Knowledge Representation meets Intelligence Augmentation

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The goal of Intelligence Augmentation (IA) is the development of tools that improve the efficiency of human intelligence. This form of human enhancement contrasts with Artificial Intelligence (AI), whereby intelligence would be produced in an entirely synthetic form. According to D.C. Engelbart (1962), "by 'augmenting human intellect' we mean increasing the capability of a man to approach a complex problem situation, to gain comprehension to suit his particular needs, and to derive solutions to problems".

Conform the importance of man in problem solving, computer systems augmenting intelligence ask for a 'human-compatible' formal model of knowledge representation (KR). Important characteristic properties of human KR are flexibility (for adjustments) and portability (knowledge in one domain can be directly used in another domain). Experience with static, fact-based KR in past decades has shown that it is inflexible and non-portable. We believe that dynamical, process-based KR offers better perspectives.

Previously we introduced a philosophically informed process view of KR (Peirce, 1931-58). The most important conclusion of our this work is that the processes of perception and cognition, hence human information processing as a whole, can be modeled in the same way (van Breemen & Sarbo, 2009).

Here we start with a recapitulation and definition of our cognitively based, semiotically inspired model of KR that complies with those philosophical considerations. As computer science in its core meaning is necessarily fact oriented, due to the limitations of current computers, the proposed theory of KR is based in logic, but this logic is less articulate than predicate calculus (regarded as a language for the specification of recursively computable functions). Note that it is a limitation of syntax, not of expressive power. In knowledge representation the restricted syntax may turn out to be more practical than the whole (i.e. predicate calculus). An example can be syntactic language processing (Sarbo, Farkas, & van Breemen, 2006) and logical conceptualization (Sarbo & Farkas, 2003).

The focus of this chapter is on an application of our theory in IA in the field of problem elicitation (Krogstie, Sindre, & Jorgensen, 2006).

The proposed model of knowledge representation models conceptualization as a process. A characteristic property of all processes, including conceptualization, is their teleological, goal-driven character. Such a process is problem elicitation, that aims at the generation of an interpretation of an input sign, e.g. an appearing problem, through communication between different actors. A major difference between our approach and Goal Oriented Requirement Elicitation (GORE) is that GORE (A.P.A. Oliveira & Cysneiros, 2008) identifies goals and orders them hierarchically, while we start with modelling the process that complies with the most encompassing goal and derive subgoals required by the process.

Since in conceptualization the final interpretation is only of interest, intermediate representations can be considered as expressions of the input from a certain perspective. Such intermediate interpretations can be associated with sign aspects introduced by the American philosopher C.S. Peirce (1931-58). Intermediate representations can be ordered in a hierarchy by using the dependencies that exist between different kinds of sign aspects.

Following this line of thinking, a quality measure for elicitation processes can be defined as follows. Utterances generated during problem elicitation can be analyzed according to their sign aspect. An elicitation process will be called well-formed, if, according to their associated sign aspects, the generated utterances can be ordered in a hierarchy, which is isomorphic to the Peircean classification of sign aspects. On the basis of differences from that hierarchy, the quality of an elicitation process can be characterized by means of a similarity measure.

An illustration of the proposed quality measure is given by an analysis of a specification found in a scientific text. This is followed by a more elaborate example, comprising an analysis of an actual elicitation process realized by professionals at a Dutch software firm (Sogeti Nederland B.V.). Assisted by a professional elicitator, three clients were asked to develop a specification of a problem with their database system. The problem elicitation process, which took 4 hours, is recorded and the generated utterances are verbalized for a later analysis. Preliminary results of this analysis show some evidences for the practical importance of the proposed KR and quality measure.

A practical conclusion drawn from our experiment is the following. If the client(s) and the elicitator(s) are both aware of the stages that their common elicitation process has to go through, then meta-level information about the process (in which stage the process is occurring now and which other stages may follow) can be used for controlling the elicitation process on object-level. In other words, the hierarchy of sign aspects can be used as pigeon-holes during the generation of an interpretation of the input problem.

References

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