Seeing Arguments through Transparent Structures

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Abstract

This paper describes a research effort that exploits information available in the FrameNet database and seeks to find, for argument-structure-bearing verbs, nouns, and adjectives, the lexical heads of the phrases that satisfy the core semantic roles of those predicates, and to create from the database of annotated sentences collections of structured clusters of words, called kernel dependency graphs. These KDGs when thus extracted from a collection of annotated sentences can be studied as candidates for the status of special collocations, but the same kinds of clusters, when discovered in raw text, can serve, in NLP applications, as indicators of the salient topics or issues in the passage from which they have been extracted. Unfortunately, there are sometimes discrepancies between syntactic and semantic "heads", and for our purposes it is the semantic head that is significant; it is thus necessary to identify grammatical structures - and the words which mark them - that can intervene, structurally, between a predicate and its arguments. When these "transparency" structures are the familiar control structures seen in various kinds of embedding predicates, we should be able to rely on ordinary parsers to identify them; but the concern in this paper is with two additional phenomena, the support verbs that separate arguments from predications that are expressed as nouns (typically deverbal nouns), and transparent nouns that syntactically take the semantically relevant nouns as their complements.

1. Introduction

As linguistic theories have become more "lexicalized" over recent years, increasing attention has been paid to the relations between semantic and syntactic structures, and particularly to the argument structure of predicators. Getting the details of these relationships right is important both for theory (learnability, lexical relations, polysemy, lexical ontologies, etc.) and for practical NLP systems, which must learn to recognize or to generate correct argument structures.

The FrameNet research project[1] is producing a database intended to be useful in NLP applications such as information extraction and machine translation, as well as that essential prerequisite for any such applications, word sense disambiguation. Effective WSD depends on information about the combinatorial behavior of a word in each of its senses, both in grammatical terms (valence, complementation patterns) and in terms of lexical collocations and sortal selection. In our own work we are testing means of automatic semantic role identification, and such information would be valuable for that as well. This paper discusses a way of combining subtle and careful (and labor-intensive) human involvement in sorting word senses, and predicting and discovering contextual differences that mark them, in the service of acquiring information about lexical selection and collocation.

The argument-bearing predicates that we consider, all requiring somewhat separate kinds of treatment, are verbs (e.g., *decide*), adjectives (e.g., *fond*), deverbal nouns (e.g., *decision*), deadjectival nouns (e.g., *fondness*), relational nouns (e.g., *name*), and idiomatic preposition phrase predicates (e.g., *at risk*).

Other parts of the FrameNet research include a way of annotating dependent nouns, such as names of things that occurs as lexical heads of NPs that satisfy particular argument slots e.g., *candle*, *apple*, *soil*). It will be of advantage to the organization of a formal lexicon to create automatic processes for discovering and recording the sortally typical fillers of the core complements and significant frame-specific adjuncts of predicating words.

Procedures for attaining the kind of information we need will result in a body of lexical and grammatically idiosyncratic information associated with each lexical predicate, by way of finding, in grammatically significant contexts, samples of phrases that satisfy given semantic roles. Polysemous predicates are certain to have different collocates for each of their senses, and often different grammatical contexts, as well: it is this kind of information that will be of use in WSD.

(1) a. Laura **phrased** her request in an insulting way.
b. My sister is **fond** of your children.
c. the colonel's **decision** to retreat
d. my sister's **fondness** for your children
e. the **name** of the garment
f. the children are **at risk** of serious harm

The examples in (1) give us the simple cases, where the kind of information needed for this effort can be found in the nearest relevant grammatical context: there are no obstacles in the way between the predicating word (the governor) and its dependents. In (1a) the Communicator appears as the subject, the Message as the object, the Manner appearing as a phrase marked by the preposition *in* and

[1]FrameNet is an NSF-sponsored resource-building effort supported under Grant No. ITR/HCI 0086132: "FrameNet++: An On-Line Lexical Semantic Resource and its Application to Speech and Language Technology." PIs are C. Fillmore and S. Narayanan (ICSI), D. Jurafsky (U Colorado) and Mark Gawron (San Diego State U). Current funding continues through August 2003.)

headed by the word *way*. In (1b) the Experiencer and Content complements show up respectively as the subject of the copula and as an *of*-phrase. In (1c) the Agent appears as the possessive determiner, the Content as an infinitive VP. In (1d) the Experiencer is expressed in the possessive determiner, the Content in a *for* phrase. In (1e) the identity of the Named object is the object of the preposition *of*. And in (1f) the Protagonist is the subject of the copula that supports this predicative PP, and the Danger shows up as the object of the preposition *of*.

