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DEVELOPMENT OF A DIGITAL LECTERN FOR TELETEACHING

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ABSTRACT

Increased capacity of the network will also provide the possibility to transmit pictures and sound. This is of particular interest if speeches, presentations or lectures have to be recorded or transmitted in order to make them accessible at a different location or to a larger auditorium. Very often additional information has to be transmitted simultaneously as for example the visualization of overhead slides or PowerPoint presentations with additional annotations. Up to now this has not been possible or only with a large number of staff and financial expenditure and thus is refused in many cases. This paper describes the construction and the functionality of a digital lectern named "Speaker's Corner" that solves the problems described above and also allows the use of conventional media.

Keywords: teleteaching, digital lectern, video capturing, presentation, digital annotations

INTRODUCTION

The available working speed of the computers as well as the continuously increasing transmission capacity of the network allows retrieving extensive information from the Internet. Thus it is possible to provide pictures and sound as well as video films next to pure text-based information, which leads to an increase of the number of video sequences as a carrier of information over the Internet. It is therefore obvious to use these possibilities also for education and teaching purposes. However, education makes very specific demands in the technical support required. It is characterized by a large number of necessary media that are frequently changed or used simultaneously. It is also characteristic that very often

analogous and digital media are mixed. If a new device is set up to support education and in particular lectures all requirements have to be fulfilled by the new technical possibilities.

However, in spite of these possibilities it is still very complex or almost impossible to provide sound, pictures and additional information like a PowerPoint presentation to the user over the Internet simultaneously. On the other hand there is an increasing demand for work on given project tasks without being physically present at the work place. Teleteaching, teleworking or network-based work are activities which are becoming more and more popular. They are used if the available technique is sufficient to process the information in an acceptable way. However, especially in the field of teleteaching, teleconferencing or telelearning the given technical constraints prevent the user from applying these methods in an effective way. The necessary expenditure does not justify the additional benefit. The arising costs are currently not justifiable, especially because the devices can only be used for a specific purpose.

MOTIVATION

Teleconferencing, teleteaching and telelearning have the highest technical demands on the available technology since several pieces of information must be transmitted synchronously. Especially in the field of teleteaching the available video conferencing systems or other whiteboard systems are not sufficient since they only provide a peer-to-peer connection. In many cases these systems only transfer sound and pictures to another location, additional visualizations like photographs, demonstration objects or PowerPoint

presentations were captured by the video camera instead of the speaker's image. In many cases the resolution is very poor and thus a noticeable loss of information occurs. In order to counter these circumstances the image of the speaker is not transferred but only the PowerPoint presentation with acoustic explanations. Video conferencing systems usually include no streaming facilities and thus a digital storing of the signals on a server is not possible. Due to the peer-to-peer-characteristic the number of subscribers is often limited to one station which needs specialized and expensive hardware to receive and decode the signal. However, in the field of education in particular the transmission of the audio signal and the picture of the speaker is not sufficient. The explanation of complex material requires additional types of information such as the representation of demonstration objects or the creation of drawings in addition to the prepared documents (PowerPoint slides).

In order to create a complete lecture including the speaker's image, sound and a PowerPoint presentation with additional annotations and to provide it on the Internet a large technical expenditure is necessary [1]. The speaker himself must not be impeded during the presentation so that a second person is needed to handle the technical equipment. This person must be present during the complete presentation time. Particularly the reworking of the generated data is very time-consuming since the video image of the speaker must be cut and synchronized with the PowerPoint presentation. This synchronization of the video picture with the PowerPoint presentation can only be done manually, an additional synchronization of the annotations to the PowerPoint slides has not been possible so far. For these additional tasks time is needed that is ten times as long as the actual lecture time and thus such a presentation becomes very time consuming and cost intensive. Furthermore, the extensive post-editing has the disadvantage that a large offset arises between the time of the actual presentation and its digital availability on the webserver. This chronological misalignment is not acceptable in many cases, for instance if the presentations are given in a rapid, chronological order and the listeners want to assist live or over the Internet respectively. Such a situation can occur for example within a lecture series for the repetition of the given presentation or for the preparation of the following presentation (lecture).

