Virtual Pedagogical Agents as Aids for High School Physics Teachers

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Abstract:

The Pathway project is improving the quality of physics teaching and the number of available physics teachers by providing virtual expert help on issues of pedagogy and content. The project combines Carnegie Mellon's Synthetic Interviews and state-of-the-art digital video library technology with pedagogical advances developed at Kansas State University, and materials contributed by master teachers. The Synthetic Interview is a technology and technique that creates an anthropomorphic interface into multimedia data of a particular kind: video of a person responding to questions (interacting with another person). The responses of the interviewee are presented in such a way as to simulate the experience of interacting with the expert.

1 Pathway

The Pathway project is improving the quality of physics teaching and the number of available physics teachers by providing virtual expert help on issues of pedagogy and content. The project combines Carnegie Mellon's Synthetic Interviews and state-of-the-art digital video library technology with pedagogical advances developed at Kansas State University, and materials contributed by master teachers. This dynamic digital library (Figure 1) for helping teachers goes beyond simply creating a collection of teaching and learning materials. It provides continuously improving assistance and expertise for teachers, all of which are related to the National Science Foundation Standards and to results of contemporary physics education research.

The most significant Pathway effort to date has been the development of Synthetic Interviews [1]. The Synthetic Interview is a technology and technique that creates an anthropomorphic interface into multimedia data of a particular kind: video of a person responding to questions (interacting with another person). The responses of the interviewee are presented in such a way as to simulate the experience of interacting with the expert. Importantly, empirical studies have shown that anthropomorphic interfaces can have a strong motivational impact compared to text or traditional multimedia, with users perceiving the persona as being helpful, entertaining, and creating a more positive learning experience [2,3].

The Synthetic Interviews in Pathway focus on good teaching practices which are consistent with the National Science Education Standards. They emphasize hands-on and minds-on activities as well as conceptual understanding of the physics concepts rather than algebraic or numerical approaches. Thus, the new-to-physics teachers, pre-service teachers and experienced teachers are able to "converse" with knowledgeable experts on their

classroom techniques and how those techniques are related to contemporary issues in physics teaching.

2 Pathway Synthetic Interviews

We have developed Synthetic Interviews of four master teachers, each of whom bring different experiences and approaches to teaching. Currently, these master teachers answer