The present paper addresses more complex cases.

2. FrameNet, the Process and the Product

2.1. The FrameNet Process

The central work of the FrameNet project is to present and describe semantic frames that are relevant to understanding the meanings of lexical items in English, and to show how the elements of frames evoked by individual lexical items are associated with the grammatical arrangement in the surrounding sentence to express the contents of a predication. Our method is inductive. Generalizations about frame structure and grammatical organization are derived automatically from a large body of sample sentences taken from a large corpus (the BNC), each of these annotated to show one combinatory arrangement for the particular targeted word for which the sentence has been chosen. In our work we have been cycling through the following steps, for somewhat more than 5000 lexical units as of this writing.

1. Pick a 'frame'
   (e.g., **Encoding**, (a speaker formulates a message in a particular way)
2. Choose a canonical example
   (*She worded her request cleverly.*)
3. Choose 'frame element' names
   (SPEAKER, MESSAGE TYPE, MANNER)
4. Make a word list
   (the verbs *word, phrase, put, express, ...*)
5. Pick words one at a time, extract examples from the corpus.
6. Annotate a sufficient variety of examples by labeling the phrases governed by the selected lexical target according to the frame elements that they instantiate.

For verbs we identify the target word and label the constituents that instantiate its frame elements (Ex. (2-a)). These can be the structural sisters of the verb, that is, those constituents inside the verb phrase that fill in the details or otherwise elaborate the description of the situation characterizable in terms of the frame. FE realizations outside of the target verb's phrasal projection can be in "extracted" position (as topicalized, relativized or interrogated constituents) or as subjects of the verb. Instead of positing empty subjects for non-finite clauses, we tag (with the ad hoc grammatical function name "Ext") the constituent that serves as the semantic subject of the verb if it is either in direct subject position (before the predicate) or in a "control" context, that is, in syntactic construction with a complement-taking verb, adjective or noun.

(2) a. [$_{Speaker}$ Nigel Cramer] was **phrasing** [$_{Message}$ it] [$_{Manner}$ by the book].
   b. Of particular interest is the [$_{Manner}$ strong] **wording** [$_{Message}$ on the question of shortages].
   c. ... [$_{person}$ Lotus 's Colin Chapman] [$_{Supp}$ was] notoriously **stingy** [$_{recipient}$ to his drivers].
   d. [$_{Wearer}$ They] [wore [$_{Descriptor}$ light-blue] [$_{Garment}$ **blazers**] ...

For frame-bearing nouns (e.g., deverbal nouns) we sometimes find all FEs instantiated within the NP, exploiting possessive determiners, pertinative (also called "relational", non-predicating) adjectives, and noun modifiers, post-nominal clausal and prepositional complements, etc. (Ex. (2-b)) But an additional source of FEs is made possible by the help of a support verb: the support verb's subject is (by the definition of support verb) an element of the argument structure associated with the object noun.

For adjectives used predicatively, we identify its complements within the adjective phrase, and the subject of an accompanying support verb (be, seem become, etc.) (Ex. (2-c)); for adjectives used attributively, we identify the noun it modifies. (The treatment of "pertinative" adjectives as FN targets is separate and is not treated here.)

For dependent nouns - nouns that head phrases that satisfy the FE requirements of a governing predicate - we tag the target, we identify in selected sentences semantically relevant governing contexts the governor and the phrase containing the target word which identifies the FE of the governor (Ex. (2-d)). (For example, for the dependent noun *gun* we might choose sentences in which it occurs with verbs like *shoot, brandish, fire*.)

