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Constraint-Based Modeling: An Introduction

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This tutorial will introduce the participants to the idea of representing declarative knowledge in terms of *constraints*, units that are more prescriptive than descriptive and that primarily support evaluation and judgment instead of inference or prediction. In this 3-hour tutorial, we first present a formal representation of constraints and explain their conceptual rationale. The tutorial will touch on the differences between constraints, on the one hand, and rules and propositions, on the other, but more time will be devoted to applications.

We develop two applications of constraint-based modeling. The first is the use of constraints as a basis for a machine learning algorithm that allows a heuristic search system to detect and correct its own errors. From this point of view, constraint-based learning is a form of adaptive search. The algorithm was originally developed as a hypothesis about how people learn from their errors, and we summarize briefly its application to problems in human skill acquisition.

Second, we develop in detail the application of constraint-based modeling to the design and implementation of Intelligent Tutoring Systems (ITS). The constraint-based knowledge representation provides a novel way to represent the target subject matter knowledge, which has the advantage of directly supporting one of the main functions of expert knowledge in an ITS: To detect student errors. More important, the constraint-based representation provides a theoretically sound and practical solution to the intractable problem of student modeling. Finally, the constraint-based representation and the associated learning algorithm provide detailed implications for how to formulate individual tutoring messages. We present multiple systems that follow this blueprint, together with empirical evaluation data. There will be on-line demonstrations and hands-on opportunities.

In the last part of the tutorial, we point the participants towards other areas of cognitive science where the constraint-based format has a potential to provide significant advantages.

Stellan Ohlsson is Professor of Psychology at the University of Illinois at Chicago. He received his Ph.D. from the University of Stockholm in 1980 and he was formerly Senior Scientist at the Learning Research and Development Center at the University of Pittsburgh. He has a long-standing interest in computational modeling of higher cognitive processes.

Antonija Mitrovic is Associate Professor of Computer Science at the University of Canterbury. She received her Ph.D. in 1994 from the University of Nis, Yugoslavia and has since led an active research group at Canterbuyy in the area of ITS.

Some prior experience of programming in a symbolic language like Lisp, Prolog or rule-based systems will be helpful, but advanced programming skill is not needed. The participants primarily need to understand the ideas of knowledge structures, processes operating over such structures, and of designing a symbolic computational system to exhibit intelligent behavior. Familiarity with one or more of the readings listed below will be helpful but is not necessary.

Readings

Ohlsson, S. (1992) Constraint-based student modeling. *Journal of Artificial Intelligence and Education*, 3(4), 429-447.

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