Chapter 11
Guru: Designing a Conversational Expert Intelligent Tutoring System

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ABSTRACT
The authors discuss Guru, a conversational expert ITS. Guru is designed to mimic expert human tutors using advanced applied natural language processing techniques including natural language understanding, knowledge representation, and natural language generation.

IDENTIFICATION
There is substantial empirical evidence that one-to-one human tutoring is extremely effective when compared to typical classroom environments (Bloom, 1984, Cohen, Kulik, & Kulik, 1982, Graesser & Person, 1994). Unfortunately, a human tutor cannot be provided to every child because there are simply not enough tutors. However, a technological solution exists: intelligent tutoring systems (ITS), which mimic human tutors, are accessible to anyone with a computer. We have successfully modeled the strategies, actions, and dialogue of novice tutors (Graesser & Person, 1994, Graesser, Person, & Magliano, 1995, Person, Graesser, Magliano, & Kreuz, 1994) in an intelligent tutoring system with learning gains comparable to novice tutors (Graesser et al., 2004, VanLehn et al., 2007). While this progress is significant, Bloom (1984) has reported that accomplished human tutors can produce even greater learning gains than novice human tutors. Building an ITS that mimics the pedagogy of expert human tutors is an ambitious research goal. To address that goal, we are building Guru, an ITS designed

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to mimic expert human tutors using advanced applied natural language processing techniques.

INVESTIGATION

Recently, Person and colleagues have undertaken a rigorous, large scale study of accomplished, expert human tutors. They have recorded fifty expert tutoring sessions, have transcribed the dialogues between tutor and student, and have coded the dialogues on both a micro-level (speech acts) and macro-level (sub-dialogues or tutoring modes). Based on our coding schemes, we have extracted dialogue models from these tutoring sessions that reflect the general underlying structure of the tutors’ conversations on multiple levels (D’Mello, Olney, & Person, in press). These dialogue models are the foundation for our approach to building an ITS because they outline what happens in an expert tutoring conversation. However, because these models are structural they are an incomplete model of expert human tutoring in two ways. First, our structural models do not specify a dialogue move’s propositional content or the choice of words within it. For example, our structural models specify dialogue move categories (e.g., question, rather than a specific dialogue move such as “What is mitosis.”) Secondly, when alternatives are possible our structural models only specify the alternatives but do not indicate which alternative is most appropriate in a situation. For example, our structural models may specify that the next tutor dialogue move should be a hint, prompt, or pump, but selecting amongst them would require assessing a number of other dialogue features (e.g., the correctness of a student’s response, the student’s overall progress, etc.)

RESOLUTION

In this chapter we describe our ongoing research efforts using our expert human tutor data to create the expert Guru ITS using applied natural language processing (ANLP) techniques, including natural language understanding, knowledge representation, and natural language generation. These ANLP techniques allow us to fill in specific gaps in our structural dialogue models and to create a functioning system. This chapter we will primarily focus on the tools and methodologies behind creating an expert ITS, but our ultimate goal is student learning. We believe that an expert ITS will enhance learning outcomes beyond current ITS technology by using the particular tactics, actions, and dialogue of expert human tutors. Therefore, the essence of our approach is to design conversations between the Guru tutor and the student to promote learning.

EXPERT HUMAN TUTORING

In order to model the conversation of an expert tutor, a corpus of expert human tutoring is needed. However, the most current meta-analysis reveals that the majority of human tutoring studies reported in peer-reviewed sources have primarily included untrained or “typical” tutors (Cohen et al., 1982). Expert tutoring studies are comparatively scarce, and such studies have included only a handful of expert tutors. In this section we review the studies that are most frequently cited in the literature and note some of the problems that have contributed to our lack of expert tutoring knowledge. First, several studies fail to indicate how many expert tutors were included in the analyses (Aronson, 2002, Fox, 1993, Derry & Lajoie, 1993, Lepper & Woolvert, 2002). Second, although some studies have included five or six expert tutors (Derry & Potts, 1998, Graesser, Person, Harter, et al., 2001, Lepper, Aspinwall, Mumme, & Chabay, 1990, Lepper, Woolvert, Mumme, & Gurtner, 1993, VanLehn et al., 2007), the remaining included only one or two experts (Shah, Evens, Michael, & Rovick, 2002, Evens, Spitkovsky, Boyle, Michael, & Rovick, 1993, Glass, Kim, Evens, Michael,
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