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ABSTRACT

This paper summarizes the activities of the Darmstadt University Department of Computer Integrated Design (Germany) related to: (1) distributed lectures (i.e., lectures distributed online through computer networks), including equipment used and ensuring sound and video quality; (2) lectures on demand, including providing access through the World Wide Web (WWW) and technology used for recording and digitizing the lecture; (3) hypermedia information environments, focusing on development of materials for a university course on Computer-Aided-Design (CAD); and (4) multimedia tutoring systems. Five figures illustrate: the multimedia and remote lecture room and individual workstations; overview of a lecture structured into sequences; the sequence of a lecture played in the WWW-Browser by a Java applet; the CAD manual in HTML with orientation and navigation structure, and the derived printed manual page; and the Java-player running a demonstration of how to use the CAD software for the derivation of drawings. (DLS)

Education of Engineering Students within a Multimedia / Hypermedia Environment — a Review

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Abstract: Universities are facing a challenge like enterprises did during the last few years. With less and less costs, the product (in this case education) should become better and better if the University will hold its its rank in the information society of tomorrow. This goal implies that teaching must become very dynamic and link direktly to research results in technology related subjects.
About three years ago Darmstadt University of Technology started to realise these ideas for the education of all mechanical engineers. This article summarizes activities of the Department of Computer Integrated Design in distributed lectures, lectures on demand, hypermedia information environments and multimedia tutoring systems. The main focus was thereby the efficient use of new technologies to improve education within the restrictions of limited resources, rather than the proof of technical realisation. Therefore feedback and evaluation had been an important part of the projects.

1. Distributed Lectures

Lectures are traditionally the kernel of university education. This traditional form implies that everybody who wants to attend has to be in the lecture room at lecture time. If the target group for the lecture is distributed over a larger area, attending the lecture can often be timeconsuming or even impossible because of other dates. Attending a lecture course at other Universities (e.g. in special topics) is not possible at all. The situation gets even more difficult if the idea of life long learning is taken into account. Therefore the possibility to distribute normal lectures online through a LAN/WAN was evaluated.

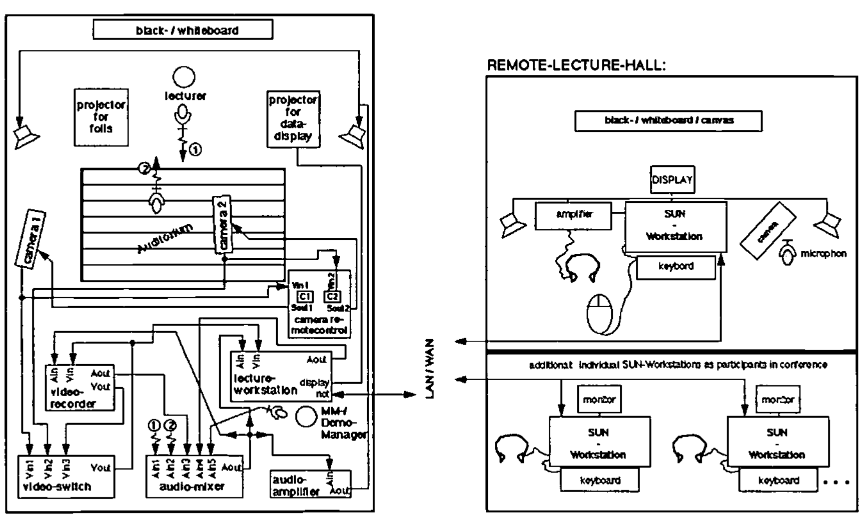

Figure 1: Multimedia lecture-/ and remote-lecture-room and individual workstations

The equipment used is shown in [Fig. 1]. Two cameras and several microphones are used to capture the lecturer, the used media like slides or writing on the black- or whiteboard and the audience. The media-manager chooses the video-signal and mixes the audio-channel that is actually transferred through the net. Both cameras are equipped with remote-control heads. Videos shown in the lecture are directly sent to the remote coumputers. Requests from remote participants are handled by the media manager and can be posed online by means of audio-amplification with the video signal shown on the canvas of the data display. The workstations used in [Fig. 1] are SUN workstations, as the conferencing tool ShowMe was used.

