The encoding of lexical implications in VerbNet Predicates of change of locations

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Abstract

This paper describes an attempt to use the information contained in VerbNet to obtain change of location inferences. We show that the information is available but not encoded in a consistent enough form to be optimally useful.

1. Introduction

Properties of particular lexical items drive many natural language inferences, and hence natural language systems intending to capture them are dependent on the use of large scale lexical resources such as VerbNet. VerbNet (http://verbs.colorado.edu/verb-index) organizes syntactic and semantic information about verbs in classes based on Levin (1993) and extended by contributions of Korhonen and Briscoe (2004) and Kipper et al. (2006). The information links syntactic subcatorization information to a representation using thematic roles and a skeletal semantic structure. This paper describes our experience using the information in VerbNet to identify predications that *can* express *physical* change of location (thus excluding *hear from, say to*). We ignore the problem of metaphorical extensions for the relevant verbs. Resources other than VerbNet will need to be exploited to insure that these non-physical interpretations are excluded.

Conceptual structure:
subconcept(leave:2, [WN *leave* synsets] role(Source,leave:2,Baghdad:4) subconcept(Baghdad:4,[WN *location* synsets via XLE entity finder] subconcept(diplomat:1,[WN *diplomat* synsets]) role(Theme,leave:2,diplomat:1)
Contextual Structure:
context(t) top_context(t) instantiable(Baghdad:4,t) instantiable(diplomat:1,t) instantiable(leave:2,t)
Temporal Structure:
temporalRel(startsAfterEndingOf,Now,leave:2)

Table 1: VN Information

2. Abstract Knowledge Representation (AKR)

Our system calculates entailments or contradictions between text fragments, a passage P and a hypothesis H, represented in a description-logic-like system (Bobrow et al. (2005)), called AKR. Some of these involve lexically based inferences about the pre- and the post-states of the events mentioned. For example for *The diplomat left Baghdad*, we need to know that before the event (pre-state) she is in Baghdad and after the event (post-state) she is no longer there. In a text the entity that changes location can be referred to in different ways: by direct objects or by argument or adjunct PPs, introduced by a variety of prepositions. For our reasoning system to work we need to normalize this information so that the same meaning has the same form in the AKR.

To give an idea of the representations produced, we give in Table 1 the simplified AKR for *The diplomat left Baghdad* without the information about change of location.

This representation says that *the diplomat* is the Theme of the leaving event and *Baghdad* is the Source but it does not tell us that before the leaving event *the diplomat* is in *Baghdad* and that afterwards she is no longer there. This is the information that we would want to add. When that information is added we would get the representation in Table 2.

This representation adds the required information by creating two new locate 'events'. They both situate the diplomat referred to in Baghdad. One is before the leave-event and the other after the leave-event. The one before the leave-event (locate:9) is declared to be instantiable, meaning that it occurs in the worlds compatible with the proposition expressed by the sentence. This captures the positive pre-state implication. The one after the leave-event (locate:10) is declared to be uninstantiable, meaning that it does not occur in the worlds compatible with the proposition expressed by the sentence. This captures the negative post-state implication.

The task then is to use the information given in VerbNet together with the information provided by our system and our lexical resources to derive this normalized representation. The modules the VerbNet information needs to be integrated with include the semantic representation of the text (Crouch and King (2006)) derived from the XLE parser (Maxwell and Kaplan (1996)) and other lexical resources such as WordNet (http://wordnet.princeton.edu/). The latter are, in our system, integrated into a Unified Lexicon(Crouch and King (2005)) (for a description of the system as a whole, see Bobrow et al. (2007)). In this paper

Conceptual structure:
subconcept(leave:2, [WN *leave* synsets]
role(Source,leave:2,Baghdad:4)
subconcept(Baghdad:4,[WN *location* synsets])
subconcept(diplomat:1,[WN *diplomat* synsets])
role(Theme,leave:2,diplomat:1)
subconcept(locate:9,[WN *locate* synsets]) — prestate
subconcept(locate:10,[WN *locate* synsets]) — poststate
role(Theme,locate:9,diplomat:1)
role(Theme,locate:10,diplomat:1)
role(Location,locate:9,Baghdad:4)
role(Location,locate:10,Baghdad:4)
Contextual Structure:
context(t)
top_context(t)
instantiable(Baghdad:4,t)
instantiable(diplomat:1,t)
instantiable(leave:2,t)
instantiable(locate:9,t)
uninstantiable(locate:10,t)
Temporal Structure:
temporalRel(startsAfterEndingOf,Now,leave:2)
temporalRel(startsAfterEndingOf,leave:2,locate:9)
temporalRel(startsAfterEndingOf,locate:10,leave:2)

Table 2: VN Information

we mainly study the way the relevant information is represented in VerbNet, henceforth VN, to determine how much manipulation is necessary to derive the required representation. In section 5 we discuss briefly the transformation of the information encoded in VN into AKR .

