Practical World Modeling for NLP Applications

Lynn Carlson
U.S. Department of Defense
Ft. George G. Meade, MD 20755
lcarlson@anl.cs.cmu.edu

Sergei Nirenburg
Center for Machine Translation
Carnegie Mellon University
Pittsburgh, PA 15213
sergei@nl.cs.cmu.edu

1 Why Does One Need a World Model?

Practical NLP applications requiring semantic and pragmatic analysis of texts necessitate the construction of a world model, an ontology, to support interpretation of text elements. Constraints on world model elements serve as heuristics on the cooccurrence of lexical and other meanings in the text, facilitating both natural language understanding and generation. Propositional meanings (defined in the lexicon in terms of links to the world model) trickle down to the text meaning representation as instances of world model entities. Our primary objective in world modeling is to support multilingual applications, so constructing a language-independent ontology is crucial. The word sense view of ontology building leads to proliferation of concepts whenever words in different languages do not “line-up” (see EDR 1990), while using a core set of “primitives” is limited for large-scale applications, if shades of meaning are to be captured. In our environment, concept acquisition is guided by examining cross-linguistic evidence and representational trade-offs. In other large-scale ontology projects, the separation of lexical from conceptual knowledge is not always clear, as in the Cyc project at MCC, a knowledge base containing millions of facts about the world (Lenat and Guha, 1990), or the KT system (Dahlgren, 1988), which classifies commonsense knowledge for English words.

In the DIONYSUS project at CMU, the world model, the lexicon and the text meaning representation are closely interconnected, in terms of their content and format. World modeling is supported by the ONTOS system, which consists of a) a constraint language, b) an ontology, or set of general concepts, c) a set of domain models and d) an intelligent knowledge acquisition interface. The basic features of the ONTOS constraint language are as follows (see Carlson & Nirenburg, 1990, for details). A world model is a collection of frames. A frame is a named set of slots, interpreted as an ontological concept (voluntary-olfactory-event, geopolitical-entity). A slot represents an ontological property (temperature, caused-by) and consists of a named set of facets. A facet is a named set of fillers. Facets refer to the status of property values, e.g.: value: actual values of property (e.g., for concept instances) default: typical value of a property sem: set of “legal” values; akin to selectional restrictions

A filler is a symbol, number, range, etc. A symbolic filler (prefixed by “*”) names an ontological concept: (ALL (SUB-

2 Ontology Building in Context: Scalar Attributes

In the ONTOS system, a mechanism relating scalar attributes (AGE, TEMPERATURE) to measuring units (TEMPORAL-UNIT, THERMOMETRIC-UNIT) allows scalar information to be converted into a standard format for interlingua representation. The DOMAIN slot of a scalar attribute defines the types of concepts the attribute can describe. In the ATTRIBUTE-RANGE slot, the sem facet specifies an absolute constraint on the range of numerical values the attribute can have, while the measuring-unit facet designates a standard unit for interpreting the constraint:

\[
\text{ATTRIBUTE-RANGE} (\text{sem} (> 0))
\]

Ontology building has never been a totally independent project in our environment. World knowledge in DIONYSUS has been acquired with the express purpose of using it in a natural language processing system. Knowledge representation requirements of such a system include, in addition to ontological specification, a representation for a lexicon entry and a language for recording the meaning of input text. The interaction between these static knowledge sources and a natural language analyzer is illustrated in Figure 1.

World modeling decisions about scalar attributes are influenced by the way the lexicon is built and vice versa. In the DIONYSUS system, relative scalar terms like high/low are not given a separate ontological status. Instead, lexical entries for such words are associated with ontologically motivated constraints on scalar attributes. The language-specific relationship between word-modifier and the language-independent relationship between concept-property is illustrated using the example of fresh-brewed coffee. In the ontology, the concept COFFEE appears as follows:

\[
\text{COFFEE}
\]

The default facet of the AGE slot expresses a typical range of values for the age of COFFEE, which can be overridden, as
Next, links between word sense and ontological concept are created for the open-class lexical items in the sentence. These links are recorded in the SEM zone of the lexical entry, where a correspondence is established between semantic and syntactic roles:

\[
\text{smell} \rightarrow \text{VOLUNTARY-OLFACTORY-EVENT}
\]

\[
\begin{align*}
\text{AGENT: ANIMAL } (^{\text{\$var1}}) & \quad \text{links to the \text{SUBJ} role} \\
\text{THEME: PHYSICAL-OBJECT } (^{\text{\$var2}}) & \quad \text{links to the \text{OBJ} role}
\end{align*}
\]

The \$var1 retrieves the meaning of the lexeme bound to the variable \$var1 during syntactic parsing, places it in the \text{AGENT} role of \text{VOLUNTARY-OLFACTORY-EVENT}, and checks to make sure that the ontologically specified constraint (\text{AGENT: ANIMAL}) is satisfied.

Finally, we illustrate the key components of the text meaning representation for a sentence:

\[
\begin{align*}
\text{clause} & \\
\text{head: voluntary-olfactory-event}_1 & \\
\text{aspect:} & \\
\text{phase: end} \\
\text{duration: prolonged} \\
\text{iteration: single} \\
\text{voluntary-olfactory-event}_1 & \\
\text{agent: speaker} \\
\text{theme: } \text{coffee}_1 \\
\text{coffee}_1 & \quad \text{age: } < 0.4 \text{ hour}
\end{align*}
\]

3 Conclusions

We have addressed some of the issues that arise when world modeling is viewed as a component of knowledge support for natural language processing. In DIONYSUS, the interdependence of ontology, lexicon and text meaning representation is such that ontology acquisition never proceeds in an isolated fashion. The discussion presented here regarding scalar attributes is just one example of ontological decision making in context. We would like to thank the members of the DIONYSUS project—Ralf Brown, Ted Gibson, Todd Kaufmann, John Leavitt, Ingrid Meyer, Eric Nyberg and Boyan Onyshkevych. Thanks also to Irene Nirenburg and Ken Goodman.

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