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VR-INTEGATE: A Knowledge-Based Authoring Tool for Virtual Reality Educational Games

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Introduction

Knowledge-based authoring tools are meant to be used by instructors who wish to author their own Intelligent Tutoring Systems (ITSs) on a certain domain. Murray (1999) highlights the potential of ITS authoring tools in giving the instructional designer a combination of facilities to produce visually appealing, interactive screens and a deep representation of content and pedagogy. Authoring tools have to be used for multiple domains. Therefore the methods incorporated in the authoring tools have to be domain-independent. However, in addition to the domain-independence, the resulting ITSs should have a learner modelling capability that may diagnose the learners' weaknesses and support a teaching method adaptive to the learners' needs. Finally, the user interface of the ITS has to be as attractive and engaging as possible.

In this paper, a knowledge-based authoring tool is described. The authoring tool is called VR-INTEGATE, which stands for Virtual Reality- INTelligent Game Authoring Tuition Environment. VR-INTEGATE provides an authoring environment to instructors who wish to create ITSs that operate through a virtual reality game. The concept of the game is used so that the ITSs may become more motivating and engaging. Moreover the ITSs are able to provide diagnostic reasoning concerning the students' answers to questions about the domain being taught.

Operation of the authoring mode

The initial input to the authoring tool is given by a human tutor who is acting as an author. The initial input consists of a description of domain knowledge in terms of hierarchies. Therefore the author has to decide what the main concepts of the lesson are, that may be represented in hierarchies. Then s/he may create hierarchies by giving data to a dialogue box of the system. First the author has to declare a description of the nodes of a hierarchy and then s/he has to declare the nodes' attributes. Finally s/he has to enter the actual data both for the nodes and their attributes. For example, in the creation of a lesson in geography an author may decide to declare the nodes "Continent", "Country", "County". Then s/he may insert attributes for the nodes, for example the Capital of a country. Finally s/he may give data, such as Continent: Europe, Country: Greece, Capital of Greece: Athens etc.After this input has been given, the tool constructs a knowledge base concerning the specific domain in the form of hierarchies. Finally, the authoring tool may automatically construct tests that consist of questions relating to the factual knowledge of the domain. All tests are part of the story of the virtual reality game.

The student modelling component examines the correctness of the students' answers in terms of the students' factual knowledge and reasoning that they have used. The diagnostic process is based on previous research (Virvou 1999; Virvou & Du Boulay 1999) in error diagnosis which explored the utility of a formal theory of Human Plausible Reasoning (Collins & Michalski 1989) in the context of an Intelligent Help System for novice users of operating systems. This research showed that Human Plausible Reasoning could be a helpful tool when employed for error diagnosis. The Human Plausible Reasoning theory (henceforth referred to as HPR) was originally constructed to provide a formal model of the reasoning that people use to reach some conclusions about questions for which they do not know the immediate answer. Starting from a question asked to a person, the theory tries to model the inferences made, based on similarities, dissimilarities, generalisations and specialisations that people often use to make plausible guesses. These guesses may be correct as well as incorrect. For the purposes of error diagnosis we exploit the fact that the human plausible reasoning that a student may have used may have led him/her to make an error. The diagnostic process makes use of domain knowledge represented in "isa" and "ispart" hierarchies.

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Educational Games Generated by the Authoring Tool

The interaction of the student with the resulting educational applications is performed through a virtual reality game. Questions to students are always asked by animated agents. Then, students may type their answer in a dialog box. The story of the educational games incorporates a lot of elements from adventure games. However, each of these elements is connected to ideas and approaches from educational software technology. The ultimate goal of a student who is a player, is to navigate through a virtual world and find the book of wisdom, which is hidden. While the player is navigating through the virtual world, s/he meets animated agents who lead the player to places where s/he can read lessons about the domain being taught. The player also finds keys, which are guarded by dragons. A guard dragon poses a question to the player from the domain of the particular educational application. If the player gives a correct answer then the dragon allows him/her to take the key. Each of these keys opens a door, which leads the player closer to the "book of wisdom". If the player gives an answer which is close to the correct one then a virtual companion shows up who tries to help the student give the correct answer. The closeness of an answer to the correct one is determined by the diagnostic process of the student modelling component which is based on HPR. In particular, a student's answer is considered close to the correct one if it is a generalisation or a specialisation or a similar one to the correct answer with respect to their position in the hierarchies that the system has constructed.

In the resulting educational applications, the system communicates with the student via three types of animated agent, the virtual enemy, the virtual advisor and the virtual companion. All three types of animated agent use synthesised voice as well as written messages. The reason that the animated agents use voice is that there are studies that show that voice messages may be more effective that written ones in the way that students react to the educational applications (e.g. Walker et al 1994).

The virtual enemy asks questions and is defeated by the student if the student answers correctly. The virtual advisor shows the student the way to parts of the theory and appears in cases when the system judges that the student has to revise certain parts of the theory or read new ones. The virtual companion appears in cases where the student has given an answer, which is close to the correct one but is not the correct one. In such cases, the virtual companion tries to help the student give the correct answer. The existence of the virtual companion has been considered quite important by many researchers for the purpose of improving the educational benefit of tutoring systems (e.g. Van Lehn et al. 1994; Kay 2001).

Conclusions

Virtual reality games may well be used for educational purposes since they guarantee the students' engagement into the educational application. One problem of such applications is the construction of the game itself and the connection of pedagogy with the story of the game. The authoring tool that we described in this paper offers a solution to this problem. Instructors may author their own educational application, which will result in a knowledge-based educational game. In this way, game environments may be re-usable and enhanced with the domain-independent reasoning of an ITS that performs error diagnosis and records the student's progress in the student model. Then the system may adapt advice to the particular student's needs. In addition the game employs animated agents who take part in the story of the game by asking questions, providing advice, instruction and collaboration to the student.

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