Practice has shown that the quality of primary sound and secondary video are crucial for the acceptance of distributed lectures by the remote participants who have been spoiled by expensive TV and cinema productions. Therefore a guaranteed high bandwith e. g. through ATM (Asynchronus Transfer Mode) and the professional skills of at least two media managers (in order to handle requests) in a specially equipped multimedia lecture room is necessary. (In a normal lecture room, the light conditions are normally very poor for taking video especially if overhead projectors are used.) The technical equipment needed to achieve a high quality transmission is considerably extensive and far from plug and play techniques. Consequently distributed lectures can only be considered as an efficient teaching method if the professional equipment and the professional skills of the operators are used full time or at least every day.

Universities should be encouraged to start cooperative efforts with the idea to reduce the quantity of lectures in each location to be able to improve the remaining lectures to a very high quality. These lectures would then be distributed to other locations and related to the qualitiy of the lecture a demand from the remote locations would arise.

2. Lecture on Demand

In the previous chapter, it is shown how lectures can be attended from different locations with the possibility of interaction. In this chapter the possibility to repeat a lecture or to attend a lecture later is dicussed. In addition to the distribution in terms of location from the previous chapter, a distribution in terms of time is now enabled naturally encompassing the loss of the possibility of direct interaction with the lecturer. This is called ´lecture on demand´ because it shall enable the students to get any of the available lectures throughout the whole year (most lectures are only once a year) from almost every location 24 hours a day.

Therefore the digitized lectures should be accessible from almost every computer in the internet with normal multimedia ability. The materials must be provided completely in standardized formats to ensure platform independece for at least a few years. Digitizing and processing of lecture material must be done using moderate manpower within a day or two, for each 90 minute lecture such that the material offered is always up to date. By attending a lecture on demand the user must get all the information that was provided within the original lecture.

The first goal can be reached by means of the WWW (World Wide Web) in combination with Java applets and source files in independent formats (such as ASCII, GIF, JPEG, SunAudio, etc.) with moderate file sizes. By analyzing lectures based on slides and blackboard writings it becomes evident that nearly all the information is contained in the combination of slides and the sound of the lecturer. Therefore these two media must be supplied in a very high quality. The video picture itself merely helps to get to know the lecturer and to give the impression of participation (which can be quite important) and not to miss important details.

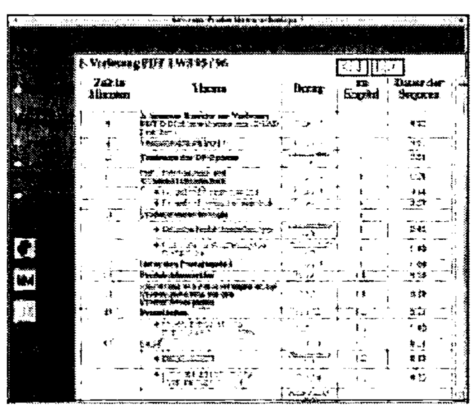

Figure 2: Overview of a lecture structured into sequences

For recording lectures, the arrangement in [Fig. 1] is simplified. One camera records the lecturer himself. The other camera is used to record the slides and the blackboard. This camera also records the sound of the lecturer via the wireless microphone such that synchronic information is available for the digitizing later on. Both cameras are remote controlled, questions from the audience are recorded with separate microphones.

The first step in processing the material is to divide up the lecture into thematical sequences (e. g. each slide shown and explained can be described as a unit). Later on these sequences can be accessed directly or found by a search engine. Therefore the sequences are described within a few words. The relation to the slides and the lenghts of the units are also documented [Fig. 2].

Lecture slides made with a graphic program can easily be provided as a GIF or JPEG picture without any loss of information. Handwriting on slides or on the blackboard can by the use of the video-recording easily be redesigned in a graphic program and also prsented as GIF or JPEG.

