Conversion of existing video teaching courses through multimedia production process

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Sommario
Esiste tuttora una vasta produzione di videocassette di materiale didattico: la loro diffusione comporta bassi costi e facilità d'uso. Esistono tuttavia alcuni limiti come sussidio didattico: a parte la carenza di interattività, una videocassetta impone a tutti gli ascoltatori lo stesso ritmo, indipendentemente dalla loro capacità di assimilazione. Non è ipotizzabile in una struttura didattica disporre di un sistema completo (videoriproduttore, TV e cassetta) per ogni studente. La diffusione di laboratori di personal computer multimediali in rete locale potrebbe risolvere questo problema se il materiale fosse convertito in opportuno formato digitale. La metodologia di conversione proposta risulta particolarmente conveniente in termini di costi/benefici e permette l'uso contemporaneo e personalizzato di materiale filmato didattico, utilizzando esclusivamente tecnologie Internet/Intranet per la sua distribuzione e utilizzazione. E' ipotizzabile quindi anche un accesso remoto e la realizzazione di videoservers con collezioni di filmati didattici per l'insegnamento a distanza. Ciò costituisce una base per l'introduzione di elementi di interattività.

1. INTRODUCTION

1.1 Computer-Based and Distance learning

Education is undergoing an evolution from traditional curricula to innovate its methodologies. All over the world, teaching institutions are experimenting the capabilities of distance network-based interactive learning.
The parallel development of computers and communications has affected education with Computer-Based Learning (CBL) and Distance Learning (DL). CBL technologies have found their way in many fields of education but their success can be classified, at the most, as modest [Ponta 7/96]. One of the drawbacks of CBL, in spite of recent approaches based on Artificial Intelligence [Woolf 95], is the difficulty to

implement interactivity. This is implemented by DL techniques, such as real time two-ways audio and video teleteaching.
Computer Networking Technologies (CNT), already well established in the academic environment and growing in the industrial one, are proving themselves to be a very important prerequisite for creating more efficient education and training environments [Ponta 10/96], especially because of the possibility of maintaining a repository of learning material that can be easily updated, demonstrated, downloaded or executed on-line.
The traditional delivery of knowledge in a classroom has some positive points: human relationship, direct and immediate interaction between teacher and students (provided they are a relatively small number), adaptation of the content to the capacity of the students (if the teacher is clever enough to get feedback). Teaching aids like slides and videotapes have been used for a long time and they complement the teacher's action. Most of the time, the teacher is present while the students watch the videos, so that he/she can properly integrate the subject [Escalada 96].
It is our opinion that a proper combination of CBL and CNT has the possibility to successfully reconstitute the interactivity features that have characterized, since the very beginning, the relation between teachers and learners. Besides, it's worth to note that in the traditional classroom-based lectures, the student is mostly a passive observer and a listener of knowledge transmitted by the teacher. With CBL (active learning), the student is the new centre of the learning process, building her/his own knowledge exploiting active experiences.
Different forms of teleteaching are being implemented. The LearnLinc [ILINC] experience is perhaps one of the most complete, presenting itself as a substitute of traditional teaching. There are also many initiatives focusing on the Internet as a complementary teaching tool [Crudele 97] where the availability of self-evaluation tests and a tutoring system are the core of the service.

1.2 The digital shift

The digital revolution introduced computers in the schools and in the Universities. In many cases the PC's are in dedicated laboratories where the students go only for specific activities. They are not yet a common teaching support, like a book or a blackboard. Internet connections are spreading (slowly, indeed, in Italy) and constitute an occasion for knowledge enhancement, when they are guided by the teacher. In fact

applications that can loosely be classified into the field "education" are nowadays quite frequent on Internet, even if they are usually characterized by an unstructured and largely individual learning process.
The implementation of CBL and CNT distance learning interactive systems is usually an expensive task especially in terms of time dedicated to the organization of the knowledge base.
In the last years we have assisted to the change from 16 and 35 mm. didactic films to the videotape. It was just a simple matter of converting to a more practical medium, which produced a positive effect of widening the audience. Now we are ready for another shift, from analogue to digital media [Ponta 11/96]. But this conversion is not straightforward and it can be very expensive if the videotape is to be transformed to a complete CBL application. Multimedia producers state that if you want to convert existing material, you have to submit it to a radical remake, because CBL is very different from videotape based courses. If this were the case, only a very little part of the enormous patrimony of videotape based didactic material would be transformed into digital format.
This projects focuses therefore on the conversion process from traditional videotapes into digital products, that can be used both from a CD or a DVD, as well as from an Internet/Intranet connection, so that they constitute a base for building distance learning environments.
The main issue is to study and implement a methodology that leads to low cost and relatively fast conversion, with a unique software modality, independent of the physical media on which the material is stored: CD, DVD, Internet. A "digital video on demand" system could therefore be established enabling the teachers and the students to have easy individual access to a video library.
The recent "Program for the development of didactic technologies 1997-2000" issued by the Italian Ministry of Education is supposed to provide all the schools with the facilities to utilize the outcome of our project.

