ABSTRACT

One of the main challenges facing web-based multimedia content creators today is the development of cost-effective digital media content for courseware that is reusable and interoperable. Given this, we propose the design and implementation of a model to manage the multimedia and metadata within a system of related topics in a course that is delivered via electronic lectures. This model not only supports the re-purposing and interchange of a course’s digital media content, but also preserves the semantic dependencies and associated media-mapping, of pre-requisite and co-requisite knowledge within a course. Coarse grain or topic-based segmentations of an electronic lecture are used as building blocks to automatically create new, media-rich, electronic lecture experiences of interest to a user and subject to the constraints imposed by the model.

1. INTRODUCTION

Recent trends in e-learning suggest that universities will increasingly offer more of their course material online[1]. One such burgeoning online e-learning solution is the capture and access of live lecture experiences. Since a large part of the educational process consists of lectures, these capture and access systems attempt to: 1) preserve a live lecture experience in its spontaneous and original format; and 2) create a media-rich, electronic version (or electronic lecture) of that experience for web-based access at a later time. One consequence of the growing acceptance for the use of capture and access technology in e-learning is that tailored and, sometimes proprietary, systems are proliferating. Notwithstanding the manuals labor costs associated with creating such content, disproportionate emphasis is being placed on capturing and providing access to the captured digital content rather than actually creating an interoperable and reusable, repository of these unique, live experiences.

Given this, we propose a model, named Mosaix, to support capture, management and access of digital content recorded from a live lecture. Such a system is a novel approach with respect to other capture and access systems because it provides a cost effective means for the content producer to create and access a collection of media streams as a synchronized unit; annotate and segment continuous media into coarse-grained learning objects; and additionally, create, correlate and structure semantic information across different media types. This allows end users to reuse the digital content of the capture and access systems as building blocks by posing a topic-based query and retrieving a new electronic lecture consisting of the topic of interest as well as semantically related topics. Furthermore, it provides a mechanism for the same digital content be shared or used outside the resource producer’s system or with other capture and access systems. We implement Mosaix within LectureLounge [2]. In the sections that follow, we provide an overview of related work in capture and access systems then describe LectureLounge and the Mosaix subsystem finally we conclude by discussing the impact of such work.

2. RELATED WORK

There are a number of systems that aim to capture live lecture experiences[3] [4] [5] [6] [7] [8] [9]. Live lecture experiences are distinguished by the fact that a subject matter expert imparts information to an audience and the audience (who is also the end user) may be part of the captured experience as well. These systems reconstruct the temporal relationship among the media streams in the live lecture experience and create a digital lecture that replays its streams with the same synchrony as the original.

These systems can be divided into two major groups, those that provide static functionality[5] [9] [7] [6] or dynamic functionality [4] [3] [8]. Capture and access systems with static functionality assume that the experience, once captured and produced, becomes a frozen asset and their goal is to provide playback for later use. Dynamic systems, on the other hand, seek to provide some extended functionality so the media assets can be used as pedagogical components in addition to presentation. MANIC [4], for example, focuses on developing intelligent tutoring using slides and video. Lecture Explorer [3] uses a video-only media stream and automatically segments it to support certain user tasks such as finding a specific topic, discovering relationships,
and filtering details. Just-In-Time Lectures [8] seeks to provide interactivity via email and access to course-related resources including assignments, exercises, supplemental text and glossaries via the Web in a distance learning environment.

In contrast to these systems, LectureLounge it is universally usable[2] and thus a cost effective means to non-intrusively capture synchronized digital video and image presentations with comparatively little manual labor. For example, slides are created automatically during the capture process; therefore, there is no need to reply upon commercial presentation graphics software. As a result, LectureLounge greatly eliminates the amount of manually labor required to produce a set of digital slides. In addition, it consists of an independent semantic layer that allows the underlying media assets to be segmented, annotated, correlated with other learning resources, structured and packaged for reuse and export.

The motivation for our design is based on our teaching experience in the area of Computer Science and recent studies that show most students who attended the class watch only a portion of an electronic lecture for the purpose of reviewing what was said about a certain topic[5]. Therefore, our approach is designed to support each individual student in formulating and automatically creating new electronic lectures as a basis for review and allow students to reinforce explicit knowledge on a topic level. It supports not only the student, but also the instructor’s task to define and deliver the information that can best advance the students’ acquisition of skills. In the remainder of this work, we describe the components of LectureLounge which satisfies the aforementioned objectives.

3. LECTURE LOUNGE COMPONENTS

The LectureLounge can be viewed as a three-tier system (Fig. 1). Tier 1, the Media Management layer, consists of the capture, archive and presentation of digital media collected from a live lecture. Tiers 2 an 3 represent a semantic layering on Tier 1. Tier 2 casts a user-defined view on the underlying raw media and essentially maps metadata to the media in the archive; and Tier 3, imposes a vocabulary and structure (depicted by the directed arrow) on the underlying user-defined view.

The motivation for such a design is based on our objective to create an interoperable and reusable, repository of unique, live experiences. We believe that separating the capture and access, or media-related view, from the semantic view will support this objective. In the next section we discuss each tier of the model.

3.1. Media Management: Tier 1

In the LectureLounge system a live lecture is captured with a Mobile Recording Unit (MRU). The MRU consists of a digital camera, wireless microphone and a laptop. A capture card built into the laptop’s docking station receives the camera signal and transcodes it into MPEG-1 or MPEG-2. In addition to the video, LectureLounge also captures the slides directly from the video projector with a VGA-grabber card. This ensures that not only the slides, but also the point and length of their appearance are captured. Since the MRU is by design mobile, it can be used virtually everywhere; furthermore the presenter’s machine is left untouched. This setup enables LectureLounge to work non-intrusively.