Up to now the problem of the synchronic integration of additional annotations in a PowerPoint presentation has not been solved. PowerPoint also offers the functionality of annotations. However, these annotations are not permanently on the slides. A paging within the slides always results in the disappearance of the created annotations. Furthermore, no ways have been found to visualize and integrate demonstration objects in a presentation. It might be necessary to employ an additional second person to operate the camera and register such objects. However, this results in a disturbance of the lecture, both for the speakers and for the listeners that assist the presentation.

CONTRIBUTIONS

In the proposed paper a possibility is introduced that allows to carry out a presentation, to acquire sound and pictures, to digitize them and to make them available to the user without a time delay. It is possible to present additional annotations to the PowerPoint slides and to integrate the visualization of transparency films or demonstration objects and to synchronize them with the presentation. Most of the tasks run automatically or can be done by the speaker without additional effort. The second person which has been needed up to now as well as the extensive reworking of the data can be eliminated and the publication time is reduced. Since the lecture is streamed and made available on a server the number of subscribers is - in contrast to a video conferencing system - almost unlimited. The recipient does not need extensive hardware anymore but free viewer programs are sufficient. However, it has to be noted that this is not a full duplex communication line but only a distributing system (one-way communication line) as it is usually needed for teleteaching. A dialogue between the speaker and the audience in the net is thus not possible.

Furthermore it is introduced how the possibilities described above are integrated in a complete device, the so-called "Speaker's Corner". The device allows the presenter to fulfill all tasks without disturbing him. With the exception of an external beamer "Speaker's Corner" contains all the necessary devices. Beside the easy operation the technical preparation time for a lecture can also be reduced to a minimum. First field reports of the use of the digital lectern in a lecture series show how the requirements were met.

REQUIREMENTS

In order to receive a comprehensive overview of the needed requirements an Internet-questionnaire has to be filled in by the potential customers, followed by a statistical evaluation which shows the most needed functionalities and requirements. The digital lectern has to fulfill the following technical requirements:

- Video capturing of the speaker: For the complete recording of all relevant information it is necessary that the speaker can be seen in the picture. It is important that no dangerous cables are placed within the auditory in order to connect the camera to the digital lectern.
- Audio capturing of the speaker: Next to the picture an important carrier of information is the audio channel. Thus it is necessary to have an audio channel that is synchronized to the picture and that is also digitized. Furthermore it has to be possible to capture the audio signal of the speaker either from an integrated microphone, to amplify and to replay it or to use the audio equipment available in the lecture room and to connect it to the digital lectern.

- Technical support of the on-site presentation: The new device is supposed to support also an on site presentation next to the task of the presentation streaming. There is for example the possibility to connect additional visualization devices such as a beamer so that the selected signal sources can be visualized. In the same way a sound system must be integrated in the device.
- Flexibility in the information delivery: An important requirement is that the system can process information from several sources. First of all it must be possible to retrieve information to be presented in advance or in real-time over a network and to copy it on the computer. Furthermore it must be possible to read data from different media as for example from floppy disk, DVD, CD or video. There should be a possibility to connect an external computer to the device. Besides this further peripherals are supposed to be connectable via an USB-connection.
For universal use the system should facilitate the use of conventional media such as paper presentations or overhead slides. It should also allow visualization of three-dimensional demonstration objects.
- Possibility for annotations: Both with conventional media as paper or transparency films and in the case of digital PowerPoint presentations the possibility to enter additional annotations must exist. These annotations must also be included in the digital recording of the presentation and should be permanently available at least for the period of the presentation.
- Possibility of online-digitalization and synchronization: All actions at the digital lectern should be registered and digitized automatically. The typical post-editing for cutting and synchronization that follows a presentation should be completely eliminated. It should be possible to provide the presentation almost synchronically on the Internet.
- Network access: In order to forward the streamed signals but also for the distribution of information a network access must be available. Likewise an additional laptop must be able to communicate with the device via a network.
- Design: The new digital lectern should have an appealing and somehow functional design. The handling of the device should be very easy also for the inexperienced user. Furthermore the functional design should allow the presenter to do all the necessary handling of the device also during the presentation. Since the device will be used in conference halls as well as in lecture halls there should be a protection against abuse or demolition.

