

What is an Intelligent Tutoring System?

Links: A column edited by Syed S. Ali and Susan McRoy

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Guest editor

Guest editor Professor Reva Freedman of Northern Illinois University writes this issue's column. Professor Freedman's research is in reactive planning and theories of discourse and dialogue processing with the goal of building better intelligent tutoring systems.

What is an Intelligent Tutoring System?

One reason that ITS is such a large and varied field is that “intelligent tutoring system” is a broad term, encompassing any computer program that contains some intelligence and can be used in learning. ITS is an outgrowth of the earlier computer-aided instruction or CAI model, which usually refers to a frame-based system with hard-coded links, i.e. hypertext with an instructional purpose.

The traditional ITS model contains four components: the domain model, the student model, the teaching model, and a learning environment or user interface. ITS projects can vary tremendously according to the relative level of intelligence of the components. For example, a project focusing on intelligence in the domain model may generate solutions to complex and novel problems so that students can always have new problems to practice on, but it might only have simple methods for teaching those problems, while a system that concentrates on multiple or novel ways to teach a particular topic might find a less sophisticated representation of that content sufficient. When multiple components contain intelligence, homogeneous or heterogeneous representations can be used.

ITS can also be classified by their underlying algorithm. One well-known category is the *model-tracing tutor*, which tracks students' progress and keeps them within a specified tolerance of an acceptable solution path.

A theme underlying much of ITS research is domain independence, i.e. the degree to which knowledge encoded in the teaching model can be reused in different domains. Although to the external observer, domain independence seems like an essential characteristic of intelligence, many experts believe that some of the essential pedagogical knowledge in every domain is fundamentally domain-dependent. For example, there are analogies used in teaching physics, and even in teaching specific topics in physics, that have no equivalents in other domains.

Task independence, or the degree to which the knowledge in the system can be used to support a variety of tasks on the part of the student, has not yet been addressed by most systems.

Journals

The International Journal of Artificial Intelligence in Education (<http://cbl.leeds.ac.uk/ijaied/>), the official journal of the International AIED Society, is the preëminent journal in the field, and is published in both print and Web-based forms.

Other journals that publish significant ITS research include User Modeling and User-Adapted Interaction or UMUAI (<http://umuai.informatik.uni-essen.de/>) and the International Journal of Human-Computer Studies (<http://www.academicpress.com/ijhcs>).

Conferences

The ITS conference is held in even-numbered years and has proceedings published by Springer. In addition to the main conference, many new ideas receive their first public presentation in one of the associated workshops. The latest ITS conference was in Montreal, <http://www.info.uqam.ca/its2000/>.

The equivalent conference in odd-numbered years is the International Conference on Artificial Intelligence in Education (AIED), which can be reached from the IJAIED home page listed above.

Every year, the International FLAIRS Conference (<http://www.flairs.com/>), a Florida-based conference with wide international participation, has a special ITS track.

Readers interested in natural language-based tutors are encouraged to check out the AAAI Fall 2000 Symposium on Building Dialogue Systems for Tutorial Applications (<http://www.pitt.edu/~itsdial/its-symp.html>).

Books and Articles

One difference between ITS and some other areas of AI is that selected older references are still relevant. The collection of classic articles by Sleeman & Brown (1982) is worth reading by any worker in the field. Wenger's (1987) textbook contains a good map of the field for newcomers and descriptions of many classic systems. Carbonell's (1970) paper, often considered in the US to be the original ITS paper, is also interesting as an example of how AI has changed in thirty years.

An extensive bibliography of print resources can be found at the Department of Education and Educational Research of Göteborg University (http://www.ped.gu.se/KIKI/5_materi.html).

ITS Projects and Centers

To provide links to as many interesting projects as possible, I have concentrated on links to major centers without wishing to slight lesser-known projects. Some major centers of ITS research include:

- CIRCLE (<http://www.pitt.edu/~circle/>), the Center for Interdisciplinary Research on Constructive Learning Environments, is a joint project of the University of Pittsburgh and Carnegie Mellon University. Pointers to the ACT-R family of model-tracing tutors can be found at this site.
- The Institute for the Learning Sciences at Northwestern University, <http://www.ils.nwu.edu/>.
- The Center for Knowledge Communication at the University of Massachusetts–Amherst, <http://ccbit.cs.umass.edu/ckc/>.
- The ARIES project at the University of Saskatchewan,

<http://www.cs.usask.ca/projects/aries/>.

- The Computer Based Learning Unit of the University of Leeds, <http://cbl.leeds.ac.uk/>.

Natural Language-Based Tutors

One interesting subarea of ITS research is dialogue-based tutoring systems, which can be considered an elaboration of the architecture described above. The underlying metaphor of these systems is conversation, often in typed form to avoid the specialized algorithms needed for speech recognition, and often including non-verbal acts such as pointing or graphics display in addition to speech acts. These systems extend research on domain independence to include issues of language independence, i.e. the extent to which resources developed for natural language understanding and generation can be reused in different tasks and domains.

Some ongoing natural-language based projects include Atlas (<http://www.pitt.edu/~circle/Projects/Atlas.html>) at the University of Pittsburgh, AutoTutor (<http://www.psyc.memphis.edu/trg/trg.htm>) at the University of Memphis, and CIRCSIM-Tutor (<http://www.csam.iit.edu/~circsim/>) at the Illinois Institute of Technology.

Related Areas

Areas related to ITS research include authoring tools, educational technology, and the new and growing area of adaptive hypermedia (<http://wwwis.win.tue.nl/ah/>).

References

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- Sleeman, D. H. & Brown, J. S. (Eds.). (1982). *Intelligent Tutoring Systems*. New York: Academic Press.
- Wenger, E. (1987). *Artificial Intelligence and Tutoring Systems: Computational and Cognitive Approaches to the Communication of Knowledge*. Los Altos, CA: Morgan Kaufmann.