fighting children; Moses parted the Red Sea," and includes such forms as "compartmentalize," "polarize," "disarticulate," "disconnect," "cut" and its subclasses, and many others. The primary event of this subclass is not a *cause-to-change-location*, although one may be implied. Some of these forms can be used in the causative/inchoative alternation, e.g., "The cream separated from the milk," and in the middle alternation, e.g., "Cream separates easily from milk" (Levin, 1993). Separate2 is analyzed as a subpredicate of *cause-a-change-of-state*, and coalesced with some other synsets of "separate" which are classified by WordNet as subclasses of change1, cause a change of state. Another subclass of move2 that has required a special analysis is that of "chase away, drive out, turn back, drive away, dispel, drive off, run off" in which the agent is causing the theme, an animate being, to move away from the agent's location.

In move3, some individual forms and some subclasses are mapped into the predicate *move-body-part*, a subpredicate of *action*. Some of these subclasses are: "move involuntarily, move reflexively - (move in an uncontrolled manner)," "dance, do a dance ..." and a few others.

The following predicates do not come from subclasses of move2 or move3, but from change1 (cause a change of state). However, they are analyzed as subclasses of *cause-to-change-location*. The first predicate *fill-or-load*, depicted on the next column, coalesces the synsets: "fill1, fill up, make full," and "fill2, fill up, become full." Of these, fill1, which is a subclass of change1 contains most of the forms, including all the "load" verbs. Fill2, a subclass of change2 (undergo a change) contains two forms. Note the different syntactic realizations of this predicate, as exemplified by "The farmer loaded the truck with hay" and "John loaded the tractors into the ship." It is not very helpful to include *instrumentality* as one of the selectional restrictions of the *theme* because anything can be loaded. However, *substance* could help to choose the correct sense of certain nouns, because it is a selectional restriction used frequently with "fill" verbs. The predicate *empty* that coalesces the synsets "empty1, make empty, make void" and "empty2, become empty, become void, discharge" becomes a subpredicate of *remove-physical-thing*, described below. The obj-if-with relation in the goal role means that this role can be realized by an obj if there is a with-phrase. For instance, "Kelly loaded the truck with hay."

```
[fill-or-load(is-a(cause-to-change-location))
(wn-map (fill1)(fill2))
(theme(substance physical-thing) (obj
                            ((prep with))))
(goal(instrumentality physical-thing) (obj
      obj-if-with (prep into on onto in)))]
```

The next major class is grouped under the synset of "remove1, take, take away - (remove something concrete, as by lifting, pushing, taking off, etc.; or remove something abstract; remove a threat ...)." Remove2 was analyzed above in the predicate *expel-human*. Remove1 forms a class by itself in WordNet.

```
[remove-physical-thing(wn-map (remove1))
(is-a (cause-to-change-location))
(theme(physical-thing) (obj))
(source(physical-thing) ((prep off from)))
(goal(nil) (nil))]
```

Remove1 contains many subclasses, most of which are mapped to subpredicates of *remove-physical-thing*. Remove3: "get rid of, remove," also forms a class by itself and is analyzed as a subpredicate of *remove-physical-thing*. WordNet does not include "rid" as a subordinate of any of the "remove" senses, but as a small class by itself containing nine forms. This work maps "rid1, free, disembarrass" to *rid*, a subpredicate of *remove-physical-thing*, in which the *theme* is realized by an "of" phrase, and the *source* by obj, e.g., "He rid the city of rats." *Empty*, another subpredicate of *remove-physical-thing*, may also realize its *theme* and *goal* with an "of" phrase and obj, respectively. Some forms under this subclass are used in the sense of "firing somebody." Rather than to reclassify these forms, a meaning postulate connects this predicate to the predicate *expel-human-agent*, explained above, if its *theme* is the concept *human*. This subclass also contains a subclass that does not express a *source*, but a *goal*. This subclass is: "abandon1 - (We abandoned the old car in the empty parking lot)," which includes such forms as "chuck," "ditch," "dispense with," and others. Abandon5: "abandon, forsake, desolate, desert, lurch - (leave someone who needs or counts on you);" which is a suclass of "leave2" is also coalesced into the the predicate: *[abandon-phy-thing-or-animate (is-a(get-rid-of)) (wn-map(abandon1) (leave2)) (source(nil)(nil))]*