3. VerbNet

VN is based on Levin classes. A Levin class embodies the hypothesis that the fact that a set of verbs have a certain syntactic alternation pattern implies that they share some aspects of their meaning. In VerbNet, the syntactic patterns are linked to thematic roles and those in turn are used in the semantics (event structure). The event structure has been inspired by Moens and Steedman (1988) and Allen and Ferguson (1994). In some cases, VN creates further subclasses (see Kipper-Schuler (2005)). In the latest distributed version, VN2-1, we have altogether 239 (sub)classes (XML-files). An example of the information provided is given in table 3.

4. VerbNet and change of location

Two types of information in VN could in principle be exploited to give us information about the change of location of the participants in an event: the thematic roles and the semantics. VN uses 25 thematic roles and one might think that aspects of meaning, such as change of location, that figure prominently in the discussion of thematic roles and entailments (see e.g. Jackendoff (1990)) would have a uniform role assignment. This is, however, not the case. Although the same thematic role names are used across various verb classes, no commonality of meaning is intended,

Class	Send-11.1
Themroles	Agent, Theme, Source, Destination
Selrestr	Agent[+animate]or+[organization], Theme[+concrete], Source[+location], Destination[+location]
Frames:	
Name	NP-PP-PP
Example	Nora sent the book from London to Paris.
Syntax	Agent V Theme Source Destination
Semantics	cause(Agent,E) motion(during(E),Theme) location(start(E),Theme, Source) location(end(E),Theme,Destination)

Table 3: VN Information

as becomes clear when reading Kipper-Schuler (2005) (especially pp. 30-34).
As an alternative to using the role names, we concentrated on the VN semantics. As is clear from the example in table 3, the VN semantics can encode the location of a participant (Theme or Agent) at the Source (the start of the event) and at the Destination (the end of the event). This type of information is the kind of information our system requires. The focus of this study was to evaluate whether this type of information is available for all the verbs that can express a change of location.

4.1. VerbNet classes with change of location

Studying the various VN classes, we identified 60 (sub)classes for which either start or end position or both can be expressed by a prepositional phrase or by a direct object[1]. Of those, however, only 28 (sub)classes have a semantic representation with Source or Destination characterizations reflected in the role names as given in table 3 above. Five classes use a representation that specifies the start or end in terms of ‘Location’ instead of ‘Source’ or ‘Destination’. The only explanation given in the documentation for VN for the use of Location is that it is more general. We do not depend on the roles names per se but on the presence of the ‘start (E)’ end ‘end (E)’ predicates for our translation, thus we can treat these five classes without difficulty in the same way as the previous ones.
A further inspection of the classes reveals that there is an alternative way that VN gives change-of-location information. This alternative representation is used when one of the conditions (start or end) is negative to indicate that the negative condition holds with respect to the same prepositional value as the positive one. This representation, sketched in table 4 is used in four classes (one of which has also the representation in table 3 for some subcategorization frames).

4.2. VerbNet classes with incomplete coverage

Together these two main representations cover several verb classes that one thinks of as centrally encoding of change

[1]In some cases, VN specifies classes of prepositions but not the members of these classes. We ignore the important problem of the choice of prepositions in this paper.

cause(Agent,E) motion(during(E),Theme) not(Prep(start(E),Theme,Destination)) Prep(end(E),Theme,Destination)

Table 4: Alternative VN change-of-location information

of location (*send, put, ...*) and some that one might not be inclined to see immediately in that light (e.g. *butter*). They do not encode a number of others where the change of location indicated are those of the participants relative to each other (e.g. *gather, mix, ...*) and some which might be thought of as rather central to the encoding of change of location, most prominently 8 subclasses of Levin's class-51 (verbs of motion).

The semantics of class-51 verbs typically encodes the information that Theme moves during the event (motion(during(E),Theme)) and that the Theme is at the location specified by the preposition (Prep(E,Theme,Location)) but no information is given about possible start or end points. This seems to follow from a distinction between intrinsically and non-intrinsically directional verbs. But, although this difference is illustrated in Palmer et al. (1998), Kipper and Palmer (2000) and Dang et al. (1998), it is not defined and it is not intuitively clear in all cases. For instance, *carry* does not seem to be intrinsically directional but in VN it has start and end point information for some of its frames. Moreover the verbs in class-51 include those that in some languages (e.g. Dutch) lead to auxiliary alternations when used with directional complements, the kind of behavior one would think of as being conditioned by arguments rather than by adjuncts.