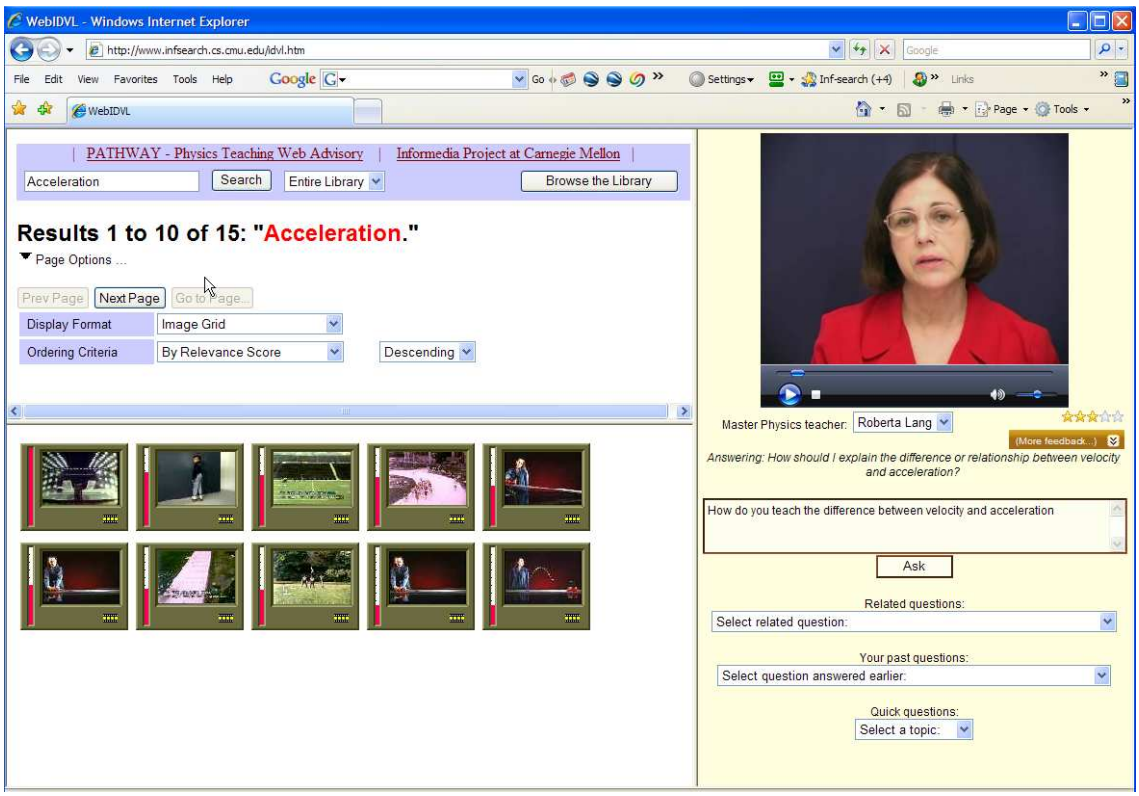

Figure 1. Pathway Digital Video Library and Synthetic Interview.

2248 pedagogical questions covering topics that span the full one-year high school curriculum. Users can pose follow-up questions which, if not already in the system will be answered by the master teacher and added to his or her Synthetic Interview. Through this process, Synthetic Interviews continually deepen in their knowledge, providing a unique, interactive resource for improving physics teaching and a model which could be followed in a variety of disciplines.

Processing of open-ended user questions is a challenging task. However, it is a tractable task because full processing and "comprehension" of the input is not required. Instead, mapping to functional meaning categories with appropriate responses is sufficient. Synthetic Interview technology employs both structural and statistical processing algorithms to perform its categorization. As users interact with a Synthetic Interview, queries and responses are stored in state variables that keep track of the history of the interactions. These variables capture information on the current topic of conversation, the length of focus on this topic and the current speaker. Subsequent queries and responses are passed through a rule base which checks for repeated queries and determines the need for and types of responses.

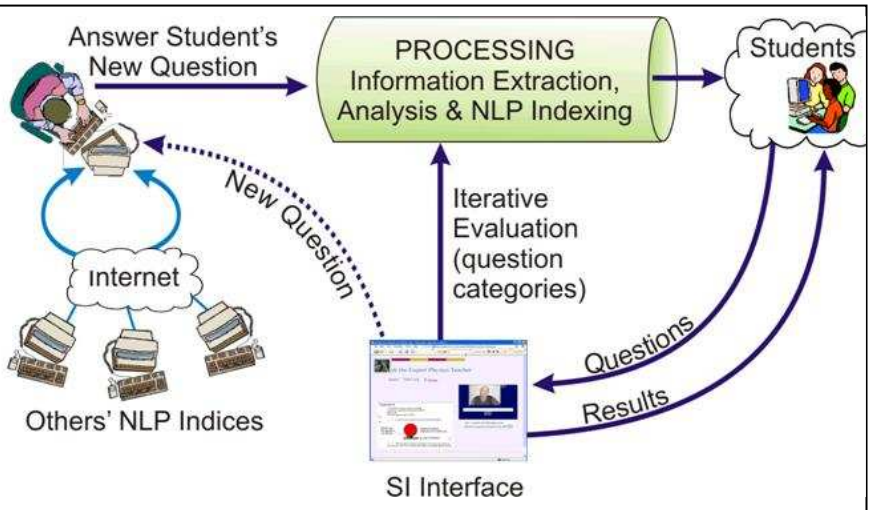

Figure 2. Synthetic Interview development process.

Effective Synthetic Interviews require iterative evaluation of question categories and extension of the response category corpus, based on continuous monitoring of the user questions (Figure 2). In practice, teachers and students ask any question they like in a conversational fashion. If the system determines it has a relevant answer to the question, the user receives an immediate response. If there is no match, the question is sent via e-mail to the appropriate respondent. The domain expert records a response, which is sent to the questioner and is entered into the corpus for the next time it is asked (dashed arrow in Figure 2).

3 Pathway Digital Video Library

Another component of Pathway is a searchable digital video library of physics demonstrations, teaching examples, and virtual video labs, Pathway–Informedia, built on Carnegie Mellon's Informedia Digital Video Library [4].

