Chapter XIII

Using Bayesian Networks for Student Modeling

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Abstract

This chapter purveys an account of Bayesian networks-related technologies for modeling students in intelligent tutoring systems. Uncertainty exists ubiquitously when we infer students' internal status, for example, learning needs and emotion, from their external behavior, for example, responses to test items and explorative actions. Bayesian networks offer a mathematically sound mechanism for representing and reasoning about students under uncertainty. This chapter consists of five sections, and commences with a brief overview of intelligent tutoring systems, emphasizing the needs for uncertain reasoning. A succinct survey of Bayesian networks for student modeling is provided in Bayesian Networks, and we go through an example of applying Bayesian networks and mutual
information to item selection in computerized adaptive testing in Applications to Student Models. We then touch upon influence diagrams and dynamic Bayesian networks for educational applications in More Graphical Models, and wrap up the chapter with an outlook and discussion for this research direction.

**Computer-Assisted Learning**

In the past couple of decades, both the research literature and the real world have seen flourishing studies and applications of computer-assisted learning. (We use computer-assisted learning to refer to computer-assisted instruction as well.) The increasing capabilities and decreasing prices of personal computers have created an affordable environment for individualized computer-assisted learning. The explosive expansion of the Internet not only provides a rich source of information but also nourishes the studies and applications of Web-based learning systems. To give a few examples, Conati, Gertner, and VanLehn (2002) have studied computer-assisted learning of Newtonian Physics; Mislevy and Gitomer (1996) have investigated the techniques for computer-assisted learning of the troubleshooting of hydraulics systems in aircraft; Mitrovic, Martin, and Mayo (2002) have designed systems for teaching the SQL database language; Horvitz, Breese, Heckerman, Hovel, and Rommelse (1998) look into the possibilities of assisting users of Microsoft Excel with software agents; Anderson et al. have developed a system for learning LISP programming (Anderson, Boyle, Corbett, & Lewis, 1990) and high school mathematics (Anderson, Douglass, & Qin, 2004); Virvou, Maras, and Tsiriga (2000) construct systems for assisting the learning of the passive voice in English; and Brusilovsky et al. have discussed issues such as course sequencing (Brusilovsky & Vassileva, 2003) for Web-based education (Brusilovsky, Schwarz, & Weber, 1996).

**Student Modeling for Computer-Assisted Learning**

In order to build the software infrastructure that supports computer-assisted learning, researchers are employing techniques for modeling important participants in the learning process. Major participants in learning activities include
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