ABSTRACT

This paper presents the advantages of using a semantic network
with default and exception abilities for a specific problem in
language processing. More precisely, we show that the features
of this semantic network provide an adequate representation of
texts expressing a general rule and its exceptions. General
statements are usually expressed in natural language by the
presence of some specific words, and they occur frequently in
our application domain. Our research is effectively integrated in
a whole project which is an interactive user-aided tool for the
design, specification and checking of the different elements including the use of graphics and
textual comments. The general cases of treatments are
represented by semantic rules which are not strict and admit
exceptions. The inferences supported by the network are
justified by an interpretation in default logic.

1 INTRODUCTION

The "understanding" of natural language by computers needs a
translation of sentences into some formal representation and the
use of some commonworld knowledge represented in a
knowledge base. Semantic networks have often been used in
natural language processing since 70's (13). As knowledge base
for syntactic and semantic processing, a KL-ONE (5) semantic
network was used in the RUS project of (4). More recently,
many research works lead to add expression of exceptions in
semantic networks (8). On the practical point of view, L. Rector
(11) showed the interest of defaults and exceptions in a semantic
network to represent medical knowledge. The system of
treatment of NL that we present is based on a semantic network.

Our research takes place in a whole project which uses artificial
intelligence techniques to help the acquisition of requirements in
software engineering. The project wants to offer an "intelligent"
environment for standard methodologies describing
requirements, including the use of graphics and textual
comments on the objects defined in the graphics. These
comments are analyzed syntactically and semantically, then
translated into the semantic network. Previous knowledge on
general and specific domain is represented as the initial state of
the network. This prior knowledge eases the parsing and allows
a partial validation of new texts. The semantic analysis permits a
coherence control of the specification and a gradual enrichment
of the knowledge base. The final result is a reliable specification
in which the most common inconsistencies have been avoided.

Our semantic network includes default, exception and negation
links. Default links are the most usual in our application.
Indeed, all along the enrichment process of a specification, the
user describes roughly the principal features and then refines
them. Often, the particular cases are in contradiction with the
general one. But it is important to represent both of them, and it
is possible only with exception link to keep a coherent network.
The only other possibility would be to know all the particular
cases at the very beginning (6), which is unrealistic, and to
prohibit general descriptions, which is unfortunate.

First of all, we describe briefly our system and its application
domain. Then we give the syntax of our semantic network, and
the representation of natural language expressions into the
semantic network language, with a special interest to default and
exceptions links. Finally we give an interpretation of the
network objects in default logic.

2 THE NATURAL LANGUAGE SYSTEM

The system of natural language analysis and representation
includes six modules.

- the editor: it gives a tool that is for a user to express his/her
specifications in some rigid structure. After a study of the
language used in software specification domain, we have
defined a few sentence types sufficient to describe
requirements. This typology has led us to restrict the allowed
syntax to some "templates" which contain some semantic
information. Each template corresponds to both a syntactic
structure and a rule for network construction. These templates
are the sentence units of requirements (for instance, function
definition, function explanation, data definition, by examples or
by decomposition).

- the syntactic analyzer: based on ATN (15), it checks for
syntactic correctness of the template content and sends some
"syntactic atoms" to the semantic analyzer. The parser uses a
syntactic lexicon which contains a general vocabulary and a
specific one on the application domain.

- the semantic analyzer: it checks for semantic validity of the
syntactic structures, builds semantic relations and translates
them into the network language. It uses a semantic lexicon in
the spirit of (14) and specific translation rules some of which are
predefined in the lexicon. The resulting interpretation is given to
the system user who can either request the system to perform
another interpretation, or rewrite his/her text.

- the semantic network: the network is KL-ONE-like,
augmented with default, exception and negation links. It
includes the knowledge base of the application and a base
controller. This base contains a minimal set of general
knowledge and domain knowledge in a long term memory, and
the semantic translation of the texts written by the user in a
working memory. The first is not called in question when the
second is enriched. After the enrichment, the network controller
performs a validation to verify the global structural correctness
of the new network.

- the semantic enrichment module: it communicates with the
semantic network and determines the validity of an integration
and the possible network modifications to be performed before.
A provisional version of the modified portion of the network is
built allowing for effective enrichment only after a first step of
validation. This local validation is performed by the network
controller, and by the enrichment module. This latter uses

Using exceptions in a semantic network for
a natural language application

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semantic rules on the domain which are not represented in the network. Once this first step of validation finished, the system proposes to the user an interpretation of the sentence. If he/she is satisfied, the semantic representation is integrated into the network.

- the validation module: it verifies that the modifications of the network are not in contradiction with the interpretation of the network entities. Some possible new contradictions could appear, or some subtle incoherences like a disrespect of constraints of non circularity on some particular relations.