(Although FrameNet annotations are labelings of sentence constituents with respect to the combinatory needs of single words within them, the use of layering developed for the treatment of dependent nouns opens the way for full sentence semantic annotation. Since the identification of the governor of a trageted dependent noun is on a separate layer in the annotation scheme, it is also possible to re-annotate the sentence selecting the governor as a target in its own right and annotate the same sentence with respect to the governor's frame. Successive operations of layered annotations can lead to frame-semantic analyses of whole sentences.)

2.2. The FrameNet Product

The FrameNet data is available in a variety of ways; these will be shown at the demo accompanying this talk.

- Lexical Entries This is a web-based report format that shows, for each LU, a definition, the frame elements present in the example sentences, and all the syntactic patterns in which they occur (the valence). Each part is linked to the sentences reflecting the pattern.

- Searching the Database This is a web front end to a search engine for the FN data, written by Hiroaki Sato of Senshu University. There are two interfaces, depending on the user's expertise and familiarity with the data structures. Searches can be performed using combinations of parameters such as frame, frame element, phrase type, grammatical function, head noun of NP of FE, etc.

- Downloading the Database The database will be available for research purposes in XML format, enhanced with RDF (DAML+OIL). The goal is to make the data both useful to NLP researchers and accessible to web applications. Although the final release will not occur until the end of the second phase of the project, an interim release is planned.

3. Extraction of KDGs

As a step toward of the demonstration that the FN database has some technical applications, e.g., word sense disambiguation, information extraction, question answering, machine translation, text data mining, and event tracking, we have defined a subordinate task, that of extracting from the set of annotated sentences certain clusters of information, which we call KDGs (kernel dependency graphs), consisting of:

- governing word
- lexical heads of the word's dependents
- the 'marking' of such components (e.g., as prepositions, complementizers, etc.)
- the semantic roles (our 'frame elements') of the phrases containing those lexical heads

In the case of the simplest KDGs (those **not** involving the transparent structures that are the topic of this paper) they can be represented, in a dependency grammar subtree, as a collection of governor-dependency links with labeled arcs. The particular subgraph that counts as a KDG will have just that information that is related to the core meaning of the governing word, but with the terminal nodes bound to lexical realizations of the particular argument types as found in attested corpus sentences.

Thus, for a sentence like *The woman gave a coin to the old beggar* we recognize

- *give* as the governor,
- *woman* as the head of the phrase indicating the Giver,
- *coin* as the head of the phrase indicating the Gift,
- *to* as the prepositional marker of the phrase identifying the Receiver, and
- *beggar* as the head of the phrase indicating the Receiver.

The simplest example of a KDG, assuming RDF specifications, then, could be presented as:

<GIVE rdf:ID="Give1">
  <giver>"woman"</giver>
  <gift>"coin"</gift>
  <receiver>"to: beggar"</receiver>
</GIVE>

(The discussion here concerns finding the head lexical item in each of the relevant phrases; when aided by a named-entity recognizer, the 'lexical head' component of the formulas can just as well be supplied with such information as Personal Name, Place Name, Institution Name,Date, and the like.)

In a research phase, finding such clusters in the set of annotations found in the FrameNet database will enable us to recognize selectional and collocational relations between lexical heads, as well as various sorts of idiomatic expressions, to the extent that they are included in the sentences selected by the project's annotators. In the application which we are in the process of devising, we are trying to use the constantly growing set of annotations as a training corpus, especially as aided by manual role-recognition techniques, to extract such clusters from an untagged corpus as well. In an application phase, correctly finding such clusters in given documents will be a part of enabling the automatic recognition of the topic of a given passage.

4. Transparent Structures

In the search for those KDGs in a passage that are the most relevant to what the passage is likely to be about, we generally want to find the most deeply embedded predication in a clause. That is, for these purposes, we will often need to ignore those (certainly not unimportant) embedding contexts that are expressions of appearance, probability, belief, perception, desire, intention, speaking, aspect, modality, causation, and even negation, in order to reach the most deeply embedded semantic core. That is, inside of *It appears that nobody wants to believe that Fred murdered Susie* we want to find *Fred murdered Susie* directly and create the following KDG.

