Pre-Processing MRSes

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Abstract

We are in the process of creating a pipeline for our HPSG grammar for Norwegian (NorSource). NorSource uses the meaning representation Minimal Recursion Semantics (MRS). We present a step for validating an MRS and a step for pre-processing an MRS. The pre-processing step connects our MRS elements to a domain ontology and it can create additional states and roles. The pipeline can be reused by other grammars from the Delph-In network.

1 Introduction

NorSource\(^1\) (Beermann and Hellan, 2004; Hellan and Beermann, 2005), a grammar for Norwegian, is a Head-Driven Phrase Structure Grammar (HPSG) (Sag et al., 2003), developed and maintained with the Linguistic Knowledge Builder (LKB) tool (Copestake, 2002), and originally based on the HPSG Grammar Matrix, which is a starter kit for developing HPSG grammars (Bender et al., 2002). An HPSG grammar can use Minimal Recursion Semantics (MRS) as meaning representation (Copestake et al., 2005). In order to speed up the parsing process (the unification algorithm), a HPSG grammar can be compiled and run (parsing) with the PET\(^2\) tool (Callmeier, 2001). The Flop program in PET compiles the LKB grammar and the Cheap program runs it. An alternative to the PET system is the Answer Constraint Engine (ACE)\(^3\) created by Woodley Packard. ACE can parse and generate using the compiled grammar.

Our goal is to create a pipeline for the NorSource grammar and use it to create small question-answer systems or dialogue systems. The first step in the pipeline is the parsing process with ACE. The next step is to select the most suitable MRS. We use Velldal’s ranking model (Velldal, 2008). The model is based on relevant sentences from our system, treebanked with [tsdb++] (Oepen et al., 2002; Oepen and Flickinger, 1998). The selected MRS is checked with the Swiss Army Knife of Underspecification (Utool) (Koller and Thater, 2006b) and our own validating procedure. Only well-formed MRSes are used in our pipeline. We also use Utool to solve the MRS and to eliminate any logically equivalent readings. The next step is to pre-process the MRS (calculate event structure and generate roles), and the last step in our pipeline creates a First-Order Logic formula from the MRS (only the easy cases).

Our contribution is the validating step and the pre-processing step.

In the next section, we give a brief introduction to MRS. Then we present details from our validating procedure. Next, we solve an MRS and eliminate logically equivalent readings with Utool. We pre-process the selected MRS in section 6. At last, we look at a way to create a First-Order Logic formula from a solved MRS and we present a few challenges from our research.

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\(^1\)http://typecraft.org/tc2wiki/Norwegian_HPSG_grammar_NorSource
\(^2\)http://pet.opendfki.de/
\(^3\)http://moin.delph-in.net/AceTop
2 Minimal Recursion Semantics

The elements of an MRS can be defined by the structure $\text{mrs}(T, I, R, C)$, where $T$ is the top handle, $I$ is the index, $R$ is a bag of elementary predictions (EP), and $C$ is a bag of constraints.

Every dog chases some white cat

(1) can have the following MRS (created for demonstration purposes):

$$
\text{T } h_0, \\
\text{I } e_1, \\
\text{R } \{ h_1;\text{every}(x_1,h_3,h_8), h_3;\text{dog}(x_1), h_7;\text{white}(x_2), h_7;\text{cat}(x_2), h_5;\text{some}(x_2,h_{10},h_9), \\
\quad h_4;\text{chase}(e_1,x_1,x_2) \} \\
\text{C } h_{10} = q h_7
$$

An MRS can be in two states: unsolved or solved. An algorithm (LKB and Utool) brings an MRS from the unsolved state into one or more solved states. An unsolved MRS has holes that are not in the set of labels, and a solved MRS has holes that are from the set of labels. The set of labels in our example: \{h_1, h_3, h_4, h_5\} and h_7}. The set of holes: \{h_3, h_8, h_9\} and h_{10}\}. A hole can be either open or closed. A hole is open when it isn’t in the set of labels, and a hole is closed when the hole is in the set of labels. Hole h_3 is closed in our example.

