Chapter 12

Information Technologies for Learning Principles of Fault-Tolerant Systems

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ABSTRACT

In this chapter, the authors present a methodology for developing a model-tracing cognitive tutor. The methodology is based on Bayesian probabilistic networks for generating pedagogical interventions. The presented probabilistic model increases fidelity assessment due to its ability of independently diagnosing the degree of mastery for every knowledge component involved in students’ actions; fidelity assessment in education is the ability to represent students’ cognitive states as close as possible for analysis and evaluation. The cognitive tutor was developed to promote a self-regulated learning approach with an open learner model. The open learner model let students change the learning flow by changing the assigned tasks. The authors explain in detail the structural construction and employed algorithms for developing a model-tracing cognitive tutor in the domain of fault-tolerant systems. Preliminary results and future work are also discussed to assess effectiveness of the proposed approach and its implication in actual educational programs.

INTRODUCTION

In this chapter, we discuss several concepts and their implementation for developing a Model-tracing cognitive tutor (MTCT). An Open learner model (OLM) is featured to support student self-assessment for promoting development of “help-seeking” meta-cognitive skills. This is based on the hypothesis about
students that do not look for help when they need it, are less probable to learn, i.e. those students do not get closer to a teacher to obtain assistance or other kind of communication, information or learning supports. Because they lack of meta-cognitive skills for “help-seeking”, besides a help-seeking student is known to become a better learner (Aleven, McLaren, Roll, & Koedinger, 2016).

Different features are presented to foment a Self-regulation learning (SRL) process that leads to improve domain-level learning outcomes. Considerations for fidelity prototyping are also discussed, and their importance for assessment stages. The aim of this chapter is to discuss and implement a methodology as a fundamental framework for developing MTCTs.

The proposal is compounded by several principles, approaches and paradigms that were implemented to build a cognitive tutor for learning the foundations of fault-tolerance systems, a very specific domain but they can be used for other domains as well. TITUS is a developed tutor by means of the proposed approach, it supports the idea of learning by doing, self-assessment and help-seeking meta-cognitive skills (Aleven, McLaren, Roll, & Koedinger, 2016; Arroyo et al., 2014). A discussion about how pedagogical interventions are generated in a rule-based cognitive model is also carried out. Finally, preliminary results are assessed to evaluate effectiveness of the proposed approach.

**BACKGROUND**

Since the beginning, humans have developed technology to solve sundry problems. Nevertheless, the creativity has led us onto a raise to develop more complex and bigger technological solutions in order to facilitate our lives. Nowadays, every person in this planet and out in the space directly or indirectly is attached to such amount of technical processes and systems that their lives depend on them. Thus, it is critical to integrate fault-tolerance support (Kulik, 1991; Martinez Bastida, & Chukhray, 2016) in every design, because of its absence increments the possibility of failure and jeopardize the reliability of such systems. Thus, proficiency about fault-tolerant systems should be faster increased with higher effectiveness in students and current professionals, in order to reduce failure risks in systems and technical processes that have a deep impact on our lives.

Intelligent Tutoring Systems (ITS) have shown to improve and accelerate learning processes. There are a wide amount of documented work about their application. They have been successfully applied in diverse domains such as physics (Aleven, Nkambou, Bourdeau, & Mizoguchi, 2010; Aleven et al., 2016), mathematics (Long, & Aleven, 2015; Arroyo et al., 2014), programming (Russel, & Norving, 2010; Wang, & Heffernan, 2012), and engineering subjects (Dzikovska, Steinhauser, Farrow, Moore, & Campbell, 2014) for instance. However, prototyping effective ITSs has shown to be a difficult complex task due to the interdisciplinary process that must be done. Moreover, the necessary time to unravel each module in the ITS structure and implement them all. There are an “endless” quantity of information and documented works about how a learning program is structured (Paquette, Lebeau, Beaulieu, & Mayers, 2015; Wieber, Lukas, & Gollwitzer, 2015; Long & Aleven, 2015; Pelánek & Jarusek, 2015; Conati, Gertner, & VanLehn, 2002; VanLehn, 2008; VanLehn et al., 2011), the way assessment is carried out (VanLehn, 2008), how graphic interfaces should be designed (Aleven et al., 2010), and other important factors that should be taken into account during the prototyping and implementation of an ITS. This cloud of information helps to improve and supports ITS development, but it creates gaps between researchers, developers and the necessary models and algorithms that might be implemented for efficiently designing an ITS.
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