Constraint-Based Processing for Discourse Anaphor Resolution

Donna K. Byron, Vanessa Metcalf   Sun-Hee Lee

The Ohio State University   Wellesley College

byron.18 | metcalf.32@osu.edu   slee6@wellesley.edu

The Problem

Anaphoric pronouns with high-order referents present a challenge to language processing applications. Sentence (2) shows an example:

(1) Pat Walker$_i$ is the new General Manager of Sudsy Soap. He$_i$ was previously Vice President of Operations.

(2) Pat Walker$_i$ {won the championship trophy at Wimbledon}$_j$. He$_i$ is the oldest player to do that$_j$.

Traditionally, grammars have represented only constraints on intra-sentence anaphors. High-order discourse anaphors require more information in the analysis of each sentence.

The objective in anaphor resolution is to determine the correct semantic contribution of the anaphoric element to its sentence. Processing is modeled in two subtasks:

CAPTURE(): using the parser output, determine what new Discourse Entities (DEs) to produce from the sentence. The information that needs to be retained for each DE includes:

- •The semantic type of the DE, i.e. is it an event, a dog, a proposition, etc. This is required so that the semantic compatibility between the DE and the anaphor can be determined. Agreement features (singular/plural etc) are needed as well.
- •Information pertaining to the topicality or discourse weight of the DE, such as how many times it has been mentioned in the discourse-so-far, and its role in the current sentence
- • The activation type of the DE's current mention, as indicated by the type of constituent used to refer to it. Demonstrative pronouns, personal pronouns, verb phrases, etc. introduce DEs with different givenness or accessibility properties.
- •The scope of the DE. For example, if it is mentioned within the scope of a negation quantifier, it may not be accessible for re-mention in subsequent sentences.

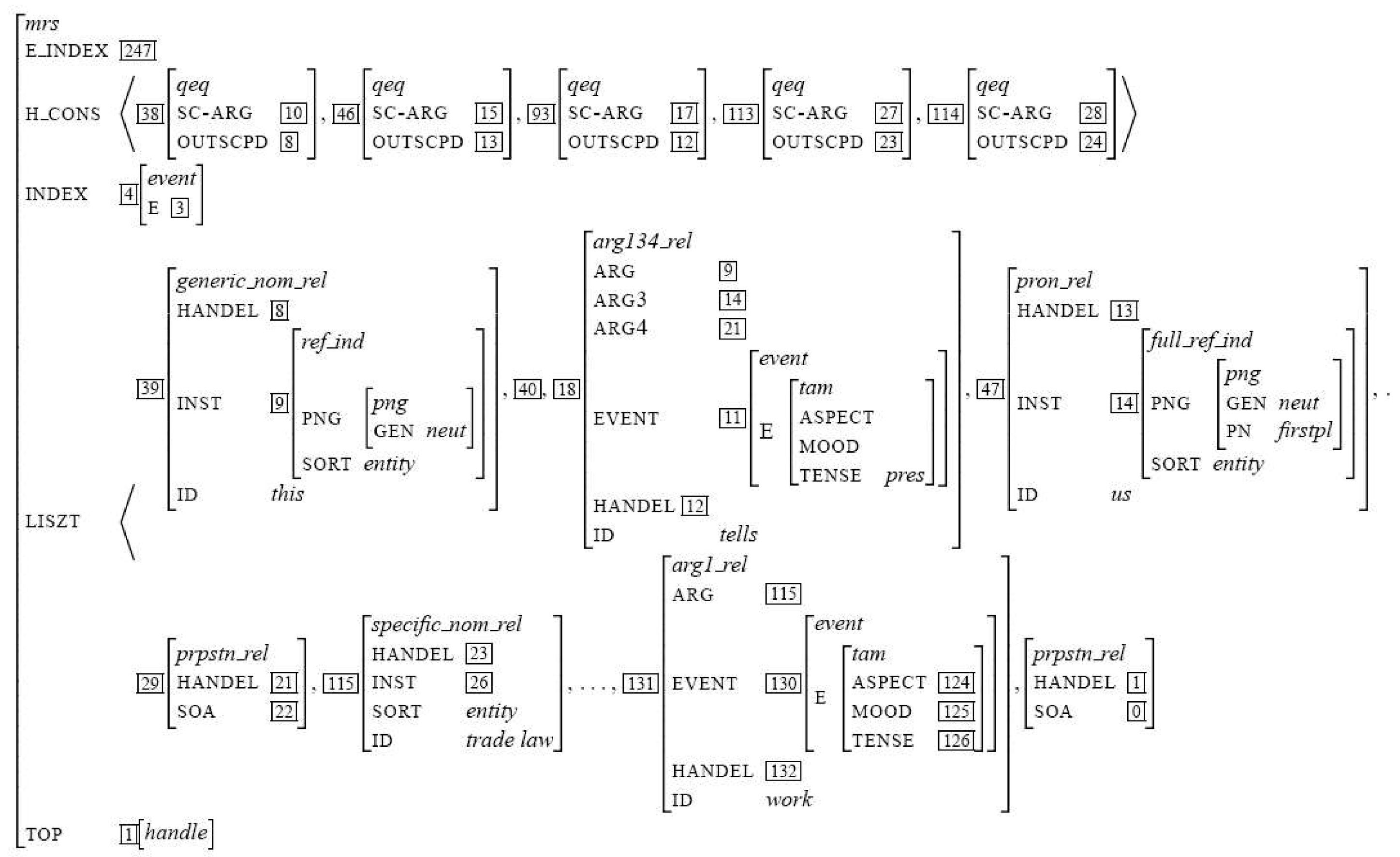
RESOLVE(): determine the meaning of anaphoric NPs. Constraining features include:

- •The thematic role and embedding level of the anaphor within its sentence. For example, the subject of the matrix clause is often expected to refer to a topical element.
- •Semantic restrictions introduced by predicates to which the anaphor is an argument, such as verb argument restrictions.
- •The type of anaphoric expression, for example definite NP vs. pronoun. Their relation to prior discourse is distinct, therefore dedicated processing for each form is necessary.

A large number of features are required to do the job properly, and many systems gather this information from disparate sources. A design goal of our system is that as much as possible of this information should be contained in the parser's output.

Our Implementation

•Our goal is to build an abstract anaphor resolution module into a widely available parser which uses standard output representations.
•Our solution is implemented within the TRALE parser, developed for the MILCA project.
•TRALE utilizes a prolog-reimplementation of the MERGE grammar.
•TRALE is an HPSG-based parser that produces Minimal Recursion Semantics features as part of the synsem analysis of each sentence.



MRS portion of the AVM for "This tells us that trade law is working"

MRS features for abstract anaphora:

- •The PNG feature lists person/number/gender agreement constraints
- •Definiteness of each NP is indicated by the relation *udef_rel def_rel*, and other NP types are indicated by *specific_nom_rel*, *generic_nom_rel*, etc.
- •Lexical semantics such as verb aspect are expressed in the Event feature
- •Argument structure is shown by following the ARG slot of arg rels
- •High-order referents are represented in event frames, indicated in this example with *arg134_rel*, and propositions are indicated with *prpstn_rel*

In most anaphor resolution algorithms, these features are approximated. For example, argument structure is approximately calculated using the NPs position in the syntax tree. Through the semantic attachment rules encoded in the MERGE grammar, our approach should produce more accurate features.

Evaluation

- Our test covers section 0001 – 1099 of the Wall Street Journal portion of the Penn Treebank.
- Includes pairs of sentences where pronoun has abstract referent, which is mentioned in prior sentence

Example sentence pairs:

5) {Prop1 {Event1 {NP1 The documents } also said that {Prop2 {Event2 {NP2 Cray computer } anticipates needing {NP3 another one hundred twenty million } in {NP4 september } } } } }

But {prop1 {Event1 {NP1 Mr Barnum } called {NP2 that=event2 } {NP3 a worst case scenario }}}

2) {Prop1 {Event1 {NP1 Securities firms } have scrambled {INF2 to find {NP2 products } that {NP3 brokers } find easy {INF1 to sell } } } } }

And {Prop1 {Event3 {NP1 the firms } are stretching {NP3 {NP2 their } nets } far and wide {Event1 to do {Event2 it=inf2 } } }

3) {Prop1 {Event1 {NP1 They } also said that {Prop2 {Event2 {NP2 vendors } were delivering {NP3 goods } } } }

{Prop1 {Event1 {NP1 Economists} consider {NP2 that=prop2 } {NP3 a sign } that {Prop2 {Event2 {NP4 inflation } is abating } } }

Noun Phrase	Proposition	Event/Event type	SOA
60	29	35	3

DEs as per [BYR02] DE Capture rules for the test corpus

The MERGE grammar was successfully modified to produce all but one of these DEs: a proposition entity produced by a reduced relative clause.

Reference resolution in this open domain data is challenging, as the constraints from predicate argument position semantic restrictions are not available.

Conclusions

HPSG feature structures with MRS semantic output are useful not only for representing within-sentence constraints but also for language processing applications that need to interpret connected discourse in context.

This experiment involved manual additions to an existing grammar, which was time-consuming and labor-intensive. Automatically acquiring the rules from a labeled corpus would be desirable.

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