Carnegie Mellon's Informedia Digital Video Library focuses specifically on information extraction from broadcast-quality video and audio content. It operates similarly to a Web search engine but does so by searching on video and audio information. Over forty terabytes, consisting of more than 30,000 hours of online news, documentary, and ethnographic videos have been collected, with automatically generated metadata and indices for retrieving videos from this library. The interface has been designed to allow efficient browsing and access to information in spite of errors in the automatically produced descriptors of content, i.e., the metadata, with empirical studies [5] and TREC Video Retrieval evaluations [6] validating the effectiveness of the video library interface. Additionally, the Human-Computer Interaction Institute [7] examines the social aspects of tools developed to assist human activity and evaluates those tools through carefully designed experiments. Informedia provides Pathway with a foundation of a unique, well-developed infrastructure and research base. It enables us to include an audio-video search engine with unprecedented capability in present science education digital libraries for use with the Pathway Teacher Cooperative.

The Pathway video corpus contains hundreds of clips illustrating concepts in kinematics and dynamics from award winning videodiscs including *Physics and Automobile Collision* [8], *Physics at the Indy 500* [9], *Studies in Motion* [10], *Physics of Sports* [11], and *Skylab Physics Videodisc* [12], amongst others. As users search and browse the library, they can create a personal on-line collection of objects (Figure 3) to be used in their lessons.

In the present Pathway, teachers may send us a video which our staff then incorporates into the library (Figure 1). In fact, Pathway serves as the digital video repository for the

Communities for Physics and Astronomy Digital Resources in Education (ComPADRE) digital library which is being developed under the auspices of the American Association of

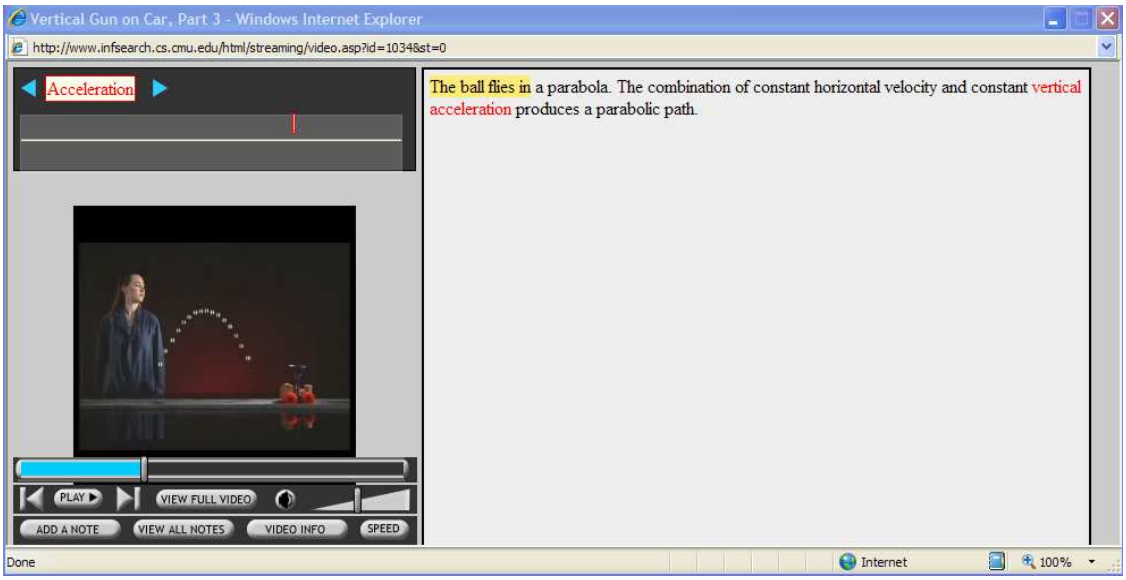

Figure 3. Pathway Digital Video Library Object

Physics Teachers, the American Physical Society, the American Institute of Physics/Society of Physics Students, and the American Astronomical Society. Until the Pathway demonstration, Informedia focused specifically on information extraction from broadcast television video and audio content. Today it is ready to accept a wide range of material relevant to physics teaching.

4 Conclusions

Pathway conveys, by example and explanation, contemporary ideas about the teaching of physics. The system will continually evolve through expanding Synthetic Interviews, assessment of its use, and feedback from users. Pathway engages new and established physics teachers into becoming part of a dynamic digital library social network. By the conclusion of the project, we will have created a community of users and contributors who provide source material for the state-of-the-art video system. Pathway shows how teachers can interact, both virtually and directly with experts in physics teaching, cooperate to help each other become more effective teachers of physics, and develop advanced recourses for their students.

This talk demonstrates Pathway capabilities and content. Additionally, the Synthetic Interview and digital video library development processes and underlying technologies are highlighted. Finally, results from early usability studies will be presented.

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