12-2002

Semantic exploration of lecture videos

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ABSTRACT

E-Learning is rapidly changing the way that universities and corporations offer education and training. In recent years, the acquisition and distribution of rich media content has been largely automated [1], However, existing applications are functionally and visually static and remain organized around the delivery media, rather than the knowledge representation and learning tasks of the student. The innovative approach of this system is the extraction of semantically meaningful structures in the lecture combined with text analysis to support task based queries. In this demonstration we will show this combination of pedagogical and content descriptions leads to novel forms of visualization and exploration of course lectures. System capabilities and semantic analysis technologies applied to lecture content obtained from a graduate level SMA (Singapore-MIT Alliance) distance education course will also be presented.

Keywords

semantic analysis, lecture analysis, e-learning, visualization, knowledge management, MPEG-7.

1. MOTIVATION

Distance learning has swiftly gained acceptance as a preferred teaching method in many higher education institutions and private corporations. Most of the digital media available for students is produced either in the form of a lecture presented in front of a live class or as recordings of talks and small group meetings. Such productions are an artifact of the traditional classroom setting where the instructor determined the lesson content and set the pace of the learning.

An increasing amount of learning today is self-directed, however, the vast amount of digitized lectures in their current form are ill-suited for this learning paradigm. The utility of such materials can be dramatically increased through semi-automatic analysis of the content to generate metadata that indexes and cross-references the media in smaller semantic modules than previously available. The increased information density provides for the creation of user-centric services for the navigation, exploration, and discovery of information and relationships in a large digital repository.

Multimedia'02, December 1-6, 2002, Juan-les-Pins, France.

The Singapore-MIT Alliance (SMA) is an innovative distance education and collaborative research program in which students at both MIT and Singapore's top two universities receive MIT courses through state of the art facilities. Over the past year, we've implemented our e-learning system with content from the SMA course, *Introduction to Algorithms* with the goal to achieve personalized management and presentation of courses through the composition of smaller information modules. Our application applies the increased variety and precision of lecture metadata to construct concept oriented course visualizations coupled with task based navigation and query abilities. We believe that the novel combination of these features provides a pedagogical learning environment adapted around a student's propensity for self-directed, constructionistic learning.

2. THE LECTURE EXPLORER SYSTEM

Several experimental lecture browsers have been developed in recent years. The BMRC lecture browser [2] provides a web-based platform for the viewing of streaming lecture videos with synchronized slides and a table of contents for the visualization of the lecture content. The IBM lecture browser [1] emphasizes the use of automatic analysis of the video and the generation of transcripts from speech to support content based access. Whereas previous lecture browsers were designed to facilitate the access and playback of lecture content, the emphasis of our lecture explorer is on the interactive visualization of lecture content and the use of pedagogical structures to facilitate task based exploration of the learning material.

The Lecture Explorer system combines three main modules: event extraction, media and knowledge management, and interactive visualization. Semantically meaningful events are extracted using multi-modal analysis of the lecture video, slides, and speech track. The metadata results are stored as MPEG-7 description schemes. The media and knowledge management module stores information as a graph structure with node semantics defined to allow efficient manipulation and traversal for the dynamic construction of interactive visualizations, including the traditional table of contents, concept map, and hyperbolic tree displays.

2.1 Media and Knowledge Management

Knowledge management, as viewed from the perspective of a student taking a course for the first time, or exploring a course to review a particular concept, entails core functionalities for organizing the lecture topics, exploring relationships among concepts, and preserving annotations about the lecture content.

The Lecture Explorer uses a graph model to represent pedagogical elements of the lecture, such as *topics*, *definitions*, *theory*, *discussion*, and *examples* as illustrated in Figure 1. These pedagogical elements are categorized by applying probabilistic models to the temporal sequence of low level events extracted from the video, slides, and speech from the lecture presentation.

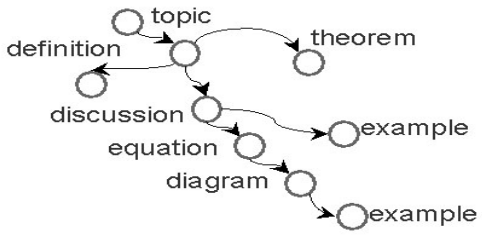

Figure 1: Lecture scene analysis provides information for the pedagogical structure of the lecture.

The representation of lecture topics and details of their presentation, thus enables the Lecture Explorer to combine content based search with high level knowledge about the type of information being presented in the lecture.

2.2 Task Based Exploration

The student may choose to explore the lecture content according to various generic tasks, such as finding specific content, discovering relationships, or filtering out certain details of the presentation. Each of these tasks corresponds to a different view of the information space for the lecture. Since the information space is represented as a graph structure, each view can be constructed dynamically.

The lecture topics for two lectures in *the* '*Introduction to Algorithms*' course are displayed as a hyperbolic tree in Figure 2. In this example, the student makes the task based query; "*Find a diagram illustrating minimum spanning trees*." The Lecture Explorer processes the request by first finding the topic, in this case '*minimum spanning trees*', then completes the task by searching within this topic for the requested pedagogical structures. The node containing the search result is centered in the display area and the nodes representing the pedagogical structures for this topic are displayed in the inset. The student can then navigate directly to the diagram and view the corresponding slide and video sequence.

2.3 Applications for Learning

The Lecture Explorer combines media and knowledge management with content analysis to provide a flexible organization of lecture material. Although the initial application domain is the exploration of large repositories of digitized course material, this approach is also useful for the exploration of corporate knowledge captured in video, eg. talks, meetings, and in house courses. In each case, there is a repository of slowly changing reference material (eg. lectures or text) which can be mined for relationships and concept clusters, as well as a set of rapidly changing information (eg. recitation, talks, or meetings) which contain new information to be integrated into the information space by the knowledge management module.

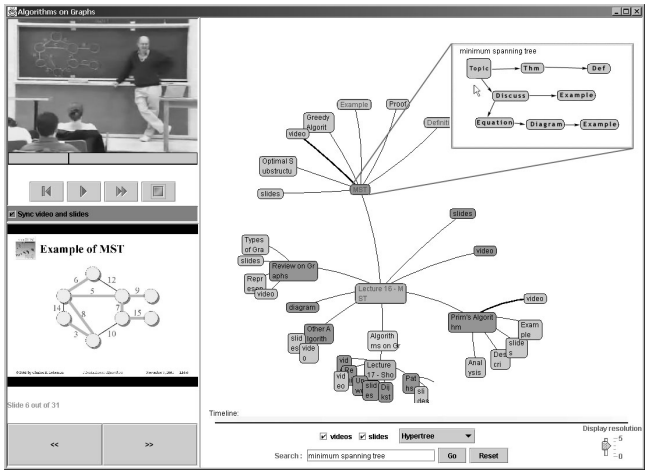

Figure 2: A snapshot from the Lecture Explorer.

3. CONCLUSION

In this demo, we present the Lecture Explorer system, which combines pedagogical descriptions of lectures with task based models for user interactions. The approach is based on the integration of knowledge management with media management to compose highly personalized views of lecture content. Therefore, this system has the potential to impact a broad range of applications where academic or corporate knowledge is captured on digital media.

4. ACKNOWLEDGMENTS

Our thanks to the LIT Media Engineering Program for supporting this research. We would also like to thank Prof. Charles Leiserson at MIT for the use of the digital media from his "Introduction to Algorithms" course.

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