The quality of sound is very important. The biggest loss normally happens right at the beginning of the process chain due to unappropriate microphones or bad recording conditions. That can easily lead to a very low signal to noise ratio. For this reason wireless microphones and high quality recievers without any sound dropouts are essential. An audio mixer is needed to adjust signal strength for the recorder. The signal must be digitized at a high quality (e. g. 16 bit, 22 kHz). Such high quality sound files can then be converted to compressed files with lower border frequency such as μlaw. This reduces the file size by a factor of almost 4 which is important for the loading time of the lecture later on. Expierence shows that the loss of quality in this step is moderate if it has been high enough initially.

The video signal itself contains the greatest amount of data but the least amount of information in this case. For reasonable response times, this amount of data must be compressed drastically. Tests of the acceptance of different presentation forms led to a method where the video-stream (25 frames per second with PAL) is split into a set of individual, high quality, compressed pictures (JPEG) taken at a constant interval (e. g. 1 sec) instead of reducing the picture quality while keeping a high frame rate. An interval of about 1 sec. leads to a high acceptance because the response times for watching the sequence are moderate, the quality of the pictures is so high that details can be seen and the user does not get the impression of a flickering film that is running too slow.

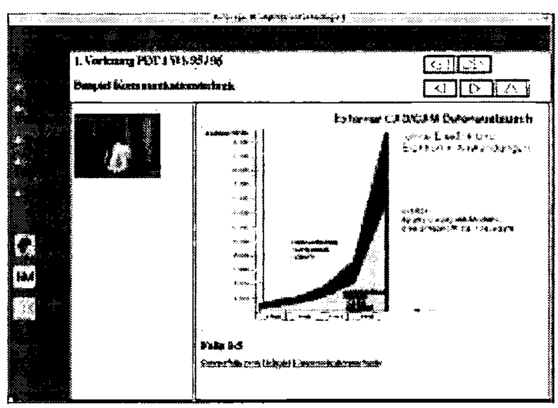

Figure 3: Sequence of a lecture played in the WWW-Browser by a Java applet

With the method described above 12 lectures (each 90 minutes long) of the course PDT 1 (Product Data Technology) have been recorded and digitized [Anderl and Vogel et al.1996] . With the method described above the entire course has a size of less than 700 MB. For access to the lectures on demand by the WWW a navigation and orientation structure similar to the one described in chapter 3 was designed. The lecture on demand can be used on any machine in the internet where a browser with full Java ability (including the performance of sound) is available. The Java applet loads one sequence at a time (slides, soundfile and video pictures) and plays it with the synchronic information given in the applet-call.

3. Hypermedial Information Environment

At the University of Darmstadt mechanical engineers get an integrated engineering education in design during their basic studies in the first and second year. This is divided into three parts. A detailed description of this education based on Product Data Technology is given in [Anderl and Vogel 1997] . All material for the CAD-course (the first of the three parts) is provided by means of the WWW. This material includes manuals for the CAD- and the PDM-Systems (Computer Aided Design- and Product Data Management-System), exercises, lecture sheets, additional information and examinations.

For an efficient use of this material an information environment had to be designed, which allows a simple navigation in conjunction with an unambiguous orientation. The actual content is separated from the means of orientation and navigation. A structure was developed to describe any of the different branches within Information-System. This allows the realisation of an automatic creation of navigation and orientation for each branch by special tools. This method leads to an Information-System that is easy to maintain. The Information-System is enriched by local search engines and manually created index pages.

The practical use in different courses showed that even though all material was directly available at each work place there is still a great demand for printouts. Normal printouts of the manuals, exercises, etc. from the WWW do not support efficient work. They are just loose pages without header or footer, without a table of contents or page numbers. These printouts cannot be used in a sensible way for personal annotations or for studying somewhere else other than in front of a computer.