When an inconsistency is detected and not resolved, or when ambiguity is not solved, the system informs the user. The semantic network does not integrate ambiguity.

3 NETWORK SYNTAX AND INFERENCE RULES

We present the only part of (7) used in this paper.

3.1 Syntax

\[ n \rightarrow \text{ generic concept } \quad \rightarrow \text{ iskindof strict link } \]

\[ \text{exclusion strict link} \quad \rightarrow \text{exception link} \]

\[ \text{general role strict link} \quad \rightarrow \text{general role default link} \]

\[ (n,m) \]

\[ (\text{ generic concept }) \]

n is the minimum cardinality of the role, m is the maximum cardinality. The concept at the extremity of a role link is called "value", "role" default links admit exceptions on "cardinality" and/or "value". An exception link is from a concept to a "ISKINDOF" default or a "EXCLUSION" default link, or from a role to an other role.

The whole network includes individual concepts, "ISA" and "ISNOTA" links (from an individual concept to a generic concept), "INDIVIDUAL ROLE" links, "RESTRICTION" (cardinality/value) and "DIFFERENCIAION" links.

3.2 Inference rules used by our deduction algorithms

We give the taxonomic rules used by the network to deduce information about a concept.

*Transitivity through "ISKINDOF" strict and default.

The managers are always employees, the employees are always persons, so the managers are always persons.

*deduction made from a default fact is a default deduction.

management secretaries are secretaries, in general the secretaries are women, so in general the management secretaries are women.

*strict deduction prevails over a default deduction

The fact that the women management secretaries are managers prevails over that they generally are not managers. In fact the women management secretaries are always managers, always women secretaries and always women.

*modus tollens.

In general secretaries are women, in general women are not managers (and vice-versa), the head managers are always managers, so in general the head managers are not secretaries (and vice-versa).

4 HOW TO USE NETWORK OBJECTS TO REPRESENT NL?

The initial kernel of the semantic network includes general knowledge: general semantic information about cases (in a case grammar terminology (9) (3) e.g. the action concept and its roles, and about the world, e.g. the concepts entity, physical object, person, and application-specific knowledge e.g. for the specification of the clocking system of a company, the concepts to clock, work place, hour's overtime. Once this kernel defined, it is gradually enriched from analysis of sentences.

Our unit of work for the enrichment is a semantic relation. It can be represented in the network by a new concept which would be sub-concept of an old one, or by a strict or default link (ISKINDOF, EXCLUSION or ROLE) between two concepts, or by a restriction on a link (value or cardinality restriction on role, or exception on any kind of default link). In the following examples we present the use of strict, default, and exception links.

4.1 What to express by strictness?

A strict link does not support exception. We use it only when the statement is strengthened by the presence of some adverb as (toujours, jamais, always, never) or some determiner as (tous, chaque, all, every). As example, we explain the most current use of ISKINDOF or EXCLUSION strict links.

Let be a sentence \( P = [D] \) NP1 be [ADV] SA where:

- D is one of the indefinite adjectives (toujours, jamais) and ADV is an adverb (toujours, jamais).
- at least one of D or ADV is present in the sentence.
- SA is a subject attribute represented by a concept named here NP2. It can be either a NP or an adjective.
- NP1 is represented by a concept named NP1.

P will be represented by a strict ISKINDOF (or EXCLUSION if ADV is a strengthened negative adverb as never) link between NP1 and NP2:

4.2 What to express by default links?

This type of objects may support exceptions. If the new statement to be represented is not strengthened in some way, we
use default link. This avoids any further difficult restructuring of the network in case of enrichment by some new contradictory information. We illustrate this with a rule for creating default roles.

Let be a sentence \( P = NP \ V \), on which the semantic analysis gives as result:
- \( NP \) is the agent of the verb \( V \).
- \( NP \) and \( V \) are represented by concepts named respectively \( NP \) and \( V \).

The semantic relation between \( NP \) and \( V \) is represented in the semantic network by a default role named agent-1 from the concept \( NP \) to the concept \( V \). This role expresses that to play the role agent for \( V \) is a definitional property\(^1\) of \( NP \). The reverse agent role from \( V \) to \( NP \) is deductible; it is explicitly created if there is something more to express on it.

\[
\text{employee agent-1} \to \text{clock} \\
(1,n)
\]

The negative form of the sentence would be represented by a cardinality \((0,0)\).

\[
\text{manager agent-1} \to \text{clock} \\
(0,0)
\]

4.3 What to express by an exception link?

When the network detects a contradiction with a default statement, it can be easily resolved by an exception link. Most often, the enrichment module decides to build the necessary exception link after asking the user a confirmation of this interpretation. We give examples of affirmative statements which are then negated; the treatment is similar for the inverse case.

