USING SITUATION DESCRIPTIONS AND RUSSELLIAN ATTITUDES FOR REPRESENTING BELIEFS AND WANTS

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ABSTRACT

A representation scheme for arbitrary beliefs and wants of an agent in respect to a situation, as well as to arbitrary beliefs and wants of other agents, is presented. The representation makes use of elementary situation descriptions (which are formulated in KL-ONE and delimitated by partitions), and acceptance attitudes in respect to these descriptions, or to attitudes thereabout. The scheme forms the representational base of VIE-DPM, the user modelling component of the German-language dialogue system VIE-LANG.

1. Introduction

Three detailled proposals have been made up to now for representing a system's assumptions about the beliefs and wants of another agent: In the "syntactic approach" [9], belief of an agent is equated with derivability in a first-order object-language theory of the agent. In the "semantic approach" [10,1], knowledge and wants are equated with accessibility relations between possible worlds. Finally, in the "partition approach" [4], beliefs and wants of an agent are equated with the presence of representation structures in specific nested belief and want spaces reserved for the respective agent.

In the field of epistemic logic, beliefs and wants of an agent have originally been regarded as "propositional attitudes", i.e. attitudes of the agent in respect to certain propositions about the world [11,12]. In this paper, a new representation scheme for beliefs and wants will be presented which is based on a similar idea, and which also integrates aspects of the partition approach. The proposed scheme forms the representational base for the user modelling component VIE-DPM [6,8], which is part of the German-language dialogue system VIE-LANG [15]. Our representation for beliefs and wants is thus fully integrated into a natural-language environment.

2. Situations and situation descriptions

In our representation scheme, basic beliefs and wants of an agent (i.e. beliefs and wants which do not concern other agents' beliefs and wants) are regarded as attitudes which the agent holds in respect to situation descriptions, either of the current situation, or in the case of wants, of a situation which is aspired by the agent. A situation, as we define it, is a set of individuals and relations between individuals. The former will be denoted by 'i', 'i1', etc., the latter by 'r', 'r1', etc. If there is a relation r (i1, i2) in the situation, the pair (r, i2) is called an attribute of i1.

For describing situations, a description language is needed. In our representation, the individualized level of the KL-ONE formalism [2] is used for this purpose. Minor re-interpretations have been necessary in order to adjust this scheme to the specific needs of belief and want representation. We assume the reader to be roughly familiar with the KL-ONE philosophy, so that we can restrict ourselves to explicating the role of KL-ONE in our own representation scheme.

Fig.1 shows a *very* simplified example of our representation, expressed in the usual network notation. Layer A forms its conceptual level, layer B its individualized level. For our purposes, it suffices to regard the former as consisting of general concepts, and general attribute descriptions associated with general concepts. General concepts can be regarded as one-place predicates which apply to individuals. Fig.1 exemplifies, that more and less specific concepts can be ordered in a superconcept hierarchy. A general attribute description consists of a role (for our purposes, a one-place predicate applying to relations) and a value restriction concept for role fillers. The latter can itself posses associated attribute descriptions, etc. More advanced aspects of KL-ONE's general level will not be considered here, since they are not as important for belief representation.

Structures of the individualized level are created by assigning individualized concepts and individualized attribute descriptions to their general counterparts. Through this process of individualization, elementary situation descriptions are created: The individualization 57 the general concept c into the individualized concept ic expresses that an individual i exists in the situation to which c applies. The individualization of the general role gr into the individualized role ir expresses that the relation r exists in the situation, to which gr applies. In both cases, ic and ir are said to designate this individual or relation, respectively.

In Fig.1, the general layer has been individualized three times. Each substructure expresses the following elementary descriptions: individuals 11-16 exist in the situation, to which the predicates 'OBJTRANS', 'JOHN', 'MARY' ('SUE'), 'BOOK', 'USER' and 'SYSTEM' apply, respectively (the latter has been left out in the central and right-hand substructure).

