Tracking Cognitive Representations

Dietmar Janetzko (DIETMAR@COGNITION.IIG.UNI-FREIBURG.DE)
University of Freiburg
Center for Cognitive Science
Friedrichstr. 50
D-79098 Freiburg i. Br., Germany

Introduction

Evidence for change of representation has been collected in fields as diverse as problem solving (Bauer & Reiser, 1990), visual reasoning (Tabachneck-Schijf, Leonardo & Simon, 1998), scientific discovery (Kuhn, 1962), metaphor comprehension (Indurkhya, 1992) and developmental psychology (Carey, 1991). Despite all differences in these fields there is a clear common denominator of work related to change of representation: cognitive structures determine what can principally be conceived in human cognition. Thus, development and selection of an appropriate cognitive structure is an indispensable requirement for addressing a problem successfully. Take the example of replacing a particular component of a complex technical system by a more efficient one. A cognitive structure that gives an account of the domain in terms of functional equivalence between components surely provides a good knowledge base to tackle the problem. Let us change the example: if in the same system a short-circuit is to be identified, the cognitive structure mentioned above is not helpful. In this case, it seems to be more promising to organize problem solving in terms of conducting elements. The shift between both structures, e.g., in different phases of problem solving, is an instance of change of representation.

The goal of this contribution is to provide pointers to *knowledge tracking*, viz., a knowledge-based and psychometric method set up to investigate changes of representation. Knowledge tracking analyzes the dominant structure concerned with problem solving. The basis of KT is the prediction of empirical data by using concept structures, viz., networks of concepts and relations. In knowledge tracking, concept structures are used as a uniform representation schema that replaces representation schemas like scripts, frames, or semantic networks. Success or failure of prediction of empirical sequential data by competing concept structures gives indication of their validity. The concept structure that best predicts empirically observed behavior may be identified and is interpreted as an approximation of the cognitive representation primarily used. KT combines results from cognitive science with mathematical methods (i.e., Markov processes).

Knowledge Tracking - A 5-Step Scheme

Analyzing changes of representation via KT involves five steps:

- eliciting concepts and relations in the domain under study and setting up concept structures;
- recording empirical data (sequences of concepts), this kind of empirical data may be obtained in thinking aloud studies or studies of HCI;
- expressing the concept structures by transition probabilities, this is essentially the transformation of knowledge-based models into stochastic models;
- predicting empirical data by using concept structures and calculation of goodness of fit scores;
- selecting the structure that produces the best goodness of fit score.

Empirical evaluation studies support the claim that the structure that gives the best account of the data may be taken to be the structure that dominates cognition. An on-line tutorial along with the possibility of applying KT via the WWW is provided by Janetzko (1998).[1] Since knowledge tracking is suitable for automatic on-line analysis of huge amounts of data, it can be very well applied to the analysis of human-computer interaction.

References

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[1] On the the client-side, the user may input sequential symbolic data, i.e., traces, and also concept structures, on the server-side a LISP program analyzes the data and returns a goodness of fit score to the user.