

## Invited Talks

### **CTAT: Efficiently Building Real-World Intelligent Tutoring Systems Through Programming by Demonstration**

*Vincent Aleven*

Intelligent tutoring systems (ITS) are highly effective in supporting student learning, but are difficult to build. The Cognitive Tutor Authoring Tools (CTAT) project started over 6 years ago with the goals of making it easier for experienced programmers, and possible for non-programmers to create an ITS. CTAT supports tutor building through programming by demonstration, an approach that has been successful in a range of application areas, but that has been applied to only a very limited degree to ITS authoring. Using CTAT, an author creates a tutor by demonstrating correct and incorrect problem solving behaviors, rather than by writing code. The resulting tutors, called example-tracing tutors, evaluate student behavior by flexibly comparing it against the demonstrated problem-solving examples. A key question is whether programming-by-demonstration can support sophisticated tutor behavior. We illustrate that example-tracing tutors are capable of sophisticated tutoring behaviors, going well beyond VanLehn's (2006) minimum criterion for ITS status. They provide step-by-step guidance on complex problems while recognizing multiple student strategies and maintaining multiple interpretations of student behavior when there is ambiguity. Example-tracing tutors have been built and used in real educational settings for a wide range of application areas. Development time estimates from these projects indicate that CTAT improves the cost-effectiveness of ITS development by a factor of 48, compared to historical estimates.

Although there is a lot of variability in these kinds of estimates, they nevertheless support our hope that lowering the skill requirements for tutor creation will support widespread adoption of ITS technology.

This talk reflects joint work with Bruce M. McLaren, Jonathan Sewall, Kenneth R. Koedinger, and the CTAT Team.

### **The Ubiquity of Constraints**

*Eugene C. Freuder*

Constraints are everywhere. The popular puzzle sudoku is an example of a constraint satisfaction problem, where a sample constraint would be "all the numbers in the first row have to be different." Real-world constraint problems can involve reasoning about costs, preferences, uncertainty, and change. Constraints arise in design and configuration, planning and scheduling, diagnosis and testing, and in many other contexts. They define problems in telecommunications, Internet commerce, electronics, bioinformatics, transportation, network management, supply chain management, and many other domains. Once problems are modeled as constraint satisfaction problems, constraint satisfaction and optimization methods may help individuals and businesses make satisfactory or even optimal choices when presented with many options and restrictions. The abundance of potential applications multiplies the opportunities to validate and motivate basic research, and to transfer technology for economic and social benefit.

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### **AutoTutor and the World of Pedagogical Agents: Intelligent Tutoring Systems with Natural Language Dialogue**

*Art Graesser*

Pedagogical agents with conversational dialogue are becoming more popular in today's advanced learning environ-

ments. The intelligence of the knowledge tracking, conversational moves, and other features of these agents have been improving over the last decade and skepticism about this technology is waning. This presentation covers the 12-year evolution of AutoTutor, a learning environment with an agent that tutors students by holding a conversation in natural language. AutoTutor presents challenging questions or problems and then engages in dialogue that guides the student in building an answer. There are versions of AutoTutor that guide interactive simulation in 3D microworlds, that detect and produce emotions, and that are embedded in games. AutoTutor improves learning over reading textbooks for an equivalent amount of time. The presentation covers AutoTutor and other learning environments with conversational pedagogical agents.

## **Linguistic Ontologies for Time and Space**

*James Pustejovsky*

Natural languages encode concepts of time in different ways and to varying degrees, using distinct grammatical, aspectual, and adverbial constructions; and yet the underlying possible relations between events and temporal expressions are universal. Similarly, languages impose very different linguistic constructions for related spatial configurations, while the underlying set of relations would appear to be logically fixed as well. For this reason, it is common to think that ontologies for both spatial and temporal domains can be designed independently of linguistic data, working from first principles within a logic of specific individuals and relations between them. In this talk, I will argue that ontology design must pay close attention to the manner in which spatial and temporal concepts are realized as linguistic descriptions. There are, however many phenomena in language that suggest a richer and more complex interaction of semantic factors in our conceptual architecture. In this talk, I discuss two such phenomena that pose significant challenges to the design of semantic ontologies for language: (a) cocompositionality — the emergence of new senses in context from bilateral composition and coercion; and (b) the structure of complex categories — where linguistic expressions can refer to “complex types” that denote both spatial and physical entities, or both temporal and spatial entities, for example. I illustrate how such phenomena can be adequately explained within theories of linguistically motivated ontologies.

## **Subjectivity Analysis**

*Jan Wiebe*

There is growing interest in the automatic extraction of opinions, emotions, and sentiments in text (subjectivity analysis) to support natural language processing applications, ranging from mining product reviews and summarization, to automatic question answering and information extraction. This talk briefly overviews two problems in subjectivity analysis at opposite ends of a continuum: subjectivity sense labeling and discourse level opinion interpretation.