3 Validate MRSes From NorSource

We want to search our MRSes for properties that can lead to problems. The Utool solvable function checks if an unsolved MRS can be transformed into one or more solved MRSes without violating the MRS definitions.\(^4\) Our validating procedure contains a set of functions. We create variables or list of variables for each function that is positive. The functions are: empty index, empty feature, empty reference, key conjunction, and argument EP conjunction. An empty index exist when the index value refers to a variable that is not an EP’s arg\(_0\). An empty feature exist when a feature value refers to a variable that is not found in the EP’s arguments. An empty reference exist when an argument refers to a variable that is not an EP’s arg\(_0\) and the variable is not in the set of feature values. A key conjunction exist when more than one EP in an MRS have the same arg\(_0\) and they are not quantifiers. An argument EP conjunction exists when an argument contains a label that is an EP conjunction. In Table 1, the variable

| EP | Feature |
|----|---------|
| $h_3;\text{pred}_1(\text{arg}_0(e_1),\text{arg}_1(h_9))$ | $e_1,\text{feature}_1,\text{value}_1$ |
| $h_9;\text{pred}_2(\text{arg}_0(u_1),\text{arg}_1(x_1),\text{arg}_2(u_{10}))$ | $u_{12},\text{feature}_2,\text{value}_2$ |
| $h_9;\text{pred}_3(\text{arg}_0(u_1),\text{arg}_1(x_1),\text{arg}_2(x_2),\text{arg}_3(u_{15}))$ | $u_{15},\text{feature}_3,\text{value}_3$ |
| $h_2;\text{pred}_4(\text{arg}_0(x_1))$ | $u_{16},\text{feature}_4,\text{value}_4$ |
| $h_4;\text{pred}_5(\text{arg}_0(x_2))$ | |

Table 1: Eps and Features

u\(_{12}\) is an empty feature. The variable u\(_{10}\) is a empty reference. The arg\(_0\) of pred\(_2\) and pred\(_3\) form a key conjunction. The argument h\(_9\) in arg\(_1\) of pred\(_1\) is an argument EP conjunction.

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\(^4\)Utool is stricter than the LKB software, see Fuchss et al. (2006).
4 Selecting An MRS

Before we create a ranking model, we analyze and compare the MRSes from our domain. We use the variable-free solution Oepen and Lønning introduced (Oepen and Lønning, 2006). We compare parts from the syntax tree, the EPs, the features, and if the MRS is solvable or not. We also present results from our validation procedure. If we parse (2) with NorSource, it yields 9 MRSes. Parts of the EP information is presented in Table 2.

| legge_v ARG1 addressee-rel | 1 2 3 4 5 6 7 8 9 |
|---------------------------|--------------------|
| legge_v ARG2 bok_n        | x x x x x x x x x |
| legge_v ARGX på_p         | x x x x x x x x x |
| på_p ARG1 bok_n           | x x x x x x x x x |
| på_p ARG1 legge_v         | x x x x x x x x x |
| på_p ARG2 bord-1_n        | x x x x x x x x x |

Table 2: Compare MRSes

We use the LOGON software to treebank ([tsdb++] and to create our ranking model (we have copied adjusted the scripts in folder lingo/redwoods). We parse with the ranking model and we select the first MRS.

5 Solving The MRS

Utool solves an MRS using a dominance graph and a chart (Niehren and Thater, 2003). The redundancy elimination algorithm (Koller and Thater, 2006a) takes a chart and a redundancy elimination file as input and returning the chart without the redundancy. We have created a redundancy elimination file according to (Koller and Thater, 2006b) for our quantifiers.

6 Pre-Processing The Selected MRS

In the pre-processing step we focus on the event structure and roles. By event structure we mean: sub events, aspectual and causal notions. Vendler grouped verbs into classes based on their temporal properties (Vendler, 1967). The verbs are classified according to duration and presence of a terminal point. A verb with a terminal point is called telic (the verb culminates). Vendler’s classes are also known by other terms such as: eventualities, situations, lexical aspect or Aktionsart. The classes are: state, point, process, achievement, and accomplishment. The verb’s connection to a class is not static, because a verb argument can move an event from one class into another. This phenomenon is called aspectual composition or coercion (Moens and Steedman, 1988).

A predicate string in an EP can contain the prefix “_”, the suffix “_rel”, a name, a part-of-speech type and a sense number. The name, the part-of-speech type and the sense number can be connected to a domain ontology definition. If we don’t have the sense number, we can have a list of domain ontology definition candidates. A predicate string can also be a unique name like in “first_position_prominent”.

Our goal with the pre-processing is:

- to connect the names in the predicate strings to a domain ontology
- to check if the predicate and the predicate arguments are valid according to the domain

A demo for NorSource: http://regdili.idi.ntnu.no:8080/comparemrs/compare
• to create a common structure for a set of verbs
• implement an algorithm for roles and states

The main elements of our solution are a predicate tree, an algorithm, a domain ontology, and a set of object-oriented classes. The predicate tree is created from the predicates and their arguments.