2. MATERIALS AND METHODS

2.1 State of the art in multimedia production and delivery

There is a wide offer of software and hardware system for producing multimedia teaching courses. Most of the leading companies are now shifting their strategies from proprietary architectures to the implementation of Internet technology CBL products: these therefore become also DL tools and applications. Therefore, for starting the

development of a multimedia course from scratch, there are various authoring tools, that differ for scope, price and usability.
The process of converting existing video material has not been very popular because of the difficulties in the digitalization process. Only recently the availability of cheap fast computers, better coding schemes and new software have allowed almost anyone to produce and edit a digital video coming from analogue sources. There are also some huge projects, like the "Teche RAI" [RAI] which aims to the conversion of all the audio-visual patrimony of the Italian Radio and TV.
Internet delivery of streaming video is a very new achievement. Even though the quality on a slow connection is low, it can be sufficient to follow a conference (what is called a "talking head") because the audio is good enough. On an Intranet most of the speed problems are overcome and a high quality video can be transmitted using the network on any PC.
One solution to the speed constraints comes from the so-called "hybrid CD-Web" packages, which offer local graphics and knowledge base while providing interaction or update through an Internet connection. Many experiments are being carried out to evaluate the pedagogical effectiveness of such approach. One of them is a demonstrator of the European project ARIADNE [ARIADNE 96] that is being held at the University of Genoa, Italy. It concerns a class without lectures and teachers (at least in their traditional functions), where learning is computer-based, communication with teachers is remote and written (Internet-based) and interaction between students is based on cooperative work.
The start up of satellite-based Internet delivery is to be mentioned, especially for broadcasting purposes.

2.2 Testing material

After examining different videotape based courses, we decided to experiment on the NET.T.UN.O (Network Teledidattico per l'Università Ovunque) Consortium [NETTUNO] video production. This consortium of Universities and enterprises provides distance education through video transmissions broadcast on the Italian TV during the night. At the end of the courses a full value Diploma in Engineering is acquired. The examinations are held in a traditional fashion in the Consortium Universities.
The quality of teaching is quite good. The images shift from a close up of the speaking professor, to drawings, schemes and animation taken from

a PC based application.
Normally a student records the TV transmissions or buys the videotapes. We believe that a better use of this courses could be achieved if the lessons were stored in a CD with indexing capabilities and fast access to specific parts, eventually updated via the Internet. A centralized Internet or Intranet videoserver could be also set up.

2.3 Methodology

A plain conversion from a PAL VHS tape to an equivalent non compressed digital format would require an enormous amount of memory and dedicated high end hardware. Compression in M-JPEG (Motion JPEG) format with a ratio of 20:1 gives normally an output quality between a S-VHS and a VHS, even though it is a lossy scheme. With this ratio you can store one hour full-size video in less than 4 Gb. We also experimented other compression schemes, first of all MPEG-1 which enables the storage of a full-size one hour video in a 600 Mb CD-ROM. We discuss its features in the next chapter.
Starting from the M-JPEG format we reduced the image size from the 768x576 pixels of PAL to a 320x240, suitable for a 640x480 PC monitor. The frame rate of 25 fps was dropped to 5 fps, because a "talking head" doesn't need such a smooth rhythm. In these conditions we could store one hour in less than 150 Mb.
The negative point of compression and reduction is the lack of sufficient clearness of any drawing or document presented by the teacher. The NET.T.UN.O videocourses contain in fact mainly two modalities: a slowly changing image (the speaking teacher) and text or graphical slides. This sort of lesson can be compared to what is now called "telepresentation". In the last months there has been a great advance in the related technology: a paper [Gemmel 97] by two Microsoft's researchers gives a very clear panorama of the current available solutions and the future enhancements.
To overcome the difficulty without having to redraw or reproduce manually all the slides, we decided to digitalize at full resolution a screen shot of every drawing or document presented in the videotape. This process is fast and easy and does not imply heavy storage needs, because those are still images. To be able to show them without scrolling on a standard 640x480 monitor, a reduction from 768x576 to 384x288 was accomplished and the image format was GIF. The main issue was how to show those images while the digitalized video is running, synchronizing them with the teacher's explanations. In the next chapters

we describe all the software we experimented to get to the final solution. The one that provided us with the most useful features was Microsoft NetShow, especially because of its capability to embed any URL in the video stream. We were therefore able to set points where a browser would start showing a full resolution image of what is shown at the same time in the running video window. So, we can deliver a complete lesson to any multimedia PC by using only one piece of software: the browser (either Netscape or Explorer) with the NetShow player.
This methodology leads to different choices of storage of the video and graphics material. Everything can be on a CD, and in this case the URL of each document points to a local file. The video can otherwise be on an Intranet server as well as the document's images, which would be fetched over the network. The step to a full Internet delivery is only a matter of quality/speed balance, but it doesn't affect too much the document's visualization which can keep its original quality also with low level communication lines.
The student can stop the video while reading more carefully the document shown on the browser. He/she is not allowed to modify it, but he/she can save the bitmap image and work on it with any graphic program, for example to annotate it for personal purposes. The streaming capabilities of the NetShow software allow to fast forward and rewind at a reasonable speed. Compared to the videotape, there isn't any problem of losing quality by using the video too much: digital videos don't get worn-out.