4 Transfer of Possession Verbs

Table 1 depicts the hierarchy of subpredicates of *transfer-of-possession*.

```
-------------------------------------------
sell                 lease
pay                  invest
trade                spend-physical-thing
  import                use-up
  export                squander
give                 get-something
  give-back             capture-an-animal
  bestow                receive-something
  feed                    graduate
    nourish             buy
  bribe                   subscribe
  distribute            accept-something
  deposit-money         accept-a-job
  lend                  accept-somebody
  offer-something       obtain
  provide               get-back
    serve-somebody        reclaim
    arm                 win-at-an-event
    fuel-an-engine        score-in-a-game
    equip                 win-in-an-election
    shelter             gain-something
  donate                  profit
    bequeath            inherit
    endow               borrow
                        gather-things
                        get-by-force-ilegly
                          annex
                          steal
```

Table 1: *Hierarchy for subpredicates of transfer of possession*

The major subpredicates are *give* and *get* which are listed last. The generic predicate *transfer-of-possession* is described below. There are two events in a transfer of possession. The *theme* refers to the thing obtained or received by the agent of the primary event, and the *co-theme* to the thing obtained or received by the agent of the secondary event. A meaning postulate infers the predicate and its roles for the secondary event. The exclusionary semantic categories in the co-theme are to impede indetifying a [for NP] as a *co-theme* when it is a *to-poss*, e.g., "He bought a book for Mary/20 dollars."

```
[transfer-of-possession
(is-a(action))
(wn-map(transfer6))
(agent(human-agent animal)  (subj))
(theme(possession  thing) (obj obj2))
(to-poss(human-agent animal)
         (obj-if-obj2 (prep for to))
        (physical-thing) ((prep to)))
(co-theme(possession -human-agent -animal
   physical-thing thing)((prep for)))]
```

The subpredicate *give* is depicted below. The only difference between *give* and its generic predicate is that it does not have a *co-theme*. The synset give3 has many verb forms. Some of them are analyzed below.

```
[give
 (is-a(transfer-of-possession))
 (wn-map(give3))
 (co-theme(nil)(nil))]
```

The predicate *feed* depicted below has some interesting garden path constructions. Compare "Beth fed the frogs insects" to "Ann fed the frogs to the snakes" and "Kathy fed the frogs."

```
[feed(is-a(give))
(wn-map (feed1) (feed2))
(agent(animal) (subj-if-obj))
(theme(food substance physical-thing)
  (obj-if-to obj2))
(to-poss(animal human-agent)
  (obj obj-if-obj2 (prep to)))]
```

The synsets supply1 and provide2 are mapped into two predicates, *provide* and *provide-inanimate-cause* depicted on the next page. The predicate *provide-inanimate-cause* subsumes all those predicates in which the thing that causes the transfer is not an animate being, but an inanimate thing, e.g., "The river provides water to many cities." The syntactic relation *obj-if-with* indicates that the role *to-poss* can be realized by an obj if this is followed by a [with NP]. This is necessary in order to handle the sentence "France also provided the missionary with new churches." The next mayor subpredicate of *transfer-of-possession* is *get-something* depicted below. Its synset, get1, is a unique class in WordNet. One of the major subclasses of *get-something* is the predicate *capture-an-animal* which has a very simple entry.

```
[provide
(is-a(give))
(wn-map(supply1)(provide2))
(theme(thing)(obj obj2(prep with)))
(to-poss(human-agent animal
        physical-thing thing)
  (obj-if-obj2 obj-if-with
                 (prep to for)))
(inanimate-cause(thing)(subj-if-obj))]
```

```
[provide-inanimate-cause
(is-a(give))
(agent(nil)(nil))
(wn-map(supply1)(provide2))
(theme(physical-thing)(obj obj2(prep with)))
(to-poss(human-agent animal
          physical-thing thing)
      (obj-if-obj2 obj-if-with
                  (prep to for)))
(inanimate-cause(-human-agent -animal
      thing) (subj-if-obj))]
```

```
[get-something
(is-a(transfer-of-possession))
(wn-map(get1))
(theme(physical-thing thing)
            (obj obj2))
(from-poss (human-agent animal phy-thing
         thing)((prep off from out-of)))
```

