This is a preliminary version of an article published in
Proc. of the 16th ACM international conference on Multimedia (MM) (Video Demo), pp. 1103-1104, Vancouver, BC, Canada, October 2008
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Automatic Lecture Recording

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ABSTRACT
We present our system for automatic lecture recording. In contrast to traditional lecture recording systems our approach aims to imitate a real camera team, consisting of multiple cameramen and a director, in order to make the recording more vivid. At first, we introduce the environment. Then, we present our approach, beginning with the director module, followed by the cameraman module and the sensor tools module, referring to the jobs of the respective human originals. The director is based on an Extended Finite State Machine, with transition conditions depending on input from sensor tools. The cameraman automatically controls iris, focus, etc., and also takes basic cinematographic rules into account. The video concludes with an example result of our virtual camera team of a real lecture. A video demo of our approach is available at [4].

Categories and Subject Descriptors
K.3.1 [**Computers and Education**]: Computer Uses in Education - *Distance Learning*

General Terms: Algorithms, Documentation, Design.

Keywords: Educational Multimedia Application, Automation, Camera-Team, Video Production Rules, Lecture Recording and Lecture Transmission.

1. INTRODUCTION
Lecture recordings are very common because they enrich and amend e-learning materials, they are easy to achieve and students can prepare for exams independent of time. But in many cases they are boring, independent of how fascinating the original session was, by only recording the slides and the lecturers audio. As television has pushed our expectations, our approach is to imitate a camera team for live production, for a more vivid video. This has two advantages: First, no time for postproduction is necessary. Second, it is possible to stream the final video directly, and it is thus possible to connect two remote lecture halls.

The basic idea to automatically record lectures or meetings is not new. While meeting recordings with 360° cameras look similar to a surveillance video [2, 5], the approaches from "AutoAuditorium" [1] and Microsoft Research [6, 8] are much closer to our approach. The main difference is that we react on events of the environment based on sensor inputs, instead of using fixed values or following a fixed camera switching scheme.

2. SYSTEM OVERVIEW
Our "camera team" is implemented as a distributed system based on several modules. The three most important ones are the director module, the cameraman module and the sensor tools module, as depicted in Figure 1. The shaded modules are not yet implemented.

As in reality, the director has the central role to communicate with all parts gathering and redistributing all messages. He determines which camera goes on air.

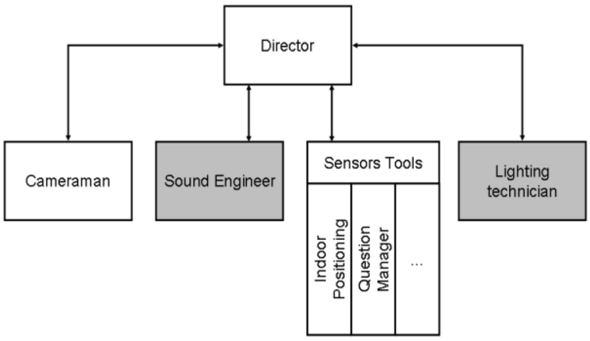

Figure 1. Overview of the system's modules.

3. DIRECTOR MODULE
The director module is based on an extended Finite State Machine (FSM), which we amended by contexts, namely a lecture context, a question context and an answer context. States showing the same shot but located in different contexts are reached by different transitions. The conditions triggering these transitions may be different. They fire with a variable probability, depending on sensor input. Figure 2 shows a simplified example of the FSM.

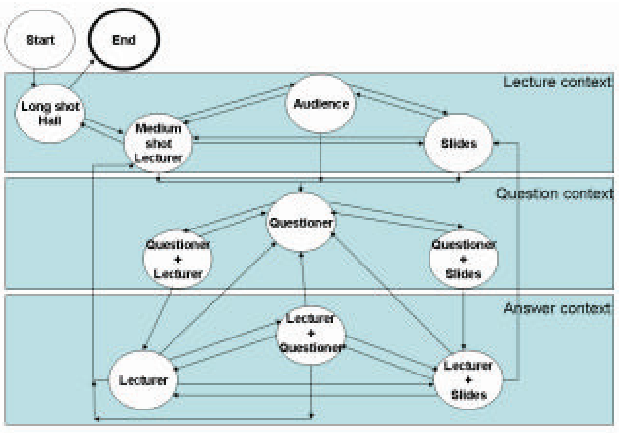

Figure 2. Simplified exemplary FSM.

