Automatic Lecture Recording for Lightweight Content Production

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INTRODUCTION

Today, classroom lectures are often based on electronic materials, such as slides that have been produced with presentation software tools and complemented with digital images, video clips, and so forth. These slides are used in the live event and verbally explained by the teacher. Some lecture rooms are equipped with pen-based interfaces, such as tablet PCs, graphics tablets, or electronic whiteboards (Figure 1). These are used for freehand writing or to graphically annotate slides. Lecturers put a tremendous effort into the preparation of such electronic materials and the delivery of the respective live event. The idea of approaches for so-called *automatic lecture recording* is to exploit this effort for the production of educational learning material. Although it is still controversial if such documents could ever be a substitute for actual classroom teaching, it is generally agreed that they make useful, gaining complements to existing classes, and their value for education is generally accepted (Hürst, Müller, & Ottmann, 2006). While manual production of comparable multimedia data is often too costly and time consuming, such "lightweight" authoring via automatic lecture recording can be a more effective, easier, and cheaper alternative to produce high quality, up-to-date learning material. In this article, we first give a general overview of automatic lecture recording. Then, we describe the most typical approaches and identify their strengths and limitations.

Figure 1. Pen-based interfaces commonly used in classrooms: Tablet PC (top left), graphics tablets (middle left and top right), and electronic whiteboards (bottom)

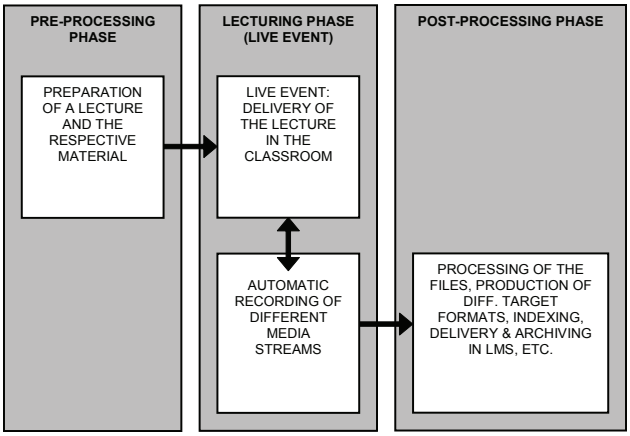
BACKGROUND

According to Müller and Ottmann (2003), content production via automatic lecture recording is lightweight and therefore efficient to realize, if the used method and its implementation is easy, quick, intuitive, and flexible. Presenters should be able to keep their personal style of presenting and teaching. In the ideal case, they are not even aware of the fact that their lecture is getting recorded. There should not be any additional preparation effort for the used electronic material. The information loss arising from the recording process should be kept to a minimum for reasons of quality, retrieval, and archiving.

Finally, one should be able to easily produce target documents for various distribution scenarios and infrastructures. Obviously, in practice, such a perfect scenario can hardly be realized, and compromises have to be made based on real-world restrictions and constraints.

The idea of lightweight content production has been developed and evaluated since the mid 1990s by projects such as Classroom 2000/eClass (Abowd, 1999; Brotherton & Abowd, 2004), Authoring on the Fly (Hürst, Müller, & Ottmann, 2006), and the Cornell Lecture Browser (Mukhopadhyay & Smith, 1999) to

Figure 2. Consecutive phases in the automatic authoring process



name just a few of the early ones. These projects (and many others) developed and evaluated a variety of approaches for this task: Media streams in the classroom can be captured automatically in various ways. Recordings are post-processed and distributed in several ways, and so on. Generally, these approaches fall into one of several categories, which we describe in detail in the next section.

APPROACHES FOR CONTENT PRODUCTION VIA LECTURE RECORDING

Processing Phases

The process of automatic lecture recording can be described by a sequence of different phases as illustrated in Figure 2. First, the teacher prepares the lecture and the required materials in a *pre-processing phase*. During the *lecturing phase*, the presentation is given to a live audience and simultaneously recorded. This live event is followed by a *post-processing phase* in which the final files and related Meta data are automatically created from the recordings. Depending on the respective approach, this post-processing might include activities such as an automatic editing of the recorded data and its transformation into different target formats, an automatic analysis of the produced files in order to generate a structured overview of its content and an index for search, and so forth. The final documents can be included into a learning management system (LMS) or distributed to the students via streaming servers, as download packages, or on CDs/DVDs.

Media Streams

Different media streams can be captured during a classroom lecture. It is generally agreed that the *audio stream* containing the voice of the presenter is the most important media stream of such a recording (Gemmell & Bell, 1997; Lauer, Müller, & Trahasch, 2004). It is normally complemented with a recording of the presented slides together with the respective annotations—the *slides and annotations stream*, which is often considered as "critical media" (Gemmell & Bell, 1997) as well. While early approaches for automatic lecture recording often settled for a temporally sorted set of still images of the slides (i.e., snapshots from the screen outputs), modern techniques generally preserve the whole dynamics of the annotations as well (i.e. recordings or screen captures of the handwritten annotations). Other media streams are, for example, the *application stream*, which contains the output of additional applications running on the lecturer's machine (e.g., a media player replaying a short video clip), one or several *video streams*, which contain a video of the presenter and/or the audience, additional *audio channels* (e.g., with questions from the audience), and so forth. In the perfect case, a lecture recording would preserve and represent the original live event as good as possible, thus capturing all relevant media streams in their most suitable quality. However, in practice often only selected data streams are recorded, for example, because of reduced availability of the required recording facilities during the live event or due to storage and bandwidth limitations during replay. Generally, the critical media of a live lecture, that is, the audio stream and the slides and annotations stream, are captured by all approaches. However, there are significant differences among these approaches, first, in how those two streams are recorded, and second, in how the additional media streams are preserved (if they are recorded at all). Recording of the audio stream is pretty straightforward. The used techniques differ only by the achievable quality and the data format used for encoding. When capturing the visual information, most importantly the slides and annotations stream, significant differences exist. In the following, we describe the respective approaches in further details.