For those eight subclasses of class-51, as well as for most of the subclasses of class-47, we need to add the relevant information to the frames. Of course we can also treat these cases in a different way and build up the representation compositionally following the suggestions in Palmer et al. (1998). What is not clear is when one can count on VN to provide a semantic representation to work with and when one has to assume it will not be there.

In other cases information needs to be restructured. Some examples are:

- class 16-concealment (*She hid the presents in the drawer.*), where one can exploit the information 'location(result(E),Patient, Location)',
- class-22 (*mix, shake, tape, etc.*), where one can use 'mingled(result(E),physical,Patient1,Patient2)' or 'together(end(E),physical,Patient1,Patient2)',
- class-23, where there is the information 'together(start(E),physical,Patient1,Patient2), apart(end(E),physical,Patient1,Patient2)',
- class-47.5.2 , where we find 'not(together(start(E),physical,Theme$_i$,Theme$_j$)), together(end(E),physical,Theme$_i$,Theme$_j$)'.

It is clear that, to get a uniform AKR representation, separate rules need to be written for these minor classes.

For the classes where some start or endpoint information is given (i.e. the 36 classes that have one of the three semantic representations discussed in subsection 4.1.), the information is often incomplete. Here are some examples. For class 9.3 (*funnel*), only endpoints are given although a combination of start and endpoint is possible (e.g. *funnel the liquid from the bottle into the cup*). For class 9.5 (*pour*), no frame with both start and end points (as in *He poured the water from the bowl into the cup*) is given. For class 9.7 a frame is given for sentences such as *Jessica loaded boxes into the wagon* but no mention is made of the possibility of a Source as in *Jessica loaded the boxes from the train into the car.* In 10.2 (*banish*) both a Source and a Destination frame are given but no frame that combines the two. A similar situation obtains with class 10.4.2: Source and Destination frames are given but no combination of both (as in *Shovel the snow from the sidewalk into the ditch*).

5. Translating the VerbNet information into AKR

For the cases in which VerbNet gives explicit change of location information, it is easy to translate this information into our AKR representation. We sketch here the translation of the VN semantics given in table 3. VN information is incorporated into our Unified Lexicon (UL), which is looked up during processing. A verb occurrence is associated with a VN semantics template. Further transformation of this template into AKR is keyed off the VN predicate "location" and is sensitive to its polarity (whether there is a "not" preceding the predicate "location") and the presence of an "end(E)" or a "start(E)" argument. We then create a new term for each VN semantics clause, translating "end" into the temporal relation "after" and "start" in the temporal relation "before". These new terms are then incorporated with the necessary adjustments into the notation illustrated in section 2.

A flavor of the type of rules involved is given in table 5 (variables are in italics)

![+instantiable(*VerbSk*,t), vn_semantics(*VerbSk*, location(start(E),*Theme*,*Source*)), +role(*Theme*, *VerbSk*, *Arg1*), +role(*Source*, *VerbSk*, *Arg2*), {new_constant(locate,*LocSk*)}]! ⇒ new_locate(*LocSk, Arg1, Arg2, VerbSk*, pos, before). +new_locate(*LocSk*, *VerbSk*, before) ⇒ temporalRel(startsAfterEndingOf, *VerbSk*, *LocSk*).

Table 5: Alternative VN change-of-location information

6. Conclusion

VN is one of the few large-scale lexical resources that include information about the semantics of particular verbs. We have found that in many cases this information is sufficient to support appropriate inferences about change of location. The usefulness of the resource, however, is lessened by the lack of documentation about the assumptions made in the encoding, specifically about the distinctions made between adjuncts and arguments. The classification is done on the basis of subcategorization frames and is thus driven by syntactic considerations separating arguments from adjuncts. As is well-known, there is no one-to-one mapping between syntactic predications and semantic ones. The latter often include as arguments constituents that are syntactically adjuncts. For lexical resources to be helpful in normalizing textual information, they have to encode the distinction between syntactic and semantic predication and be systematic about the correspondence between the two. In the case of change-of-location information, VN does not do this and, as a consequence, the information provided, while useful, still requires a substantial amount of further normalization to get to genuine change-of-location entailments in all the cases where they are possible.

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