4.3.1 When to create an exception on a default role?

Let suppose that the network contains the representation of the sentence \( P = NP \) be \( NP2 \). Let a new sentence be \( P' = D \) \( NP1 \) be not \( NP2 \), where \( D \) is one of the indefinite adjectives (certains, quelques, some, any). \( P' \) will be represented by a new subconcept \( NP1 \cdot 2 \) of \( NP1 \), with strict links ISKINDOF to \( NP1 \) and EXCLUSION to \( NP2 \). The network detects a contradiction: \( NP1 \cdot 2 \) ISKINDOF \( NP2 \) by transitivity from \( P \) and \( P' \), and \( NP1 \cdot 2 \) EXCLUSION \( NP2 \) from \( P' \). The enrichment resolves it by creating an exception link from the concept \( NP1 \cdot 2 \) to the default link from the concept \( NP1 \) to the concept \( NP2 \).

<table>
<thead>
<tr>
<th>Concept</th>
<th>Role</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>secretary</td>
<td>woman</td>
<td>les secrétaires sont des femmes; quelques secrétaires ne sont pas des femmes (secretaries are women; some secretaries are not women)</td>
</tr>
<tr>
<td>woman</td>
<td>sec-not-woman</td>
<td></td>
</tr>
</tbody>
</table>

\(^1\) Definitional properties are inherited, they correspond to starting links; the roles arriving to a concept express only the ability for an instance of the concept to play this role; the reverse role is necessary when to play a role is part of the definition of a concept, as it is the case here.

5 INTERPRETATION IN DEFAULT LOGIC

For details on default logic, see (12). A default is written like: \( X : Y \) \( Z \).

\( X \) is the prerequisite (that is necessary to apply the default), \( Y \) is the justification (from which the negation prevents the application of the default), \( Z \) is the consequent (that is inferred when the default is applied).

A normal default is like: \( X : Y \)

\( Y \)

A semi-normal default is like: \( X : Y \wedge P \)

We used "semi-normal" defaults derived from research of (10). For each default link ("iskindof" and "exclusion") they attribute an unary predicate. The advantage of these defaults is the modularity. For the interpretation of the modus tollens we are inspired by (1) who proposed a default called "free" because it has no prerequisite.

**ISKINDOF** default link:

\[
\begin{array}{c}
A\\
\end{array} \quad \begin{array}{c}
\text{Lab}\\
\end{array} \\
\begin{array}{c}
(\neg B(x)) \land \text{Lab}(x) \\
\end{array} \quad \begin{array}{c}
A(x) \Rightarrow B(x) \\
\end{array}
\]

For the modus tollens interpretation: If the default is applicable we infer \( A(x) \Rightarrow B(x) \), so if \( A(x) \) is true we infer \( B(x) \) else if \( \neg B(x) \) is true we infer \( \neg A(x) \).

**EXCLUSION** default link:

\[
\begin{array}{c}
A\\
\end{array} \\
\begin{array}{c}
\text{Lab}\\
\end{array} \\
\begin{array}{c}
(\neg A(x)) \land \text{Lab}(x) \\
\end{array} \quad \begin{array}{c}
A(x) \Rightarrow \neg B(x) \\
\end{array}
\]

**GENERIC ROLE** default link:

\[
\begin{array}{c}
A\\
\end{array} \quad \begin{array}{c}
\text{Lab}\\
\end{array} \\
\begin{array}{c}
R\\
\end{array} \\
\begin{array}{c}
B\\
\end{array} \\
(0,m)
\]

\( (\ast) A(x) : (\exists y (x, y) \land (y, R(x, y)) \mid 1 \leq m) \)

\( (\ast) A(x) : (\exists y (R(x, y)) \Rightarrow B(y)) \)

\( (R(x, y) \Rightarrow B(y)) \)

Default \( (\ast) \) interprets the role cardinality and default \( (\ast \ast) \) the role "value". Our defaults justify the rules used by our algorithms (cf. 3.2.). Under some constraints on the network, its net theory has a single extension. That means that there is no ambiguity in our knowledge base.
6 CONCLUSION

We have presented the basic rules for using a semantic network with exception ability for the representation of natural language. The existence of exception and default links allows to express together general rules and particular cases which do not respect them. Without exception, the network had to be modified to avoid contradiction. The general rule must be suppressed to keep only the particular ones. This requires to reorganize the network, which is costly and difficult. Moreover, in our application of enrichment, this happens often, and anyway general rules with their particular cases are both needed. This work results in a knowledge base of the application in which most of the inconsistencies and all ambiguities have been removed. Moreover, the deduction mechanism is justified by an interpretation in default logic. This paper focus on exception use without details on natural language analysis or on the enrichment part which are studied thoroughly in (2). But we only treat a restricted natural language without grappling hard difficulties. An implementation in Smalltalk80 is in progress on Apollo workstations.

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