Therefore it was necessary to develop and implement a method that allows the conversion of a structured HTML document into a well laid out paper document that achieves the quality of a document created originally with a text processing application.

The result shown in [Fig. 4] was achieved by parsing the HTML manual to TEX using its defined structures and deriving postscript files afterwards. In practice this method has proved to be very efficient for the documents used within the CAD-course which are primarily designed for the use in HTML and secondarily for use in the form of printouts. Changes in these manuals and exercises are done easily and are available for everybody instantly.

It is obvious that only such semantic constructs can be parsed successfully from HTML to TEX which have an equivalent there. E. g. a table containing pictures, often used to arrange pictures on the screen of the browser, cannot be expressed in TEX. Workarounds in the parsing algorithm will never be generally satisfactory. Therefore the best way in such cases is to declare that such semantic constructs must not be used in the HTML sources which may undergo conversion into a postscript file. This results in the declaration of a HTML subset as a kind of styleguide.

On the other hand there are semantic constructs in TEX like the caption of a picture (which is linked to the rule that picture and caption always have to be on the same page) that don't have an equivalent in HTML. For some constructs semantic rules where established within the HTML styleguide that would allow the parser to recognise an artificial HTML caption if it was there or leave it out (after a picture) if not.

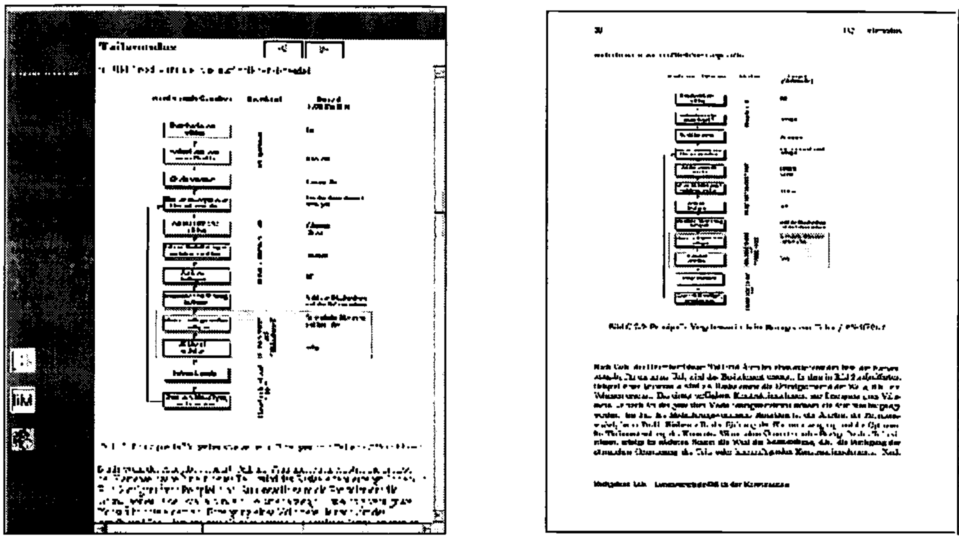

Figure 4: Manual in HTML with orientation and navigation structure and the derived printed manual page

For documents which contain a considerable number of mathematical equations and which are primarily designed for use as a printout and only secondarily for the in HTML the opposite approach should be preferred. The quality of the source format will always be better than that off the derived one. Hence in this case it is suggested to start with TEX, define which subset may be used and derive the HTML as a secondary form of presentation.

Important for both ways of working is that the source files contain the structure of the document separate from any layout description. The layout itself is generated by algorithms within the browser or the LaTex code. Documents that are designed within modern textprocessing systems (e. g. Microsoft Word) are not based on this idea and the file formats of these systems are far away from a fixed standard (even taking RTF (Rich Text Format) into account). Therefore there was no significant effort made to derive these formats from HTML or vice versa.

