Adaptive Virtual Tutor Based on the Inference of the Student's Memory Content

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Abstract. This research work presents an adaptive and embodied virtual tutor. Our proposed tutor is able to adapt the execution of a pedagogical scenario according to the estimated student's level of knowledge. To achieve such a goal, we rely on Mascaret, a meta-model for knowledge representation in a virtual environment and on an inference of the student's memory content. This inference permits the tutor to adapt the execution of the pedagogical scenario and to choose an individualized assistance according to the evolution of the student.

Keywords: Procedural learning · Adaptivity · Student's memory

1 Introduction

Virtual Reality is considered as one of the technologies with the most potential to improve procedural learning. However, procedures are learned gradually as a result of practice, for that, learners must repeat them. Throughout the repetitions, the tutor's pedagogical actions are usually scheduled using pedagogical scenarios. Taking into consideration that each student evolves differently during the repetitions, it is important to adapt the pedagogical scenario according to the student's evolution. The real-time adaptation of the pedagogical situation to a student is one of the major objectives of Intelligent Tutoring Systems (ITSs). Our proposed model[1] permits a tutor to execute a pedagogical scenario and especially to adapt its execution to the individual evolution of the student.

2 The MEMORA Model

Our work proposes a model to formalize the four ITS components (domain model, student model, tutoring model and interface) and the interactions between them.

Domain Model For the definition of the domain model, we use Mascaret [1]. It is a virtual reality meta-model based on the Unified Modeling Language (UML). It covers all the aspects of virtual environments semantic representation:

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domain's ontology, environment's structure, entities' behavior and both user's and agents' interactions and activities. In Mascaret, pedagogy is considered as a specific domain model. Pedagogical scenarios are implemented through UML activity diagrams containing a sequence of actions. These actions can be either pedagogical actions, like explaining a resource, or domain actions, like manipulating an object. The fact that Mascaret is a meta-model has two main interests. Firstly, specific domains are considered as data. This allows domain experts to provide the knowledge themselves in the ITS. Secondly, these data remain explicit during the simulation, thus they can serve as a knowledge base for agents.

Interface One of our main contributions to the interface model consists in embodying the virtual tutor. To achieve such a goal, we integrated the Embodied Conversational Agent (ECA) platform, Greta [2]. Greta characters are able to select and perform multi-modal communicative and expressive behaviors in order to interact naturally with the user. It is important to notice that in Mascaret, any entity which acts on the environment is considered as an *agent*. Particularly, the ECA and the human user are considered as *embodied* agents. The basic actions that an embodied agent is able to perform are: verbal communication (e.g. giving an information, answering), action realization (e.g. facial expression and actions that modify the environment) and navigation. The system is able to recognize the realization of each of these actions performed by the user.

Student Model In ITS, student models infer the student's cognitive and affective knowledge, to represent their relevant characteristics and the past interactions with the system [3]. As we are dealing with teaching human activities in industrial systems, the cognitive knowledge that our student model has to infer is related to memorization. This implies the transformation of stimuli (coming from the tutor and the environment) into knowledge that can be stored in memory. In our student model, we rely on the general theoretical framework proposed by Atkinson and Shiffrin [4] which divides human memory into three structural components (see Fig. 1): Sensory Memory (SM), Working Memory (WM) and Long-Term Memory (LTM). We propose an implementation of this framework

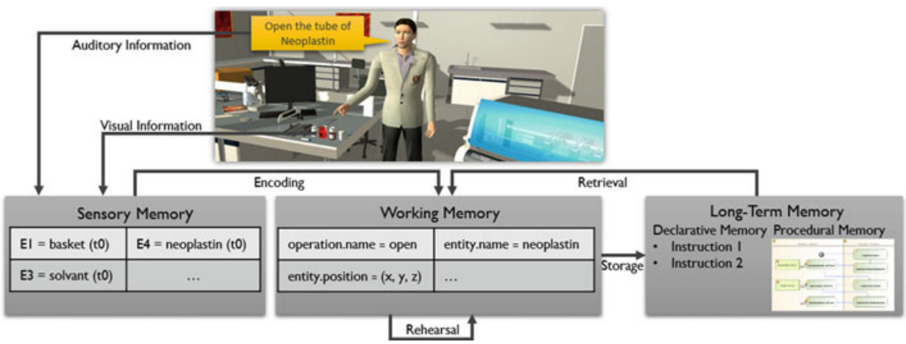

Fig. 1. Formalization of the encoding and structuring of instructions in the memory.

for learning procedures on industrial systems. In our work, incoming stimuli from the virtual environment and tutor are restricted to those related to vision and hearing. Thus, the student can see 3D objects and hear instructions uttered by the tutor about activities to realize. Therefore, we encode data about the objects and activities. For the formalization of the information encoding in all memories, we rely on the data formalism proposed by MASCARET. This formalism is hierarchical, which permits us to infer the knowledge level of the learner.

The role of the SM is to select relevant information among the continuous flow of stimuli that our senses deliver us. Perceived information is converted into a construct that can be stored in the SM. Only prominent information (e.g. objects that have been highlighted) is transferred from the SM to the WM. The WM stores and manipulates information based on the content of the SM and the LTM (prior knowledge). The level of complexity of the information that will be stored in the WM depends on the student's prior knowledge. By complexity of information we mean the type of formal representation and the number of attributes set. This prior knowledge is retrieved from the LTM. The transfer of some elements related to an action, from the WM to the LTM, takes place when the student completes the action [5]. The LTM is used to store permanently relevant information coming from the WM. It is composed of procedural memory (the procedure to learn) and declarative memory (domain model concepts). The choice of the information, its level of complexity and when it will be stored in the LTM depends on the pedagogical actions done by the tutor.

Tutor Behavior The goal of our proposed tutor behavior is to adapt the execution of the pedagogical scenario according to the student model represented in our work by the student's memory. The tutor behavior takes into account the action done by the student and compares it to the domain knowledge. If the realized action is expected by the tutor (e.g. correct action, right answer), then the transfer to the LTM occurs. The adaptation of the execution of the scenario takes place when the action performed by the student is unexpected (e.g. incorrect action, negative facial expression). In this case the tutor modifies the inference on the content of the WM and realizes another pedagogical action.

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