Realistic Limitations in Natural Language Processing for an Intelligent Tutoring System

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Introduction

Although an intelligent tutoring system (ITS) and a human tutor may have the same goals, they do not have the same skills available for achieving those goals. CIRCSIM-Tutor v. 3 is a natural-language based ITS which tutors students on problem solving in cardiac physiology. We examine a corpus containing over 5000 turns of human-to-human tutoring sessions in order to determine the salient features leading to student success. We determine which of those features can be replicated by an ITS and develop alternatives for the others. To reduce the input processing burden, we substitute mixed-initiative processing (Carbonell, 1970) for true cooperative conversation, short-answer questions for free-text input, and the use of explicit questions for the use of turn-taking rules. To obtain the most "bang for the buck" in text generation, we emphasize precise responses to student input, simulation of the discourse patterns of expert tutors, and the provision of variety in both pedagogy and language as substitutes for complex mental processing. Our goal is to keep the tutoring process as interactive as possible while providing both broader and deeper domain coverage.

Simplifying the Input

True cooperative conversation, where tutor and student are equal partners in choosing and responding to topics, requires the tutor not only to understand free-text input but to track the student's plan as well. Instead, CIRCSIM-Tutor ends each turn with an explicit short-answer question in order to reduce the burden on the input processor without restricting the student's use of language. For example, human tutors might say "First we need to know how HR [heart rate] is controlled," knowing that the student will respond cooperatively, or ask "How is HR controlled?" since they are comfortable with their ability to understand the answer. But people expect a program to give them a clear indication when it is their turn to respond. CIRCSIM-Tutor achieves the communicative intent of questions like those above with short-answer questions such as "By what mechanism is HR controlled?" or "What controls HR?".

Generating the Response

Instead of dividing processing between a pedagogical planner and a text planner, our text planner, TIPS, divides the work between the *tutorial planner*, which makes discourse decisions at the dialogue level, and the *turn planner*, which assembles individual turns.

TIPS uses an expanded form of schemata to simulate discourse patterns of expert tutors. For example, if it notices that the student has given inconsistent values to two variables, it might say, "How can X increase and Y decrease?" Multi-turn schemata are used to simulate more complex patterns, as in the example below.

T: ... What equation determines the value of MAP?
S: MAP = CO * TPR.
T: Correct. And you have predicted CO increases and TPR increases. So how can you say MAP decreases?

To ensure responsivity to the student, TIPS can replan after every turn. If the student does not understand the point of a multi-turn schema, it can respond to the student's error or drop the schema in favor of a different one. Rather than merely evaluating the student's answers as right or wrong, it can issue acknowledgments, restate answers which are close but not exact, rebut untrue statements, and provide tips for students who are on the path toward a correct answer.

We have tried to provide a variety of ways to teach each topic, including options at the pedagogical, syntactic and lexical levels. Additionally, since the turn planner builds a turn at a time from semantic forms provided by the tutorial planner, we can generate additional variety by combining semantic forms into sentences in different ways.

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Reference

Carbonell, J. R. (1970). AI in CAI: Artificial intelligence approach to computer assisted instruction. *IEEE Transactions on Man-Machine Systems,* 11(4), 190–202.