<MURDER rdf:ID="Murder2">
  <agent>"Person"</agent>
  <victim>"Person"</victim>
</MURDER>

In that case, the "packaging" structures did not break up the elements of the KDG, but in the case of a sentence involving "raising" and "equi" constructions, like *Fred is likely to have decided not to murder Susie*, the lexical material representing the Agent role in the murder scene (i.e., the word *Fred*) is structurally separated from its predicate by a probability adjective *likely* and an Equi-type "control" predicate *decided*; the search for the Agent has to be able to "see through" these various structures.

In the case of such well-understood control structures, parsers are (or some day will be) able to make the right connections. But there are two ways in which we need to go beyond these familiar structures: first, by including nouns as well as verbs as governors, and second, by recognizing two kinds of elements that are capable of intervening structurally between the components of a semantic KDG: support verbs (which make it possible to identify NP-externally

realized arguments of nouns, especially nominalizations), and the kind of nouns we are characterizing as transparent. In these cases we are dealing with situations in which there is a discrepancy between the syntactic head of a phrase and its semantic center.

4.1. Transparent Nouns

We mean by transparent nouns those nouns that occur initially in a *Noun + Noun* construction for which the surrounding context selects, or is selected by, the second noun rather than the first. In other words, this is a case in which there is a discrepancy between the syntactic "head" of the phrase and its semantic "head". Nouns that behave in this way are of many kinds, suggested by the following lists:

Parts	*part of the room*
Measures	*liter of wine*
Aggregates	*herd of wildebeest*
Types	*kind of fish*
Unitizers	*bout of the flu*
Evaluatives	*her jerk of a husband*

The syntagmatic relations that such nouns are transparent to (shown below with underlining between the collocates) can include that between an adjective and the noun it modifies (*a _nice hot cup of _coffee, the _wrong kind of _impression*), between a verb and the head noun of its semantic object (*_drank a liter of _beer, won't _eat that kind of _fish*), between a verb and its subject (*a group of _onlookers were staring at the sight*), a subject noun and its agreeing verb (*a group of _zebras were _standing near the post*)[2], between a locative preposition and its object type (*_in this part of the _room, _on that part of the _shelf*)and between a possessive determiner and the kind of relational noun that, in certain contexts, requires a possessor (*_her jerk of a _husband, _my gem of a _wife*). (Svensson, 989; Napoli, 1989; Fontenelle, 1999)

As an example of a sentence which offers significantly different syntactic heads and semantic heads of its NPs, we can consider the following one, modeled on more than one sentence in the Penn Treebank.

The majority of tobacco producers use a form of asbestos in this kind of filter

Here the semantically informative KDG is not the one that would be derived solely from the syntactic heads of the constituent nominal phrases, namely,

```
<USE rdf:ID="Use3">
    <agent>"majority"</agent>
    <ingredient>"form"</ingredient>
    <product>"in: sort"</product>
</USE>
```

but rather

```
<USE rdf:ID="Use3">
    <agent>"tobacco producers"</agent>
    <ingredient>"asbestos"</ingredient>
    <product>"in: filter"</product>
</USE>
```

This is by no means to claim that only the KDGs discovered in this way are necessarily the main communicative point of a passage, since the so-called transparent surrounding structures will in some cases be exactly the point of the passage. Thus, a statement to the effect that *Bill reported that Fred murdered Susie* might be a part of a claim about Bill's duplicity, and his role as the subject of *report* is the key to the passage; and in the case of certain kinds of transparent nouns we have to recognize the important difference between the main points in *Bill ate a quantity of apples* versus *Bill estimated the quantity of apples*, where in the latter case the verb *estimate* has *quantity* as its major dependent, not *apples*. The reality, here, of course is that there is more than one *Noun + Noun* structure in English, and the word *quantity* can figure in two of them. In the one case it is a transparent noun, and its fellows are such words as *bunch*, *group*, *lot*, and the like, and in the other case its fellows are such words as *size*, *magnitude*, *age*, etc. (Fontenelle, 1999)

4.2. Support Verbs

In our treatment of Support Verbs we go beyond the familiar list (often called light verbs) more or less limited to those shown in Ex. (3-a)-(3-d), and one or two others[3]; we include verbs that add registral, aspectual, and other semantic aspects to the predication, as well as a number that appear to be collocationally highly restricted Ex. (3-e)-(3-g), tending towards a variety of lexical functions best described by Igor' Mel'cuk (1996).