2.4 Technology used

We have been experimenting with different compression methods and various delivery systems which we summarize below. We used a FAST AV Master board and a Movie Machine II, both affordable (well under 1000 ECU) solutions for any Windows 95 PC. The computer was a Pentium 133 with EISA disks which are cheaper than SCSI. Comparing them to the performance of a Ultra Wide SCSI-2 we found that with the latter it is possible to produce full screen VHS quality videos, without dropping frames. Special AV disks (that do not have the thermal calibration which sometimes stops the writing flow) would be even better: anyway we do not think that the full screen image is necessary for our purpose.

2.4.1 Microsoft NetShow

This new software package [NETSHOW] aims to the delivery of video

and audio material over the Internet. The main component is the player which is now delivered free of charge. An editor and a server are other components.
The greatest advantage of this new software is its codec-independence. That is you can choose the best compression solution for your purposes while having only one delivery system which embeds the necessary decompression software.
One major feature is the capability of inserting "markers" in the videostream: they can execute any application on the desktop. We have been using it for opening URL's where we stored the high quality screen shots of the slides commented by the teacher.
NetShow is included in the latest versions of Microsoft Internet Explorer, and it can be used as an external application by Netscape Navigator. There are two possible layouts: having both the video and the slides in the browser's window or keeping them in separate windows, so that they can be resized and eventually reduced independently.
One important point is the capability of using http protocol to connect to a NetShow server, in alternative to UDP. This solves the problem of connecting through a proxy or through an IP masquerading firewall. There is only a minor decrease of speed. To deliver a NetShow video, the server software is not needed if there aren't concurrent accesses to the same files.

2.4.2 MPEG

Because of the aim to produce low-cost material, we could not afford to work with MPEG-2 [MPEG], which would give the best quality (practically equal to the original videotape). We tried the MPEG-1 compression, which produced a good result but, without specialized hardware, required a very long time to convert an M-JPEG source via software (e.g. Xing): for a single minute it took half an hour.
MPEG-4, a standard built for network transmission, is currently used in Microsoft NetShow and we were able to experiment with it. We found that its quality is sufficient but not better than other compression software.

2.4.3 RealVideo

The current version of RealPlayer [REAL] has improved quality also over very slow connections. There are two main codec: the Real one and the Iterated ClearVideo [ITERATED] fractal compressor. The latter

produces a very good output but it is tremendously slow. It took hours on our PC to compress only a few seconds.
An interesting feature is the marking of parts of the running images as "hot spots" so that clicking on them makes the browser jump to any location. Unfortunaltely, this process cannot be automated so that the jump takes on even without any request.

2.4.4 VIVO

The software by VIVO [VIVO] has a wide choice of compression schemes, according to the transmission rates you are goring to use. It can also produce videos in Microsoft's Net Show format, using all its capabilities, through a powerful conversion and editing program. The quality is good, especially on the higher rates and we consider that in this moment it may be the best choice.

2.4.5 VDOlive

The software by VDOnet Corp. [VDO] has quite a wide diffusion all over the world. Its quality is fairly good. They have recently announced a new version that can be used through a proxy.

3. RESULTS AND DISCUSSION

The results of our first tests are promising. We are now heading to the complete production of one course, for the purpose of testing it with some students who have to prepare themselves for the examination. This will assess the efficacy of our methodology, which allows a cost effective and simple reuse of videotapes over the network, either an Intranet or, with some limitations, the Internet.
We believe that videos with didactic material need to be digitalized to increase their intrinsic value in a modern environment. It is not always feasible to rebuild contents using multimedia authoring tools or CBT methodologies, because it supposes a very high cost. In this case only the most important products were worth conversion.
We are aware that our methodology can be applied only to material that shares the same structure of the NETTUNO video courses. Fast moving images, like the ones that can be found in videos about physics experiments require a different approach. Anyway, the very high rate of software production in the field of digital imaging, with more and more efficient codecs, makes us quite sure about the increase of the quality. Meanwhile we can say that some good results can already be obtained

with the existing technology.
The availability of such an affordable conversion system widens the opportunities of enhancing existing didactic videotape based libraries also with interactive and cooperative tools, which of course require more resources, but constitute a major advancement in the teaching effectiveness.

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More information about the project, together with results and demos is available at http://projects.elis.it/mpp

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