Toward a Domain-Independent Framework to Automate Scaffolding of Task-Based Learning in Digital Games

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ABSTRACT

This poster describes a framework that automatically generates learning support scaffolds to guide task-based learning. The aim is to combine the exploratory learning principles prominent in digital games with the rich user modeling and adaptation of intelligent tutoring systems.

Keywords

Task-Based Learning, Interactive Narrative, Digital Games, Scaffolding, Narrative Generation, Scaffolding

1. INTRODUCTION

This poster describes a framework uses a novel approach to combine the exploratory learning principles prominent in digital games with the rich user modeling and adaptation of intelligent tutoring systems. Dozens of learning principles have been identified in digital games [1], but they are most frequently implemented as fixed alternative paths tightly woven into the structure of particular games. These multiple options afford a *non-linear* game structure that rarely coincides with deep modeling of student knowledge or dynamically adaptation to individual users common in Intelligent Tutoring Systems (ITS).

Non-linear Task Based Learning, or *NLBTL*, uses an exploratory *non-linear* environment that grants a high degree of task-selection autonomy to the student to facilitate *task-based learning*. The goal of *task-based learning* is to provide students deep understanding of processes involving interrelated tasks. The student is guided to discover sequences of actions that produce interesting or useful results (e.g., RNA transcription, besieging a castle, or knee surgery). In the proposed framework, the exploratory learning mechanisms of digital games are related to the deep student models of intelligent tutoring systems through the medium of interactive narrative.

2. SYSTEM ARCHITECTURE

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One reason to use a digital game as a learning platform is that it necessarily contains a computable **world model** of the domain and all the objects contained in the domain. As shown in Figure 1, the student forms internal **mental model** of the world based on observations and experiences in the world, while the system builds a **student model** which is its best guess of the current state of the student's mental model.

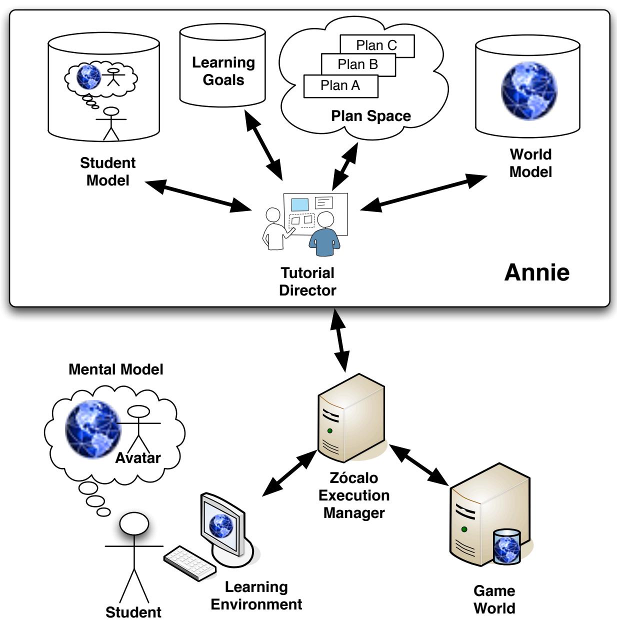

Figure 1: Annie's System Architecture

The system is named "Annie" in honor of Anne Sullivan, who taught the rules of verbal communication to Helen Keller, when Helen could not see, speak, or hear. Similarly, an agent-based tutor communicating with a human mind through the medium of an open non-linear world must intelligently cope with uncertainty of the student's understanding. Figure 1 shows Annie's dependency upon Zócalo system [8]. The Zócalo Execution Manager controls the progression of this plan, informing Annie of all the actions taking place in the world and allowing Annie to change the plan as necessary.

3. NARRATIVE SCAFFOLDING

Murray and Arroyo define *scaffolding* as exactly the assistance required to keep a student in the "zone of proximal development" (ZPD), which lies just beyond what the child can do alone[6]. The role of the tutor is to ensure that the learner is not overly confused by challenges that are too difficult or overly bored by challenges that are too easy. Either condition can lead to frustration, distraction or disengagement. As skills are mastered, scaffolding assistance is *faded* or removed.