4. Multimedia Tutoring System

The experience in lectures and courses concerning CAD- and PDM-Systems has clearly shown that demonstrations how to use the various functionalities of these systems are essential for participants who want to comprehend the usage. The techniques of lecture on demand and hypermedial manuals as they are discussed above both are not able to store and reproduce the full information given in such a demonstrations. The ´lecture on demand´ cannot provide the required picture resolution (e. g. 1024 x 768 pixels) which is clearly above normal video resolution. In the hypermedia manuals such demonstrations could only be transfered to long passages with a few sentences of text in between batches of sequential pictures. Such documents are normally quite tiring to work with, the reader has to switch continuously between description and the pictures themselves to understand all the steps of the process being explained. In the original demonstration the viewer had the possibility to watch the screen and to listen to the explanation at the same time. Within the multimedia tutoring system this possibility is given on demand for a set of demonstrations (tutorials) [Anderl and Vogel et al.1997] .

Each tutorial is divided into sequences of moderate length (e. g. 2 - 5 min.). The digitized sequence consists of a number of high resolution pictures, soundfiles, the text that is spoken in written form and information about the synchronisation. This material is accessed through the WWW by a platform independent Java applet running on the client of the user [Fig. 5]. This Java client offers a wide variety of control possibilities. The sequence can be stopped, rewound, viewed in single steps - even scrolling through the sequence (e. g. to find one special action) is possible. In cases where no sound is wanted, the spoken text appears in a separate window in written form instead.

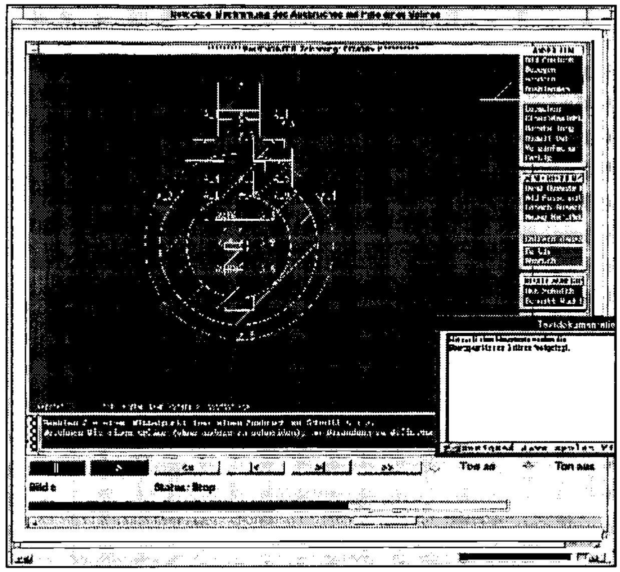

Figure 5: Java-player running a demonstration of how to use the CAD-Software for the derivation of drawings

This technique was frequently used with a high acceptance during the CAD course in 1997 although the performance of Java was still rather poor under the operation systems used at this time. The multimedia tutoring system enabled the students to repeat what they had seen in the lecture right at that time when they where putting it into practise - especially when they got stuck with one or other functionality of the CAD-system. Questions that were posed during the course by email could often been answerd quickly with a link to related sequences.

5. Conclusions

In this article it was shown, how modern multimedia and hypermedia techniques could already be used to improve university teaching. Benefits could be achieved in the amount and the quality of the available teaching material, in the efficiency of the distribution of this material and in some cases in the efficency of teaching large numbers of students. Generally speaking multimedia and hypermedia techniques enable the creation of higher quality course material which should lead to courses of higher quality themselves. But improving the quality of any course will always be time consuming wether multimedia and hypermedia techniques are used or not. Luckily these techniques allow now an instant distribution of all material to a large number of students somewhere in the WWW. If this advantage is exploited through teaching cooperations the resources gained by reducing the actual redundancies in creating course material can be used to improve the material and the courses themselves.

To reach this goal the university must avoid the main mistake many enterprises did in the past: Not the reduction of costs but the improvment of quality and of innovation should be the primary motive power of all structural changes. If the universities make use of the chances that are inherent in multimedia and hypermedia they will be perfectly prepared for the challenges of tomorrow in the educational sector.

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