- Intuitive usage: Usage of the digital lectern should be simple and intuitive. With that a short training period should be possible. Only the speaker is responsible for the handling of the device. His presentation should not be disturbed by this additional task.
- Mobility of the device: Due to the currently high costs of the device schools, universities and large conference hotels cannot afford a digital lectern for every lecture room. Therefore the devices must be designed to be transportable in order to move them from one room to the other.

REALIZATION

The realization of this given requirements has lead to a new product named „Speaker’s Corner“. It is described in two parts, the realization of the design and the technical realization. It is, of course the goal to optimally combine the requirements of design and technique in one single device.

REALIZATION OF THE DESIGN

For the design basically functional aspects were taken into account. However, "Speaker’s Corner" should also have an appealing outfit. At first different design studies were carried out in order to determine the best solution (Figure 1) [2].

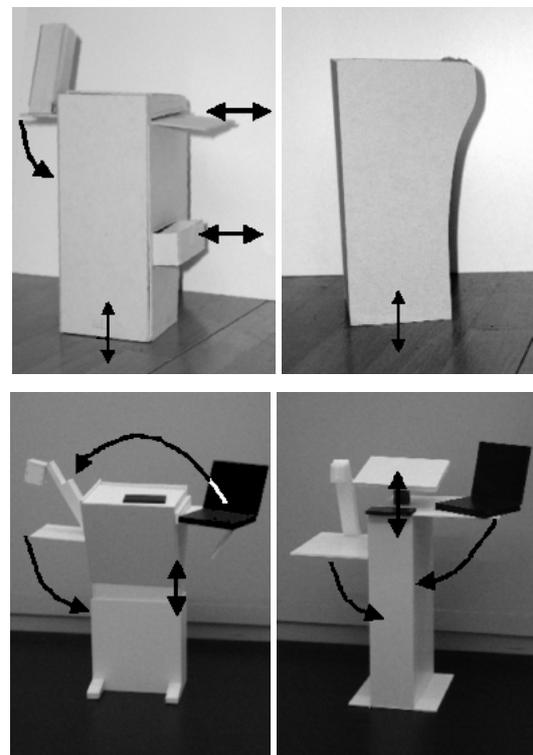


Fig. 1 Different design studies

All solutions provide sufficient space for the feet in order to allow comfortable working. A height adjustment guarantees an ergonomic height of digital lectern for the individual user. All controls for the operation of the presentation as well as for switching to the different signal sources are within the user's view and reach. This is particularly important for the WACOM tablet since this is used for the presentation and also for the annotations. Additional compartments allow the storage of additional accessories within the device. The basis of the device was designed large enough to guarantee secure handling.

The design propositions 1 to 3 in particular offer the possibility to integrate the entire equipment into a case in order to provide adequate protection against unauthorized use. This requirement is not completely achieved by design proposition 4 since the work surface of „Speaker's Corner“ remains almost unprotected. Nevertheless this proposition was realized for aesthetic reasons. The reason is that all the other design propositions look very awkward and are therefore a small stimulus for using the digital lectern. The protection against improper use in design proposition 4 was implemented in such a way that in case of non-use the entire device can be put into a box and locked. The box also provides space for all peripherals.

For the height adjustment in design proposition 4 only the work surface, i.e. the WACOM tablet, is changed but not the complete installation. When using the device additional work areas can be opened on the left and the right side of the lectern and additional space is available now to place a laptop computer. Corresponding connections at "Speaker's Corner" guarantee both the network access and the power supply for these additional devices. As can be seen from the model the possibility exists to visualize demonstration objects, pictures or transparency films. Since transparency slides require a back illumination the table of the document camera was equipped with a film that can be electrically illuminated. The film can be turned on by a switch on the front panel of "Speaker's Corner".