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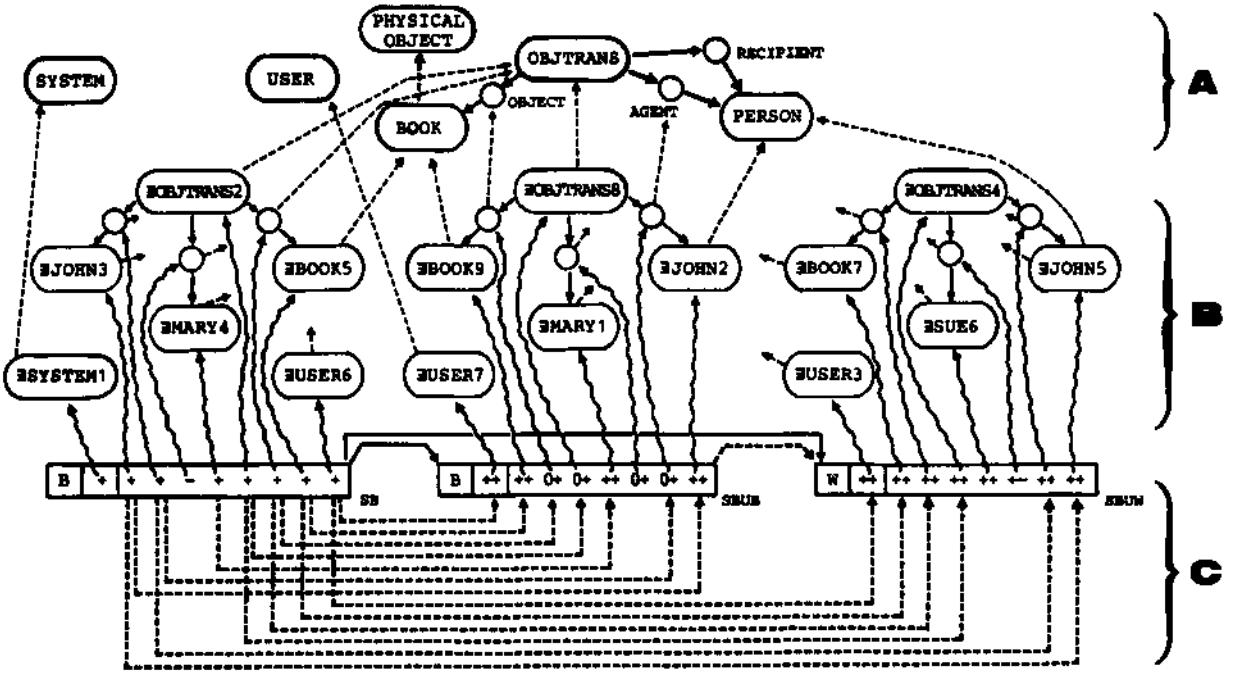

Moreover, relations exist between 11 and 12, 11 and 13, and 11 and 14, to which the predicates 'AGENT', 'RECIPIENT' and 'OBJECT' apply, respectively.

It is important to mention that, apart from being the language used for situation descriptions, structures of the individualized level also serve two other purposes in the VIE-LANG system. They are the target structures for the parser [14], which individualizes general concepts and attribute descriptions that are addressed by input words. Moreover, they are the starting point for the NL generator of the system [3], This threefold usage of individualized structures facilitates the transformation of a user's input into assumptions about his beliefs and wants, the transformation of beliefs of the system into system replies, etc. [6,8],

3. Single acceptance attitudes for representing basic beliefs and wants

In VIE-DPM, basic beliefs of an agent (i.e. beliefs about the current situation) are represented by describing the situation from the agent's point of view. The descriptions are expressed by individualized KL-ONE structures, the agents position is captured by indicating the acceptance attitude which the agent holds in respect to these situation descriptions. Acceptance attitudes may take the values '+', '-' and '0' (actually we use a continuous range of values). They are applied to the elementary situation descriptions, i.e. to the individualized concepts and roles.

When applied to the individualized concept ic, the valuations '+', '-' and '0' express that the respective agent accepts that / does not accept, that / 1s uncertain whether ic denotes an individual in the current situation (i.e., that/whether there is an individual in the situation to which the predicate of the general concept of 1c applies). When applied to the individualized role ir of an Individualized attribute description, '+', '-' and '0' express that the respective agent accepts that / does not accept, that / is uncertain, whether such a relation as is described by ir exists in the situation. These interpretations are observed by all access and inference procedures.

An example is given in the left side of Fig. 1 (part B), where the agent (in this case, the system) accepts everything but the individualized role between the individualized concepts labelled '30BJTRANS1' and '3MARY4'. This means that the agent (in our case, the system) does not accept that there is a relation between 11 and 13, to which the predicate RECIPIENT applies. Thus, though it believes that John gives somebody a book, it does not believe that Mary is the recipient.