When selecting the next transition, our approach starts determining all transitions going out from the active state and initializes their probabilities. In the next steps, these probabilities are modified: At first, they get decreased in proportion to how recently the possible new state was active. Then the sensor inputs, are evaluated; they also influence the transition probabilities. At last the camera motion of the camera corresponding to the new state is taken into account.

The transition with the highest probability is then selected. So, the behavior of the director module is always similar in similar situations but seldom identical.

4. CAMERAMAN MODULE

The job of the cameraman consists of three parts: a technical, an aesthetic and a communicative one. We have implemented these parts in the cameraman module. The technical part consists mainly of aiming at a target, adjusting the iris and focusing. Figure 3 shows a detailed view.

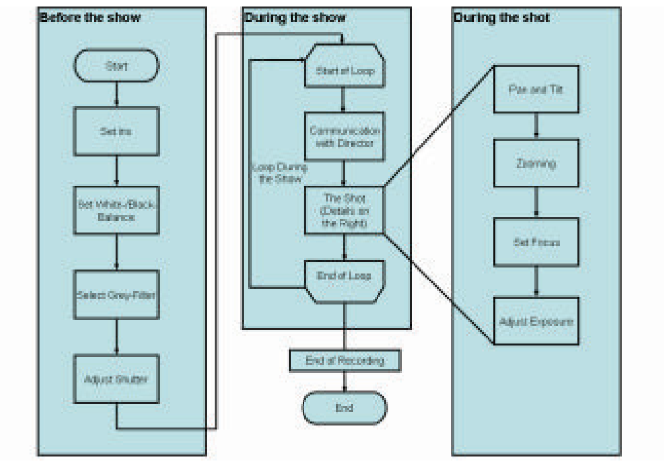

Figure 3. Flowchart of the cameraman's job.

The communication with the director is crucial. In a human camera team this is done via intercom. We use XML messages over TCP. The cameraman module gets its orders, what to show and how to frame, etc. Simultaneously, the cameraman module reports back the percentage of motion in its image and the camera status; they are used as camera-sensor inputs by the director module.

The aesthetic part can not be realized by the cameraman module alone, in contrast to the human role model. It needs additional sensor inputs preprocessed by the director module, e.g., the coordinates where to aim next. Here the sensor tools module comes into action.

5. SENSOR TOOLS MODULE

The sensor tools module includes two parts up to now, an indoor positioning system and a question manager software suite. As mentioned above, the cameraman module requires coordinates where to aim next. We take advantage of PDAs which we use anyway for interactive quizzes during the lecture [3, 7]. So, we are able to get the coordinates of a PDA of a student. In addition, the lecturer can also be equipped with a PDA if he/she moves around.

The coordinates are relevant if a student wants to ask a question. A question manager (QM) suite was implemented to map the question–answer workflow, which enables the director to switch the contexts accordingly and transmits the coordinates of the questioner to the director, which sends these to the cameraman module. In addition, we also use this software to carry the questioners' audio from the PDAs' microphone to the audience sound stream via the question manager server. Figure 4 gives an overview of the question manager suite.

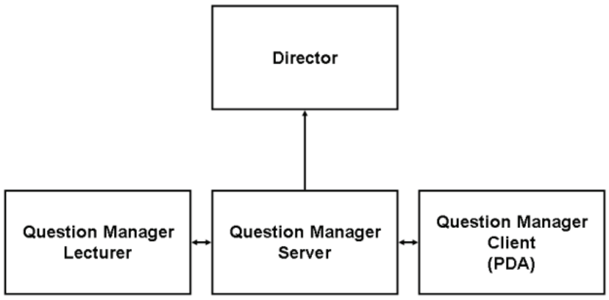

Figure 4. Overview of the Question Manager Suite.

6. CONCLUSION

The entire distributed system described above has been extensively tested in our lectures and is in the last steps of fine tuning. We will evaluate the system in the next term at our university. Besides the sound engineer module and the lighting technician module shown in Figure 1, a stream switcher module supporting all commands from the director are future work on the project. So, the lectures can be recorded automatically and in a vivid way. For more information and a video example, see [4].

7. REFERENCES

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