All additional elements can be lowered in case of non-use so that finally a slim pillar remains in which all modules are integrated and locked. It is not necessary to open the tables of the document camera and for the placement of the laptop computer in order to use "Speaker's Corner". In this case only the slim pillar remains but not all the functionalities of the device can be used.



Fig. 2 General view of the device

TECHNICAL REALIZATION

The technical realization is shown in the following block diagram (Figure 3):

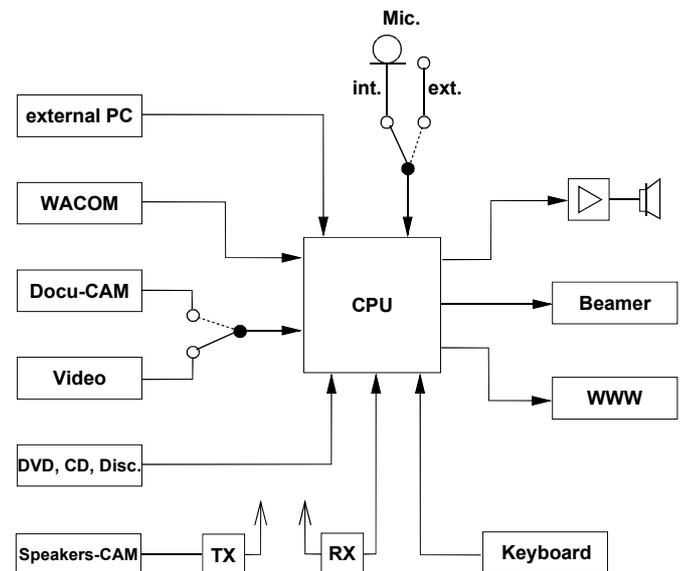


Fig. 3 Block diagram of the digital lectern

The main part of "Speaker's Corner" is a dual P4 1,7 GHz personal computer with Windows 2000 as an operating system.

All peripherals are connected to this computer, in addition it is used for the presentation of the PowerPoint slides and for the streaming of the camera signal. It provides the net accessibility and can be used to buffer the streamed data.

For the transfer of data on this computer the available network access can be used but also DVD, CD, floppy disk as well as further devices connected to the USB interface. Furthermore, an external computer can be connected to „Speaker’s Corner“ via an UTP connection. In order to do this DHCP must be activated on the guest computer. This guest computer is connected via a crossed UTP cable and receives its IP-address from "Speaker’s Corner" in order to realize the data exchange. The UTP-cable is firmly connected to "Speaker’s Corner" and can be stowed away easily in the corpus of the lectern.

For the additional visualization of documents, transparency films or demonstration objects an additional document camera exists which can be activated by the speaker if required (Figure 4). The signal of this camera is represented both on the WACOM tablet and on the connected beamer. This allows the listeners to see the object taken by the camera and the signal is available in video stream for the remote listeners.

The head of the document camera is turnable and adjustable in its inclination. Thus it is possible to place the demonstration objects not only on the table of the document camera but also next to the digital lectern. This is of particular interest for large demonstration objects. Furthermore the document camera has a remote controlled zoom lens in order to show the whole demonstration object as well as details of it. Since the speaker is not behind the digital lectern during his explanation but next to the demonstration object the zoom lens of the document camera can also be controlled by an infrared remote control.



Fig. 4 The document camera for additional visualization

The speaker’s image is taken by an external camera which is connected to the lectern" via a 2,7 GHz wireless link. Thus it is possible to transmit the camera signal without the placing of cables in the auditorium. Since the speaker is physically present in the conference room the camera signal does not appear on the beamer but is available on the streaming signal to provide the speaker’s image to the external listeners. When installing a wireless link the local regulations, e.g. FCC regulations, have to be followed. These regulations might differ in different countries.

The camera is placed on the opposite wall of the lecture room, it is removed from the field of view of the audience. The camera is fix-focused onto the place of “Speaker’s Corner” and thus reduces the freedom of movement of the speaker because otherwise he will leave the cameras image. However, it will be possible to have an overall view of the camera but in this case the speaker’s image is too small for the remote auditorium.

