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Mobile and Web Tools for Participative Learning

Por
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Dissertação apresentada na Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa, para a obtenção do grau de Mestre em Engenharia Informática.

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Mobile and Web Tools for Participative Learning

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Dissertation submitted at the Faculty of Sciences and Technology, New University of Lisbon, in partial fulfillment of the requirements for the degree of Master of Science in Computer Science Engineering

Supervisor: *Professor Doctor Nuno Manuel Robalo Correia*

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Resumo

A combinação de diferentes tipos de media tem sido crucial para os processos de ensino e aprendizagem. Os recentes desenvolvimentos das tecnologias multimédia baseadas em Internet de banda larga e em dispositivos móveis podem melhorar a comunicação entre professores e estudantes, e permitir aos estudantes estudar em qualquer local e em qualquer momento, progredindo ao ritmo que desejarem. A utilização destas novas plataformas e a facilidade de partilha de material multimédia em ambientes educativos, permite um ensino mais participativo e torna o estudo de interfaces um aspecto crítico nos sistemas multimédia de aprendizagem.

O trabalho apresentado explora interfaces e ferramentas para aprendizagem participativa, com recurso a sistemas multimédia educativos baseados em Internet de banda larga e dispositivos móveis. Neste trabalho foi desenvolvido um sistema educativo para a Web, que permite armazenar, transmitir, procurar e partilhar conteúdo de aulas gravado em vídeo e a sua extensão para suportar Tablet PCs. O sistema Web, desenvolvido no âmbito do projecto VideoStore, explora interfaces de vídeo e anotações de vídeo que incentivam o trabalho participativo. A utilização de Tablet PCs, através do projecto mEmLearn, procura incentivar o trabalho participativo, permitindo aos estudantes enriquecer os materiais de ensino e partilhá-los com outros estudantes e professores.

Palavras-chave: Multimédia, Ensino Participativo, Dispositivos Móveis, e-Learning, m-Learning

Abstract

The combination of different media formats has been a crucial aspect on teaching and learning processes. The recent developments of multimedia technologies over the Internet and using mobile devices can improve the communication between professors and students, and allow students to study anywhere and anytime, allowing each student progress at its own pace. The usage of these new platforms and the increase of multimedia sharing applied to educational environments allow a more participative learning, and make the study of interfaces a relevant aspect of existing multimedia learning systems.

The work done in this dissertation explores interfaces and tools for participative learning, using multimedia educational systems over Internet broadband and mobile devices. In this work, a Web-based learning system was developed, which enables to store, transmit, search and share the contents of courses captured in video and its extension to support Tablet PCs. The Web system, developed as part of the VideoStore project, explores video interfaces and video annotations, which encourage the participative work. The usage of Tablet PCs, through the mEmLearn project, has the aim to encourage the participative work, allowing the students to augment the course materials and to share them with other students or instructors.

Keywords: Multimedia, Participative Learning, Mobiles Devices, e-Learning, m-Learning

Acronyms

API	Application Programming Interface
CD	Compact Disc
CSS	Cascading Style Sheet
DOM	Document Object Model
IIS	(Microsoft) Internet Information Server
ISDN	Integrated Services Digital Network
JPEG	Joint Photographic Experts Group
HP	Hewlett-Packard
HTML	HyperText Markup Language
HTTP	HyperText Tranfer Protocol
MPEG	Moving Pictures Experts Group
MS	Microsoft
PC	Personal Computer
PHP	PHP: Hypertext Preprocessor
PDA	Personal Digital Assistant
POSI	Programa Operacional para a Sociedade da Informação
SDK	Software Development Kit
SOAP	Simple Object Access Protocol
SMIL	Synchronized Multimedia Integration Language
SMS	Short Message Service
SMTP	Simple Mail Transfer Protocol
SQL	Structured Query Language
TV	Television
VCR	VideoCassette Recorder
WAP	Wireless Application Protocol
WMV	Windows Media Video
XML	eXtensible Markup Language

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Chapter 1

Introduction

The work featured in this dissertation applies recent multimedia developments, using Internet and mobile devices, to educational environments. The developed work is composed by a Web-based learning system to broadcast, search and add information to recorded video lectures. Video interfaces and tools were developed allowing the access from different platforms: regular desktops, iPod devices and Tablet PCs. These platforms reduce temporal and physical constraints and increase the users interaction.

1.1 Motivation

Communication can be defined as "the activity or process of expressing ideas and feelings or of giving people information" [44] and plays a crucial role on teaching and learning activities [20]. Consequently, the media (medium), "the way of communicating information", [44], can not be ignored on educational contexts. Nevertheless, there is a number of ways to present information for communication [2]. Multimedia can be presented as the usage of two or more information representations or presentation modes [29]. The use of multimedia as part of the human cognitive process has been studied and developed for a long time. The combination of different media content can eliminate information and cognitive gaps caused by using a single media format [29] and one of the oldest examples of this approach is the combination of drawings with text (Figure 1.1).

With time, multimedia has been changing and the appearance of new technologies allowed new media formats. The usage of photographs, reproducing real representations of places, objects or events (Figure 1.2), and video, reproducing audio and moving images (real or animated)

(a) (b)

Figure 1.1 Drawings Combined with Text: (a) Comets with chinese characters on silk, China, circa 300BC [1] (b) Solar system from Nicholas Copernicus Manuscripts, circa 1520-1541 [2]

(Figure 1.3), with the aim to communicate, to share ideas and knowledge, can be considered examples of those changes.