(3)
a. make a decision, an announcement, ...
b. take a bath, a walk, a bow, ...
c. have a fight, an argument, a conversation, ...
d. give instructions, advice, encouragement, ...
e. say a prayer, tell a lie, sing a song
f. sustain injury, suffer a loss
g. commit murder, wage war

In addition to providing the possibility of converting an event noun into a verbal predication and finding a place for one of its major arguments, support verbs serve many important functions. For example, sometimes the choice of support verb serves to disambiguate an object noun

(4)
a. have an argument (Frame: **quarreling**) (*have* goes with reciprocal activity nouns)
b. make an argument (Frame: **reasoning**) (*make* goes with monologic speech nouns)

Sometimes pairs of support verbs profile different participants:

(5)
a. perform an operation *vs.* undergo an operation
b. submit an application *vs.* receive an application

Sometimes support verbs profile different phases of a scenario:

(6)
a. make a promise
b. break a promise

[2] In the subject-to-verb examples, the intervention is structural rather than linear.

[3] Perhaps the most detailed treatment of the standard support verbs is Akimoto (1989), which treats *give*, *have*, *make* and *take*.

c. keep a promise

Sometimes a support verb selects a particular register:

(7) a. make a complaint *vs.*
b. file a complaint, lodge a complaint, register a complaint

Sometimes the subject of a support verb stands for the direct object of a transitive event type:

(8) a. deserves honest reconsideration
b. merits immediate publication
c. requires careful examination

The two kinds of intervening structures can operate together in various ways. A transparent noun, for example, can intervene between a support verb and its object (*deserves a certain amount of consideration* or between an event noun and the semantic head of its complements (*my objection to that kind of proposal*).

4.3. Complex Constructions Using Support Verbs

By treating *be* and *come* as support verbs and *in* and *into* as markers, we can describe a family of constructions around *possession* as a frame-evoking noun. The details involve choice of support verb (*be* for the stative situation, *come* for the dynamic), prepositions *in* for the stative and *into* for the dynamic), and the difference between the inflectional and the phrasal genitive, we find that a single KDG connected with *possession*, namely:

<POSSESSSION rdf:ID="Possess4">
<possessor>"senator"</possessor>
<possession>"documents"</possession>
</POSSESSION>

is derivable from any of the following expressions, one noun phrase type (a.) and various clausal constructions:

(9) a. the senator's possession of certain documents
b. The senator is in possession of certain documents.
c. Certain documents are in the senator's possession.
d. The senator has certain documents in his possession.
e. The senator has come into possession of certain documents.
f. Certain documents have come into the senator's possession.

5. Summary

There are both language-descriptive and practical-applicational reasons for wanting, and needing, to build KDGs from text and hence to clear the way for their discovery by knowing where to find, across various kinds of syntactic barriers, the selectionally and collocationally important lexical connections. An automated method for deriving KDGs from text could give us information about the central issue in a given passage and could thus be useful for information retrieval, document routing, event tracking, etc.

The Framenet KDG project can be usefully compared with the PropBank project at the University of Pennsylvania. The Penn project is producing parses of sentences from the Penn Treebank which identify main verbs of the sentences and their syntactic arguments and adjuncts. (See *http://www.cis.upenn.edu/~dgildea/PropBank/*.) The KDG work in FrameNet differs from this, though there are hopes that the two projects can blend. The two projects differ in that while in PropBank the entire constituents are identified with particular argument types, in FrameNet only the lexical heads (or certain kinds of abstract symbols in the case of named entities) are to be listed; PropBank is recording full parses of the sentences, where the KDG is intended to contain only core arguments; PropBank sorts the constituents into a small number of mostly syntactically defined groups (Arg0, Arg1, and Arg2 being the main ones, but various semantically defined types of adjuncts as well); and FrameNet does, but PropBank does not, associate the arguments with frame-relevant semantic role names.[4]

6. References

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[4]Dan Gildea (formerly of FrameNet) has comparisons of PropBank and FrameNet in respect to lexical coverage (in *http://www.cis.upenn.edu/~dgildea/VerbNet/*, but since the FrameNet valence descriptions are not yet publicly available, comparisons of the analyses are not available.