Using a selector switch on the front panel of the device a video recorder or another video or audio source can be connected instead of the document camera. Depending on the position of this selector either the PowerPoint presentation, the signal of the document camera or the signal of the video recorder is active and thus visible to the auditory.



Fig. 5 Connection of the camera to "Speaker's Corner" via a wireless link

While placing the transmitter and the receiver of the wireless link of the camera it has to be ensured that both devices have a free line of sight. Objects in the propagation path of the electro-magnetic wave lead to an additional attenuation of the signal and influence the quality of the picture to be transmitted.

Therefore the listeners on site only see the picture from the selected source while the remote listener has the following content on his screen (Figure 6).

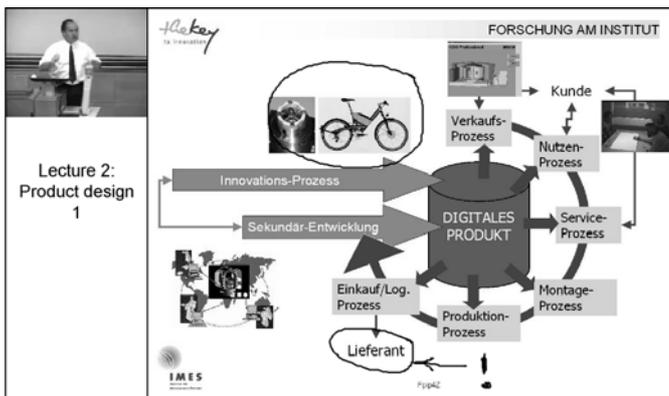


Fig. 6 Screen content for the remote user

In the upper left corner of the screen (Figure 6) is the streamed picture of the speaker. Since this picture is not the main carrier of information it was consciously chosen smaller. Tests with users in the network brought out that the speaker's image is needed for psychological reasons. Otherwise the character of a lecture gets lost. In the field below additional information can be displayed such as the title of the lecture and/or the name of the speaker. In the main window the most important carrier of information is represented, i.e. the PowerPoint presentation as well as possible annotations. If another source is selected instead of the PowerPoint presentation by the selector switch on the front panel of the device, e.g. the document camera, this signal will appear in the main window.

In addition to the video signal "Speaker's Corner" is also able to handle audio signals. An external audio signal can be

fed into "Speaker's Corner" and be amplified. A microphone can be connected to amplify the speaker's voice via the built-in audio booster. Thus the device is also usable in rooms which do not have their own audio equipment.

The central input and output device of "Speaker's Corner" is a screen with a pen-based input device instead of a mouse. The WACOM tablet PL-500 is a 15,1" flat screen that also offers the possibility to perform interactions by use of a specific pen [7]. The pen input works on an inductive principle and thus operating errors by touching the screen with the finger are impossible. This input device from WACOM allows the operation of all Windows functionalities including the Office applications like PowerPoint. The Office applications are extended by an additional software "Just Write" [8] that allows the attachment of annotations to a presentation by the use of the WACOM board (Figure 7). The annotations are also added with the inductive pen of the WACOM tablet. It is shown in Figure 7 that in the upper edge of the screen a popup-menu is available which contains additional tools for annotations like line thickness, pen color or simple geometrical figures. Furthermore, there is the possibility to add slides for further explanations. In contrast to similar Office plug-ins these annotations are lasting i.e. they do not disappear during the changeover onto the next slide. The annotations do not change the original PowerPoint file but are saved in a separate file. When restarting the presentation the speaker has to decide whether he wants to use the already available annotations or not. For large text entries or control instructions a keyboard is mounted on a telescopic slider underneath the WACOM tablet.