Most of its subpredicates require a human as agent, but some take an animal as agent. Another class is formed by the verbs belonging to the synset receive1 and receive2 whose predicate is:

```
[receive-something(is-a(get-something))
(wn-map(receive1) (receive2))
(theme(award -human-agent physical-thing
 -perception thing) (obj obj2))]
```

The exclusionary categories *human-agent* and *perception* are intended to exclude the sense of receiving, or welcoming somebody, and that of receiving experiences, or experiencing something, from this predicate. Those senses are mappped into their own predicates.

The synset win1 (be the winner in a contest or competition) that is a unique class in WordNet has been mapped into the predicate *win-at-an-event* which has become a subconcept of *get-something*. The synset win2 (win something) is mapped into the predicate *gain-something*. Two other subpredicates of *get-something* whose synsets form unique classes in WordNet are *gather-things* (gather1) and *get-by-force-or-illegally* (take14).

5 Conclusions and Related Research

We have described a method for defining predicates for WordNet verb classes and illustrated it by analyzing some major WordNet verb classes. The thematic roles of the predicates are connected to WordNet ontology for nouns and to the syntactic relations that realize them. Our approach to building verb meaning is based on the decomposition of a predicate into subpredicates. Subpredicates inherit not only thematic roles, but also inferences as explained in (Gomez, 1996). Inferences will be defined for generic predicates and subpredicates subsuming a large class of verb forms. The final product will be a network of predicates linked by subsumption, and inferences, and connected to the WordNet ontology for nouns and to grammatical relations. As of this writing we have defined predicates for 70% of WordNet verb forms.

We are using the term "inference" to refer to both entailments and non-monotonic inferences, also called defeasible inferences. The term "entailment" is used in the sense of analytic implication (Quine, 1960). A sentence, say *s1*, entails sentence *s2* if *s2* is true in every world in which *s1* is true. An example of entailment is "if Peter killed the roach, the roach is dead." An example of non-monotonic inference is "if Peter likes apples, he eats them." Of course, it is very important to bear in mind that the difference between non-monotonic inferences and entailments is a question of degrees as Quine (Quine, 1953) has argued convincely. See (Gomez, 1996) for a discussion.

Our work differs from the semantic role list approaches (Fillmore, 1968) in several essential aspects. First of all in our method, the semantic roles are not defined independently of the meaning of the verb and are not semantically unanalyzable. In addition, the number of thematic roles depends on each predicate, and not on some general criteria saying which thematic roles there will be, irrespective of each predicate. Any thematic role in a predicate corresponds to a meaning relation from which inferences specific to that predicate or subpredicates must be established. Consider the sentence "These birds fly 11,000 miles from their breeding grounds to their winter home in the Antarctic." What is the thematic role corresponding to the NP "11,000 miles?" Some semantic relation needs to be recognized so that inferences such as "there is a distance of 11,000 miles between the breeding grounds of these birds and their winter home" can be established. We have recognized that semantic relation by creating the role *distance* meaning the distance traveled by an animate agent in a *change-of-location* predicate (Gomez, 1998). The inference is based on *that* role *and* on *that* predicate. Because the NP "11,000 miles" is not a subcategorized argument of "fly," why call it a "role" and not an "adjunct"? From a semantic point of view, it makes no difference whether one calls it "adjunct" or "thematic role." Dowty (Dowty, 1991), then, asks that, if one assigns a thematic role to measures of distance, why not assign a role to "quickly" in "She walks quickly." Our answer is that we should assign a role to "quickly." But, that role, whatever its name, should not be placed in the predicate *change-of-location* but in the *action* node because it can be inherited by every subpredicate of *action*. It makes sense to say "She eats/studies/writes/... quickly," but not "She eats 20 miles." Thus from our point of view, an "adjunct" is a role that is inherited by every subpredicate of *action*.