Digital games researchers tout a ZPD-like construct they call the "optimal gameplay corridor" [3]. Research in both games and ITS often feature charts similar to Figure 2, where the horizontal axis corresponds to the user's time, and the vertical axis measures task difficulty. Tasks that are too difficult push the student into the zone of confusion depicted by in progressively deeper shades of red. Conversely, as tasks become too easy, the student moves lower into the the zone of boredom shown in progressively deeper shades of blue. Thus, Annie's job is to dynamically adapt the learning plan to add or fade "scaffolds" in the form of alternative decompositions of interactive narrative plans as required to keep the student engaged and learning in the ZPD.

The field of interactive narrative studies the automatic generation of stories within virtual worlds in which human users interact with one or more computer controlled agents, [4], [2]. Mott found that adapting interactive narrative for exploratory learning demands that user autonomy be sufficient to support exploration of specific "hypothesis-generation-testing cycles" [5]. Annie builds on approach of balancing narrative and user goals first described in the Mimesis system [7]. Mimesis generates plans for actions of agents in a story world based on hierarchical task decompositions and discrete causal requirements. Annie leverages the Mimesis architecture to select the task decompositions that best move the learner toward the ZPD at each point in execution of the learning narrative.

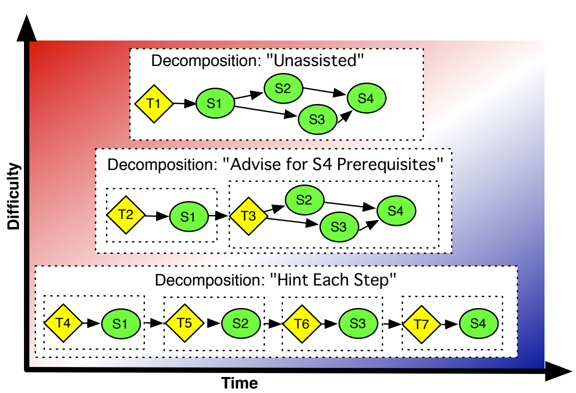

Figure 2: Task Decompositions for Scaffolding

Figure 2 is a simplified example of how Annie automatically generates scaffolding. The dash-bordered rectangles represent alternative decompositions of a a single tutorial *task*. These sub-tasks may consist of any combination of student actions (green ovals), or tutorial actions (yellow diamonds). The decomposition labeled "Unassisted" is the most challenging because it consists of a single system-initiated prompt, labelled **T1**, followed by four partially-ordered tasks to be accomplished by the student. The decomposition labeled "Hint Each Step" is easiest because it minimizes the cognitive load on the student by breaking the task down into four individually prompted actions.

4. OPERATIONAL OVERVIEW

As noted above, Figure 2 is an oversimplification. In practice, Annie's choice of particular decompositions is driven not by a gross approximation of the student's general capabilities, but rather by specific knowledge gaps perceived by the student model. The student model is based entirely on the student's knowledge of the actions in the *ZWorld*, especially their preconditions and effects.

At initialization, Annie constructs its knowledge base, called the *ABase*. The *ABase* is begins as traditional planning library that describes the operators in the *ZWorld*. It is then amended with pedagogically-focused elaborations of each operator. Annie constructs an initial tutorial plan consisting of a plausible partially-ordered sequence of student and system-initiated actions that is guaranteed to bring about a specific goal state for the world, but merely strives for a particular state of the student model.

Annie's run-time behavior consists of a cycle, or loop. This loop iterates each time an action is taken in the world, either by the student or the system. Following the action Annie consults an extensive library of general **diagnostic** templates to update student model. These templates encode domain-independent plan reasoning diagnostics such as cases where a student seems to be ignorant of a precondition of a particular operator. Annie uses the updated student model in consulting a second extensive and domain-independent library containing **remediation** templates that can be used to generate narrative scaffolding.

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