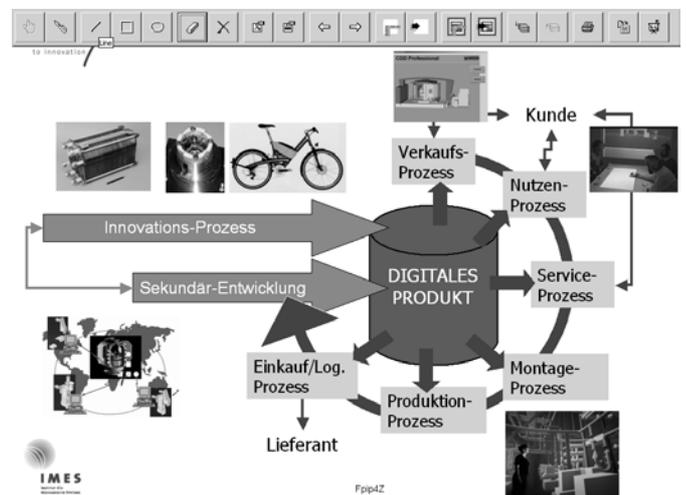


Fig. 7 Input menu "Just Write"

For the capturing, digitizing and streaming of the available signals different software packages are available. Tests showed that the software package from Real, that is Real producer, Real server and Real Player, is most suitable for the given task. The principle of the complete streaming is shown in Figure 8:

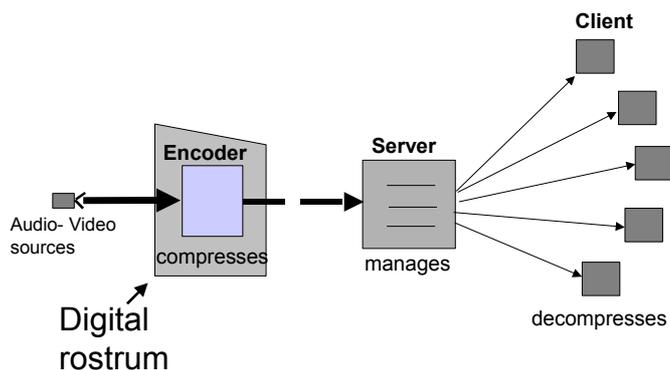


Fig. 8 The principle of streaming and the client-server architecture

The signals from the different sources are transferred to "Speaker's Corner", compressed and encoded by the Real Encoder. Afterwards the signals can be stored either locally or on a server via a network. The server manages the compressed and coded signals. He provides the signals on request to the clients with a resolution adapted to the available transmission rate. Finally the clients decode and decompress the signal and make it available to the user. If no network is available to store the data on a server, the data can be stored first locally on the hard disk of "Speaker's Corner" and written on CD after the presentation has finished.

When starting the software of "Speaker's Corner" first a software is started up which carries out the monitor recording. Then the Real Producer as well as a software "Camtasia" are started twice to record the signal from the external camera and from the monitor recording [5]. Since both processes are started almost simultaneously a synchronization between the two video streams is guaranteed. The start up of the programs is done by a batch file so that the user only has to press a single button.

In order to reduce the amount of data and to save transmission bandwidth both video streams [3] [6] have different graphical and chronological resolutions. The video picture of the speaker has a resolution of 256 x 192 pixels and a repetition rate of 15 hertz. Thus a fluent representation of the speaker, synchronized to the audio signal, is possible. The main frame has a resolution of 1024 x 768 pixels with a repetition rate of 1 Hz. Between the generation of the data and the availability on the server there is a maximum time difference of approx. 40 s which is basically caused by the compressing and the encoding. In addition non predictable delays arise from the net delay and the decompression on the client's side. The tests carried out showed that with this chosen chronological and graphical resolution a 90-minutes lecture produces a data amount of approximately 900 MBytes. For the user in the network a net transmission rate of at least 500 kB/s is required. This will be easily realized in the very near future since the capacity of the nets is increasing rapidly. Within the Intranets of schools and universities, where "Speaker's Corner" will be mainly used, this data rate is already available [4]. At lower transmission rates the amount of data must first be buffered locally on the computer.

FIRST RESULTS

"Speaker's Corner" was tested in an 8-week-experiment in education (lectures). In this experimental phase the device was in use for approximately 350 hours. The practical experience showed that the device can be productively used after a 10-minute training. Thus the training period is extremely short compared to a longer lecture series. However, it is still too long for a single lecture. With the help of a more user-friendly software the expenditure to store data on a server via a network can be reduced.