After capture, the material is further processed and ingested into the LectureLounge system. This task requires no human interaction beyond placing the MRU online and editing a configuration file needed by the ingest driver. During the ingest phase, duplicate slides are filtered and the times when discreet events occurred in the lecture (in this case, the time each slide changed) are extracted. The metadata acquired during this phase is stored in a relational database, which serves as the back-end of the LectureLounge web portal. The live lecture is recreated by synchronous playback of the video and slides using SMIL 1.0. technology.

3.2. Metadata Management: Semantic Layering

3.2.1. The Mosaix View: Tier 2

After ingest, the subject matter expert can begin to build the semantic layer(Tier 2 of Fig 1). In order to do so, the expert is presented with a storyboard as shown in Fig.2(a), representing the set of time-stamped images obtained during ingest. Since the timestamp of each image is known, the storyboard provides nonlinear access, to any continuous media that was recorded during the lecture and subsequently
loaded in the Resource Window in Fig. 2(b). The storyboard serves as the basis for partitioning the entire live lecture experience into individual units as well as allowing the subject matter expert to correlate semantic information across different media types within each unit.

(a) Storyboard Window

(b) Resource Window

Fig. 2. Building a Semantic Layer.

Given this segmented, high-level view of the live lecture experience, the expert can selectively group slides and use the Resource Window in Fig. 2(b), to associate additional course related information and semantics with each set of selected slides. The expert can augment the prerecorded lecture with user-defined, context sensitive anecdotes to further refine or didactically structure an electronic lecture at an arbitrary point. During playback, all the annotations are transformed into SMIL 1.0 files and are ultimately delivered in synchrony with the prerecorded slides and video and individuals using the same presentation system can view these new annotations files as well. Although the annotation process requires manual overhead, automatic processes to segment video and create relevant annotations such as: topics, slide titles, description of learning objectives, web links, books, chapters, assignments, or test questions may be subject to substantial error; we, therefore rely upon subject matter expert to create such annotations manually.

As the expert groups selected slides into coarse-grained learning objects, modules constructed with MPEG-7 descriptors are created and stored internally as an XML data-type in a relational database. When an end user searches for a module, a text search is performed on selected fields of the XML structure. A user can either retrieve a single module, several, unrelated modules or all modules semantically related to the chosen one. Each module can be used as a mosaic or building block to automatically create new electronic lectures of interest to them. A new electronic lecture is created by automatically sequencing the individual modules in a SMIL 1.0 format. To export to module to another presentation or learning management system, each module is converted to a SCORM-compliant learning object.

In order to support search and retrieval mechanisms, the semantic content creator selects the appropriate area, unit or topic categories from the Resource Window in Fig. 2(b) while creating a module. The sequencing and vocabulary imposed on the modules is defined in the ontological layer described in the next section.

3.2.2. The Ontological View: Tier 3

In order for a module to be located and sequenced semantically with other modules, the domain knowledge i.e. area, unit, and topics used in tier 2 must be structured. An ontology can be defined as the specification of vocabulary, including relations, for a domain of discourse and can be built from the semantics of a single problem domain. We focus on building a domain specific ontology in the area of Computer Science. The vocabulary and structure for such an ontology is based on the Association of Computing Machinery(ACM) core body of knowledge in the area of Computer Science. This body of knowledge is a three level hierarchy consisting of: areas, units(with corresponding learning objectives) and topics. Before the ontological view can be mapped onto tier 2, the units and topics for a specific area must be sequenced according to the subject matter expert’s view of the course. It is our experience that when a course is taught, structuring of topics, identifying learning objectives and selecting relevant terminology is often done anyway and given to the students in the form of a syllabus or course outline. To do this electronically, the author uses drop down menus to associate a cardinal number with the units and topics of a given area: thus imposing a sequencing on the topics associated with each module created in tier 2. Each topic, unit and area is given a unique identifier and the associations between domain knowledge are represented by the is-predecessor-of and is-successor-of binary relations. The domain knowledge is represented by a directed graph and we built a semantically-related concatenations of modules using a modification of the Bellman-
Ford algorithm to find the shortest path between all pair of modules from the target module to a foundation module satisfying the is-predecessor-of relation. The foundation module represents a foundation topic (a topic which has been assigned cardinal number of one) upon which other knowledge is built and this module has no parent in the graph.

4. FUTURE WORK AND CONCLUSION

The interrelationships in the Mosaix are dependent on the robustness of the superimposed ontological layer. In future work, we will examine ways to scale the ontological layer to include for example, prerequisite knowledge between different courses in the ACM body of knowledge and others topics defined by ACM but included in the core. Additionally, we will incorporate student models into our systems.

In this work we have described the superimposition of a model onto a capture, management and access system that creates electronic lectures from live lectures. We believe that the personal nuances an instructor imparts during a live lecture experience is invaluable and it is of benefit to the pedagogical community as a whole to preserve the cultural memory of these experiences in their spontaneous format. However, the value (cost benefit) of a lecture preservation system lies in its ability to be reused in a way that supports the student’s effort to gain reinforcement and in its ability to be shared with other learning management systems. The impact of such work along with other open-access initiatives can ultimately improve both the pedagogical product and process for web-based multimedia learning environments.

5. REFERENCES