This approach does not lead to a propagation of roles since their number and nature depend on the generic predicate and its subpredicates. The critique of "role fragmentation - the subdivision of a single role into many subroles as result of subsequent analysis (Dowty, 1991) - is valid if the entailments are based exclusively on the role, but not if they are anchored on the role *and* the predicate. The roles that we have used throughout our analysis have differences in meaning across diverse generic predicates, or verb classes. For instance, the meaning of the role *theme* in a change of state verb, say "break," is different from its meaning in a transfer of information verb, say "tell." Hence, if the entailments are based only on the role, one would be compelled to recognize several types of *theme* (Dowty, 1991), but because the entailments are based on the predicate and on the role, this is not necessary. Role entailments are shared by subpredicates of a generic predicate not across generic predicates.

Our approach also differs from those analyses that attempt to reduce the verb semantic analysis to a small set of notions e.g., Jackendoff'localist hypothesis (Jackendoff, 1990), Dowty-Vendler's aspectual hypothesis (Vendler, 1967), Dowty (Dowty, 1979), or to a small set of primitives (Schank, 1975). Our major critique to reductionist analyses are Quinean (Quine, 1960) in nature, namely meaning is holistic. Trying to reduce verb meaning to a small set of notions is going to fail because verb meaning is intersentential. One may take some verbs whose meaning can be reduced to some few principles, or notions. Verbs of change of location fit very well within the localist hypothesis, while verbs of creation seem to support the aspectual hypothesis. But, if you consider a verb like "graduate" the situation is rather different because many sentences mediate to form its meaning. One may say that it is an accomplishment verb, but that is not saying much. Trying to provide a CD representation (Schank, 1975) for it seems hopeless. The key point here is that the representation needs to make possible the inferences normally associated with such verb. For instance, that if one is asked which school Clinton attended, one should say "Yale" upon reading that Clinton graduated from Yale. Hierarchical predicate decomposition and inferences shared by subpredicates of the same generic predicate is the solution that we offer. However, we always keep in mind that meaning is a question of degrees. It can be approximated, but not fully grasped. Fortunately, approximation is all we need for the task of natural language processing.

References

D. R. Dowty. 1979. *Word Meaning and Montague Grammar*. Dordrecht: Reidel, Dordrecht.

D Dowty. 1991. Thematic proto-roles and argument selection. *Language*, 67:547–619.

C. Fellbaum. 1993. English verbs as a semantic net. Technical report, Princeton. CSL Report 43, revised March 1993.

C. J. Fillmore. 1968. The case for case. In E. Bach and R.T. Harms, editors, *Universals in Linguistic Theory*, pages 1–88. Holt, Rinehart and Winston, New York, NY.

F. Gomez, C. Segami, and R. Hull. 1997. Determining prepositional attachment, prepositional meaning, verb meaning and thematic roles. *Computational Intelligence*, 13(1):1–31.

F. Gomez. 1996. Acquiring intersentential explanatory connections in expository texts. *International Journal of Human-Computer Studies*, 4(1):19–44.

F. Gomez. 1998. Semantic interpretation of unrestricted domains using wordnet. CS-TR-98-2, Jan. 1998.

R. Jackendoff. 1990. *Semantic Structures*. MIT Press, Cambridge, Mass.

B. Levin. 1993. *English Verb Classes and Alternations: A Preliminary Investigation*. University of Chicago Press, Chicago.

G.A. Miller, R. Beckwith, C. Fellbaum, D. Gross, and K. Miller. 1993. Introduction to WordNet: An on-line lexical database. Technical report, Princeton. CSL Report 43, revised March 1993.

J. Pustejovsky. 1995. *The Generative Lexicon*. MIT Press, Cambridge, Mass.

V.W. Quine. 1953. Two dogmas of empiricism. In *From a Logical Point of View*. Harvard University Press, Cambridge, Mass.

V.W. Quine. 1960. *Word and Object*. MIT Press, Cambridge, Mass.

R. Schank. 1975. *Conceptual Information Processing*. North Holland, Amsterdam.

Z. Vendler. 1967. *Linguistics in Philosophy*. Cornell University Press, Ithaca, New York.

Y.A. Wilks. 1975. Preference semantics. In E.L. Keenan, editor, *Formal Semantics of Natural Language*. Cambridge University Press, Cambridge, UK.