On the other hand the use of the hardware was almost free of problems. In particular the usage of the WACOM tablet was done very intuitively since the input is realized with a pen-like device. Since the appearance of the desktop (normally the PowerPoint desktop) only has insignificant changes from the software "JustWrite" no difficulties in its usage emerged. However, it turned out that the keyboard is needed during the presentation in order to flip among the slides (realized by a known PowerPoint functionality). During the presentation the pen is in the annotation mode and used for drawing and writing. Thus the pen is not in the mouse mode that is needed to flip the slides. It would be possible to change the mode within the selection menu of "JustWrite" but it is simpler to use the available keyboard instead. The handling of the digital lectern did not cause additional work for the speakers and no negative influence on the presentation was noticed.

During the test phase "Speaker's Corner" was only used in an allocated room. The device could be moved around easily within the room on the Teflon gliders. However, the gliders are not suitable for longer distances between different rooms or on an uneven floor. In order to attain better portability constructive changes and improvements have to be made. In particular the device should be transportable together with the box.

When using a wireless signal transmission of images and sound of the remote speaker's camera to "Speaker's Corner" an interference with wireless LANs installed in the same room could occur. Especially when several computers are logged in into the wireless network the channel separation between the radio-controlled LAN and the camera link was insufficient.

CONCLUSIONS

The feasibility of a digital lectern was introduced that supports a presentation consisting of PowerPoint slides, additional annotations as well as audio and video signals of the speaker. The presentation consists of different video signals which can be streamed simultaneously. Furthermore there is the possibility to use conventional transparency films and to visualize demonstration objects and to include them in the digitized video streams. A possibility is introduced to make a complete presentation available to an auditorium over a network as a live video stream or a digital record. The digital lectern was designed in such a way that the handling can be done by the speaker himself without additional operating expenditure.

The complete device was tested in lectures in order to check its efficiency and its operability. It turned out that the usage of the device is very fast and simple. However, the operator control for administrative operations can be designed in an even more user-friendly way.

In conclusion all requirements made in chapter "Requirements" were met very well by the first constructed preproduction model. So far the demand for the portability of the device has not been completely fulfilled. Since the first preproduction model was used in a single room, transportation appliances had not yet been considered.

FUTURE WORK

Future work will be on a further improvement of the operability of the digital lectern. Further tests will be carried out in order to find additional requirements and to integrate a re-worked concept into a new design.

While the present digital lectern was designed for stationary use in a lecture hall the new re-worked concept will guarantee better portability and thus a more universal use of the device. Apart from the corresponding transportation appliances the weight of the entire device has to be reduced.

A further improvement of performance of the hardware as well as a further optimization of the software (in cooperation with the involved companies) will lead to a higher resolution and a higher frame rate in the video stream. Thus the capability of the device is prepared for the higher bandwidth of the nets that is expected for the future as well as for a higher transmission capacity. This technology makes it possible to digitize and to stream a presentation which includes additional videos within the PowerPoint presentation. Further work will also deal with the compression procedures and how they can reduce the currently high amount of data. Furthermore it has to be examined which radio-controlled links are available and suitable to transmit the video signal of the remote camera. The interferences with the radio-controlled LANs should thus be eliminated. In a new model of "Speaker's Corner" a wireless microphone will be installed in order to guarantee more freedom of movement to the speaker. This is necessary for example whenever he wants to provide explanations of a demonstration object which is not on the table of the document camera.

Tests will be performed with a self-adjusting camera in order to realize a larger field of motion for the speaker without leaving the camera's image. In addition the remote user will see a larger image of the speaker since the camera is not set to an overall view but is zoomed onto the speaker.

The planned revision of the existing prototype will focus on a design that is suitable for industrial manufacturing.

ACKNOWLEDGMENTS

The equipment described above was designed in view of the necessity of providing access to lectures and presentations to a larger auditory and of making lectures digitally available to students preparing their exams. The design and the realization of the first prototype was made possible by the financing of the Center for Product Development at the ETH Zurich.

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