Chapter 4.7
Knowledge Representation in Intelligent Educational Systems

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ABSTRACT

In this chapter, we deal with knowledge representation in Intelligent Educational Systems (IESs). We make an effort to define requirements for Knowledge Representation (KR) in an IES. The requirements concern all stages of an IES's life cycle (construction, operation, and maintenance), all types of users (experts, engineers, learners) and all its modules (domain knowledge, user model, pedagogical model). We also briefly present various KR schemes, focusing on neurules, a kind of hybrid rules integrating symbolic rules and nuerocomputing. We then compare all of them as far as the specified KR requirements are concerned. It appears that various hybrid approaches to knowledge representation can satisfy the requirements in a greater degree than that of single representations. Another finding is that there is not a hybrid scheme that can satisfy the requirements of all the modules of an IES. So, multiple representations or a multi-paradigm representation environment could provide a solution to requirements satisfaction.

INTRODUCTION

Recent developments in computer-based educational systems resulted in a new generation of systems encompassing intelligence, to increase their effectiveness; they are called Intelligent Educational Systems (IESs). Intelligent Tutoring Systems (ITSs) constitute a popular type of IESs. ITSs take into account the user's knowledge level and skills and adapt the presentation of the teaching material to the needs and abilities of individual users. This is achieved by using Artificial Intelligence (AI) techniques to represent pedagogical decisions as well as domain knowledge and information regarding each student. ITSs were usually developed as stand-alone systems. However, the emergence of the WWW gave rise to a number of Web-based ITSs (Brusilovsky, 1999), which are a type of *Web-Based Intelligent Educational System* (WBIES) (Hatzilygeroudis, 2004).

Adaptive Educational Hypermedia System (AEHS) (Brusilovsky, Kobsa, & Vassileva, 1998) are another type of educational system. These systems are specifically developed for hypertext environments such as the WWW. The main services offered to their users are adaptive presentation of the teaching content and adaptive navigation by adapting the page hyperlinks. Compared to ITSs, they offer a greater sense of freedom to the user, since they allow a guided navigation to the user-adapted educational pages. Furthermore, they dynamically construct or adapt the educational pages, in contrast to ITSs where the contents of pages are typically static. Enhancing AEHSs with aspects and techniques from ITSs creates another type of WBIES.

A crucial aspect in IESs (hence, WBIESs) is making decisions on the proper adaptation of the system to the user needs. This is mainly done by mimicking corresponding human decision making. So, a crucial aspect in the development of an IES, and hence of a WBIES, is how related knowledge is represented and how reasoning for decision making is accomplished. Various knowledge representation (KR) schemes have been used in IESs. An aspect that has not received much attention yet is defining requirements for knowledge representation in IESs. The definition of such requirements is important, since it can assist in the selection of the suitable KR scheme(s).

In this chapter, we present an effort to specify a number of requirements that a KR scheme that is going to be used in an IES should meet in order to be adequate. Based on them and a comparison of various KR schemes, we argue that hybrid schemes satisfy those requirements to a larger degree than single schemes. Such a hybrid scheme, called *neurules*, is presented as an example. However, our final argument is that only multiple representations or a multi-paradigm environment would be adequate for the development of an IES. This chapter is an extension of the work of Hatzilygeroudis and Prentzas (2004b).

The chapter is organized as follows. The following section specifies the KR requirements. Then, a number of KR schemes and how they satisfy the requirements are presented. The next section compares the KR schemes and, finally, we end the chapter with our conclusions.

KR REQUIREMENTS

Introductory Aspects

As in other knowledge-based systems, we distinguish three main phases in the life cycle of an IES: the *construction phase*, the *operation phase,* and the *maintenance phase*. The main difference from other knowledge-based systems is that an IES requires a great deal of feedback from the users and iteration between phases. Three types of users are involved: *domain experts*, *knowledge engineers*, and *learners*. Each type of user has different requirements for the KR scheme(s) to be used. We call them *user requirements*, since they mainly concern the needs of the users.

Some of the user requirements are related to the general requirements for a KR language, such as efficiency and naturalness. Efficiency mainly refers to how quickly conclusions are drawn, whereas naturalness refers to how easy it is to construct and understand sentences of a KR language as well as inference steps (Reichgelt, 1991).

On the other hand, the system itself imposes a number of KR requirements. An IES (as well as a WBIES) consists of three main modules

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