![Predicate Tree Diagram]

**Figure 1: The Predicate Tree and the Movement Class**

Frank kjører veien til Dragvoll
Frank drives the road to Dragvoll

(3)

The predicate tree on the left in Figure 1 is created from (3). The algorithm searches the predicate tree and for each node in the tree it finds templates from the domain ontology. A template contains checks against the domain ontology, a return function and a return class. One of the templates used in our example is shown in Table 3. The variable X is replaced by vei_n1 in our example. The final class for

| key  | nodes check list       | return class |
|------|------------------------|--------------|
| mod5 | node(n,X) isa(X,path_n1) new path node(subpath,til_p1) |

**Table 3: Template Example**

(3) is shown on the right in Figure 1. We have defined three return functions: “new”, “call” and “fork”. “New” creates the return class from its arguments. “Call” is used when one node consumes another. For example in “VP PP”, the PP can be consumed by the VP. “Fork” is used when different classes are connected. For example in “My uncle goes to town” we have a Family class and a Movement class that are connected through the variable for the uncle. The Movement class for (3) contains the following information:

**movement**

- event(e1:kjøre_v1)
- subject(x2:frank_na1)
- path
- object(x9:vei_n1)
- end-point(x1:dragvoll_na1,t2)

**checks**

- has(dragvoll_na1,location)
- isa(vei_n1,path_n1)
- templates [tv2, pp2, mod5]

The Movement class is a result from analyzing a number of different sentences about objects changing location. The Movement class is a process and it can contain a path, a departure, an arrival, a road (named path), a vehicle etc. A number of these objects are connected. For example the beginning of the process and the beginning of the path. The beginning of the path and the departure. We have implemented an algorithm for detecting the roles work and cargo. Work indicates an object that is using energy. Cargo indicates an object that is being transported.
The classes can be used as they are in a further reasoning process, or they can generate EPs and features that are inserted into the MRS. For example, the state \textit{at\_location}(x_4, x_1) can be inserted in an EP conjunction.

### 7 Logic Form

The solved MRSes are not yet formulas in First-Order Logic. We have to convert arguments that are in a Higher-Order Logic, insert the \textit{not} operator, and use the quantifiers from First-Order Logic. An argument that has an EP conjunction or has a handle needs to be rewritten. An argument with a handle is replaced with the \textit{arg}_0 from the EP of the handle. We can give a reference and a predicate to the conjunction or we can find a candidate in the conjunction. We use the latter method. The predicate \textit{neg\_adv\_rel} is converted to the operator \textit{not}. We have connected some of the NorSource quantifiers to the First-Order Logic quantifiers \textit{exist} and \textit{all}. Quantifiers like \textit{some}, \textit{few}, etc can be assigned to a group \textit{/} type of their own. We place an operator between the arguments “RSTR” and “BODY” in our quantifiers:

\[ \exists(y)[\textit{pred}_1(y) \textit{operator}_1 \\forall(x)[\textit{pred}_2(x) \textit{operator}_2 \textit{pred}_3(x, y)]] \]

We have defined \textit{operator}_1 as \& and \textit{operator}_2 as \rightarrow. The formula from (3) is:

\[ \exists(x_1)[\textit{na}(x_1, \textit{dragvoll}) \\land \exists(x_2)[\textit{na}(x_2, \textit{frank}) \\land \exists(x_9)[\textit{vei\_n}(x_9) \land \textit{kjøre\_v}(e_1, x_2, x_9) \land \textit{til\_p}(u_1, x_9, x_1)]] \]

The meaning of the MRS quantifiers are preserved with the extra predicates: \textit{q\_meaning}(u100, x_1, \textit{def}), \textit{q\_meaning}(u101, x_2, \textit{def}) and \textit{q\_meaning}(u102, x_9, \textit{def}). These predicates need to be inserted into the logic formula.

### 8 Challenges

The first challenge is to find a representative selection of sentences from the domain. The sentences are treebanked and used in our ranking model, and their selected MRSes are also used for creating domain ontology definitions. We use a virtual profile where we can add new annotated profiles.

We need to find a way to process our quantifiers that are not in First-Order Logic. At this early stage we can use off-the-shelf theorem provers and model finders as described in Blackburn’s and Bos’ reasoning framework for First-Order logic (Blackburn and Bos, 2005). We must classify different kinds of questions and commands, and we need to describe how to process them.

So far, we have connected types for each EP together, but sometimes a more detailed structure is required in order to express meaning. A part of one structure can connect to a part of another. In the examples: “the cat sits in the car”, “the cat sits on the car”, and “the cat sits under the car”, there are three different locations related to the car. We have a container in the car, an area on top of the car, and a space under the car. This extra information needs to be used together with the MRS. Sometimes more ambiguities are introduced and we need a ranking. For example in “Fred poured coffee on the thermos”, the most probable is when the coffee ends up inside the thermos and the less probable version where the coffee is poured on the outside of the thermos. We also want to use previous situations and the discourse so far in our pre-processing step.

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