AutoTutor: An Intelligent Tutor and Conversational Tutoring Scaffold

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The Tutoring Research Group (TRG) at the University of Memphis has developed a computer tutor (called AutoTutor) that simulates the discourse patterns and pedagogical strategies of a typical human tutor (Graesser, P. Wiemer-Hastings, K. Wiemer-Hastings, Kreuz, & TRG, 1999). The dialog mechanisms of AutoTutor were designed to incorporate conversation patterns that exist in naturalistic tutoring sessions (Graesser, Person & Magliano, 1995), as well as some ideal strategies for promoting learning gains. AutoTutor was originally designed to help college students learn introductory computer literacy, such as the fundamentals of hardware, operating systems, and the Internet. Evaluations of AutoTutor have shown that the tutoring system improves learning and memory of the lessons by .5 to .6 standard deviation units compared to rereading a chapter (Graesser, Person, Harter, & TRG, in press).

Instead of merely being an information delivery system, AutoTutor is a collaborative scaffold that assists the student in actively constructing knowledge by holding a conversation in natural language. A dialog manager coordinates the conversation that occurs between a learner and a pedagogical agent, whereas lesson content and world knowledge are represented in a curriculum script and latent semantic analysis (Landauer, Foltz, & Laham, 1998). LSA and surface language cues guide the evaluation of the quality of student input (Wiemer-Hastingset al., 1999). There is an animated conversational agent with facial expressions, synthesized speech, and some rudimentary gestures. The modules of AutoTutor are uniformly weak rather than strong when considering parsing, semantic interpretation, dialog planning, domain reasoning, student modeling, and discourse production; the weakness of these modules arguably reflects the capability of human tutors. We are currently developing a hybrid version of AutoTutor that incorporates both weak and strong computational modules.

As an example of a weak module, a dialog advancer network (DAN) manages the exchange by specifying appropriate discourse markers (e.g., *Moving on, Okay*), dialog move categories, and frozen expressions within the tutor's turn. The content of selected dialog move category is generated by a separate mechanism, so there is a natural segregation of dialog functions from substantive content. There are the following different categories of dialog moves that AutoTutor generates: main question, short feedback (i.e., positive, neutral, negative), pumps (*uh huh, tell me more*), prompts (*The primary memories of the CPU are ROM and _____*), prompt response (*and RAM*), hints, assertions, corrections, and summaries. The DAN is formally an augmented state transition network because the selection of a dialog move category on tutor turn N+1 is sensitive to a large space of parameters computed from the dialog history. The DAN in AutoTutor-1 does a fairly impressive job in managing the conversation, based on our performance data (Person, Graesser, Pomeroy, Kreuz, & TRG, in press), even though it does not incorporate sophisticated dialog planning capabilities.

AutoTutor was designed to be reusable for other knowledge domains that do not require mathematical precision and formal specification. In order to test the portability of the AutoTutor architecture, we developed a version for the domain of conceptual physics. Together with computer literacy, conceptual physics is one of the fields in which extra tutoring sessions are

needed. The target population for the tutor was undergraduate students taking elementary courses in conceptual physics.

In the transition of AutoTutor from computer literacy to physics only three modules needed to be changed for the new subject matter: (1) a glossary of terms and definitions for physics, (2) an LSA space for conceptual physics, (3) a curriculum script with deep reasoning questions and associated answers for physics. The three modules can loosely be affiliated with metacognition, comprehension, and production. Changing the glossary required approximately 15 man hours. This process is relatively easy: definitions from text books need to be included in order to give AutoTutor the possibility of accurately answer metacognitive questions ("What does X mean?"). The majority of AutoTutor's comprehension mechanisms use LSA, so setting his long-term memory representation is an important process. The LSA space needs to be trained with an adequate corpus of texts applicable to the knowledge domain, such as text books, chapters, and technical articles. After the corpus is prepared in an electronic form, we declare the parameters of LSA, such as the number of dimensions and size of document units. The training of the LSA space takes less than an hour (Cleaning up the corpus (removing code, pictures, etc.), however, could be time consuming, in our case approximately 10 hours). Most of the work, however, lies in the curriculum script. Since AutoTutor's architecture only allows one particular format, the curriculum script needs to be carefully changed. Questions need to be defined, ideal answers need to be formulated, hints, prompts and pumps need to be included. AutoTutor's application to computer literacy had three topics, each consisting of 12 deep-reasoning questions. Changing the curriculum script to conceptual physics required approximately 20 hours for 3 questions/problems. However, an authoring tool makes this process less time-consuming than most intelligent tutoring systems because the format of the entries are descriptions in English rather than structured code (e.g., Lisp, Prolog). Several lesson planners can simultaneously work on the transition and do not require sophisticated programming expertise.
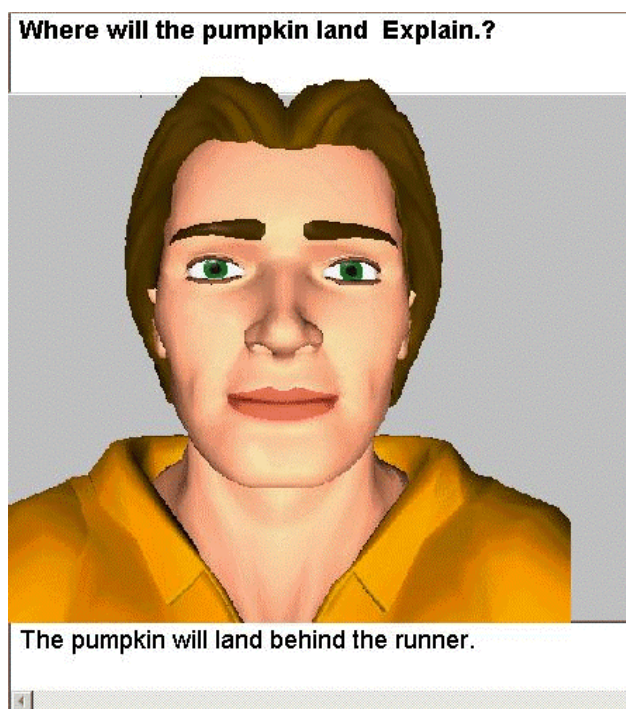

Figure 1. Screen shot of AutoTutor interface

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TUTOR      Okay, let's begin. Hello, I'm Marco. I'm one of the computer
           tutors developed by the Tutoring Research Group, at the
           University of Memphis. I try to help students learn about
           Physics, by having a conversation with them. Let's get
           straight to the demonstration. Suppose a runner is running in
           a straight line at constant speed, and the runner throws a
           pumpkin straight up. Where will the pumpkin land? Explain.
STUDENT    The pumpkin lands behind the runner.
TUTOR      Anything else?
STUDENT    I don't know.
TUTOR      Okay. What is the horizontal velocity of the pumpkin?
STUDENT    The pumpkin has a constant horizontal velocity.
TUTOR      so? The horizontal velocity of the pumpkin is the same as the?
STUDENT    Could you repeat that?
TUTOR      Once again, the horizontal velocity of the pumpkin is the same
           as the?
STUDENT    runner.
TUTOR      The same as the runner. Okay. Also, the man and the pumpkin
           have the same horizontal velocity. What can we say about the
           horizontal velocity of the pumpkin if there is no force acting
           on the pumpkin in the horizontal direction?
STUDENT    its constant.
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Note that this transcript only presents a small part of the rich information (pauses, intonation, gestures) that AutoTutor provides in the interaction with a student.

Table 1. Sample of a student interaction transcript

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