Basic wants of an agent are represented in VIE-DPM by describing the situation which is aspired by the agent. The acceptance attitudes can then Be" employed in a similar way: when applied to an individualized concept or role in such a description, the valuations '+', '-' and '0' express that the respective agent accepts, that / does not accept, that / is indifferent to whether the individualized concept or role should designate an individual or a relation in that situation. For instance, when regarded as a description of an aspired situation, the left side of Fig.1/B expresses that the agent wants John to give a book to anybody but Sue.

By using individualized concepts which possess no attribute descriptions, or only attribute descriptions with *very* general role fillers, it is furthermore possible to represent basic "unsaturated" beliefs and wants. An example for the former is that an agent believes that / does not believe that / is uncertain whether there is an x so that p(x), and for the latter that an agent wants that / does not want that / is indifferent to whether it should be the case that there is an x so that p(x). Examples for such beliefs and wants include, e.g., that a believes that John gives something to. Mary, or that a wants

that someone should give a book to Mary.

4. Partitions and multiple acceptance attitudes for representing beliefs and wants in respect to beliefs and wants

To allow for a parallel representation of both an agent's basic beliefs and wants, and his/her beliefs and wants in respect to beliefs and wants of other agents, the individualized level of our representation is separated into partitions. So-called "contexts" have been introduced which tie together either the (hypothesized) basic beliefs of an agent, or his/her (hypothesized) basic wants. Beliefs and wants of an agent in respect to beliefs and wants of other agents are then represented through context hierarchies.

Fig.1 shows a simplified example with three contexts: context SB contains the system's beliefs about the current situation, SBUB the system's beliefs about the user's Reliefs about the situation, and SBUW the system's beliefs about the basic wants of the user.

SBUB and SBUW contain not only single, but double acceptance attitudes. The additional valuation expresses the attitude of the modelling agent in respect to the valuation of the modelled agent with regard to the particular situation description. The meaning of this additional acceptance attitude depends on the type of superordinated context. If this is a belief context, the valuations '+', '-' and '0' express that the modelling agent accepts that / does not accept that / is uncertain whether the modelled agent assigns the particular acceptance attitude to the particular situation description. If the superordinated context is a want context, these additional valuations express that the modelling agent accepts that / does not accept that / is indifferent to whether it should be the case that the modelled agent assigns the particular acceptance attitude to the particular description.

Fig.1 gives an example for the former. In each attitude pair, the left value specifies the attitude of the modelling agent, and the right one that of the modelled agent. SBUB expresses that S is uncertain whether U believes that John gives Mary a book. (Just for comparison: the belief of S, that U is uncertain whether ... would be expressed by reversing the '0+' pairs.) SBUW expresses that S believes that the user wants John to give the book to anybody but Sue.

The nesting of belief and want contexts can obviously be arbitrarily extended, if necessary. Triple acceptance attitudes are then assigned to descriptions on the third level, quadruple to descriptions on the fourth level, etc. Thus arbitrarily nested beliefs and wants in respect to beliefs and wants of other agents (such as that S wants that U believes that a does not believe p) can be expressed in the representation scheme. It is also possible to represent arbitrary "reflexive" belief and want nestings, i.e. constellations in which the modelled agent of a lower context is identical with the modelling agent of a superordinated context.

6. Discussion

The representation system of VIE-DPM has been completely implemented in an index-sequential data base, which is accessible through Interlisp [5]. It should be noted that, due to a lack of space, only a small portion of our representation could be described in this paper. More advanced topics, such as the representation of "knowing (wanting to know) whether", "knowing (wanting to know) the x so that p(x)", as well as the representation of "or-beliefs", mutual beliefs and infinite-reflexive beliefs (a generalization of mutual beliefs) have been described in [7,8]. All these beliefs are arbitrarily combinable, and in principle there is no limit to the possible depth of nesting. These characteristics are particularly important in the field of user modelling. Though the usual depth of embedding is not excessive in this field (it hardly ever goes beyond the levels 3-5), the diversity of belief and want combinations which can arise even in normal communication is quite impressive [6,8].

Our representation demonstrates that, when advocating the partition approach for the representation of basic beliefs and wants, one is not compelled to also introduce additional sub-partitions for not-beliefs and "or-beliefs", as was done by [4]. Thus the doubts of [10,13] concerning the feasibility and efficiency of multi-partition processing do not apply to our proposal.

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