Extending Hybridity within the YAK Knowledge Representation System

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1 YAK

YAK [6] is a hybrid KR system, and in its foundations is similar to Classic [3] and Loom [8]. The core of the system is a "traditional" TBox/ABox hybrid representation language (with some peculiarities), enhanced, possibly in a "principled" fashion, with other hybrid modules representing different kind of knowledge and reasoning. The system, fully implemented in CommonLisp (and with an optional graphical user-interface machine-dependent), is the main knowledge representation module of the AlFresco natural language system, a multimodal dialogue prototype for the exploration of Italian art history.

The expressivity of the YAK TBox comes out from a study about the balancing of expressiveness, functional adequacy and formal properties of deductive procedures. It has been shown in [5] how some constructs — though enhancing expressive power and still maintaining tractability — do not give an intuitive behaviour to the language, from the point of view of both meaning and calculus.

The classifier provided within the YAK system has a tractable, sound and complete algorithm. Moreover the classifier is speeded up by a caching mechanism and an intelligent name expansion scheduling, borrowed from the tabular approach used in nondeterministic natural language parsers.

The ABox is a simple object oriented language, just like Classic: individuals are instances of concepts and incomplete descriptions are allowed. The query language has the same expressive power of the individual description language, with one variable.

2 Extending Hybridity

I quote James Schmolze [11] because I believe that this position is still of great topical interest:

> Terminological systems must fit within larger representational frameworks. It is therefore time to assess how well previous and current KR systems have integrated terminological, (grounded) propositional, equational, rule- based and other representations and reasoners. (...) it is important to address the larger context in which such systems are placed and used.

Motivations and new ideas for the KR field often are originated within the natural language processing community. Prototypical knowledge for prediction in natural language understanding [7], belief representation for user modeling in a multi-agent dialog [2], reasoning about sets to handle conjunctions, plurals and natural quantifiers [1], reasoning about time relations [12] [10] are some aspects that we have taken into consideration. We are also exploring the possibility of reasoning in a coherent way with procedural attachments (following Classic) and production rules [14], and of using Weyhrauch's FOL system as an alternative ABox [4].

Within the framework of a complex hybrid architecture supporting multiple reasoning modalities, several aspects must still be addressed. The need of a greater expressivity to represent complex relations in natural language should be considered a major topic in the KR research — see, as an example, the KODIAK system [13]. Another important issue concerns the inference control procedure in the assertional component, as far as a single conclusion can arise out of different modalities which have different import. In these cases a belief revision mechanism [9] is central in order to manage nonmonotonic effects.

2.1 Prototypes

In this research project [7] the problem of instance recognition within an extended hybrid knowledge representation system is addressed. Structural aspects of concepts are represented at two separate levels, the terminological and the prototypical; individuals are expressed in the frame-based assertional component. The hybrid reasoning mechanism recognizes the type of the individuals with respect to the terminology, making use of reasoning with prototypes.

Basic ideas are shared with the so called Dual Theory about the mental representation of concepts. Within this theory concepts have a twofold representation: a "core description", useful for compositional meaning, and an "identification procedure" for typical instance recognition. Our own realization of such a distinction is that the core strictly defines the necessary and sufficient properties for the concepts (only the necessary ones in the case of primitive concepts), while the identification procedure is a similarity mechanism that works over a collection of perceptual and functional properties. We call such a collection the *prototype* for that concept. Within the identification procedure a "similarity model" is introduced that describes the probability rating that an object belongs to a class, supported by the similarity that the object shares with the prototype of that class.

The hybrid reasoning mechanism we propose extends the recognizing process of individuals in the assertional component. It makes use of the terminological knowledge to derive a first type assignment for the individual. This attribution is successively improved by comparing the description of the individual (via the similarity mechanism) to prototypes stored in the prototypical component. Prototypical knowledge is linked to appropriate names in the terminology through primitive concepts.

The apparatus distinguishes between qualitatively different information and yet can deal with the problem of preferences among the results of similarity-based reasoning.

2.2 Beliefs

This work is the attempt to import into the hybrid framework the ideas about *relevant beliefs* of [2]. The goal is to model an artificial agent — the system — which reasons subjectively about the beliefs of other agents in communication with him, in addition to its own beliefs.

The knowledge base has been partitioned into *viewpoints* each one representing a set of complex nested beliefs, i.e. what the system believes the agent `A` believes the agent `B` believes ... about some topic. Topics are simply individual descriptions (or, more generally, ABox propositions) present in the viewpoint. A topic is *believed with respect a viewpoint* if it is logically implied by the knowledge directly stated in the viewpoint or if it is entailed by *ascription*. The ascription mechanism tests the truth value in the "preceding" viewpoints according to a "particular" order; the process fails if at some point a contradiction is detected. The *relevant beliefs* theory presents a method concerning the ascription mechanism for determining whose beliefs are relevant in generating nested beliefs and in what order are they relevant.

Within YAK a 3-values — true, false, unknown — hybrid retrieval function (`believe?`) has been implemented, which recursively checks the logical implications and the contradictions in the nested viewpoints.

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