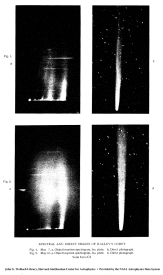
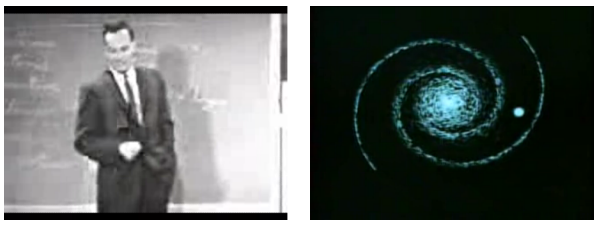


Figure 1.2 Photographs Combined with Text: Photographs of Halley Comet, 1911 [3]



(a) (b)

Figure 1.3 Video Screen Shots: (a) Recorded lecture of Richard P. Feynman at Cornell University, 1964 [4] (b) Galaxy animation from Carl Sagan TV series, Cosmos, 1980 [5]

The appearance of digital platforms allowed new compositions of media content, new ways of sharing it, and therefore, new ways for multimedia interaction (Figure 1.4). The digital platforms also promote active, collaborative and participative learning [33], activities that contribute to improve the learning process [17]. These platforms transformed the communication between professors and students, and concepts like computer-based training, online learning and e-Learning (electronic Learning) were introduced. The first multimedia learning systems increased the participation of students on their learning process, reenforcing the need to study

[1] From `http://www.nasa.gov/mission_pages/deepimpact/media/f_ancient.html`, Jan., 2008

[2] From `http://www.bj.uj.edu.pl/bjmanus/revol/titlpg_e.html`, Jan., 2008

[3] From `http://adsabs.harvard.edu/abs/1911LowOB...2....3S`, Jan., 2008

[4] From `http://www.youtube.com/watch?v=ozF5Cwbt6RY`, Jan., 2008

[5] From `http://www.youtube.com/watch?v=j7jqlKuFf84`, Jan., 2008

and improve multimedia interfaces and access tools, applied to educational environments [1].

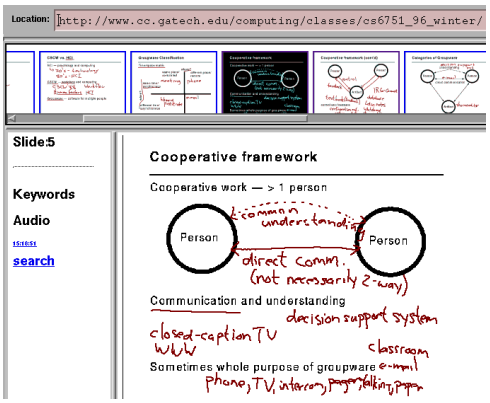


Figure 1.4 Digital learning system screenshot: Web interface of the Classroom 2000 project, one of the first multimedia learning systems, 1996 [6]

Currently, the Internet and the increase of network bandwidth help people to share media content, particularly digital video [26]. In addition, mobile devices are also popular, their usage is increasing as multimedia record/playback devices [9, 34] or as tools to promote collaborative and social activities [34]. The YouTube system (Figure 1.5) and the iPod device (Figure 1.6) are well known examples of existing platforms for multimedia sharing and broadcast, using these recent technologies. Broadband Internet and mobile technology also motivated new paradigms for multimedia interfaces and access tools, such as, video browsing and navigation; video and image display in small screens; portable pen-based technology, which allows to write and draw over a screen with a pen, in the same way that a person can write on paper with traditional stylus; and touch screens, which responds to human touch [24, 25, 26].

These latest developments can also be applied to learning environments, helping professors and students to share ideas and knowledge [34]. Mobile technology promoted a new concept, Mobile Learning, which can be expressed in a simple way as learning through mobile devices [35]. With remote and mobile access to learning materials, students can study anywhere and anytime, and each students can progress at its own pace [43]. Additionally, mobile devices can provide students other information about their location in space and time [35]. Mobile devices combined with Pen-based technology can also improve and foster creative learning [5]. The usage of these new platforms and the increase of multimedia sharing on educational environments allow a more participative learning and make the study of interfaces and access

[6] From Article: [1]

Figure 1.5 YouTube screenshot: Excerpt from Carl Sagan TV Series, Cosmos [7]

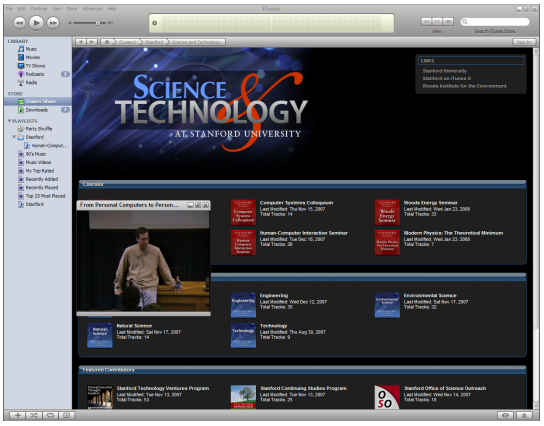


Figure 1.6 iTunes/iPod: screenshot from Stanford on iTunes, the video can be transfered to iPod device [8]

tools a relevant aspect of current multimedia learning systems [24, 25, 26].

1.2 Solution Overview

The described work explores interfaces and tools for participative learning, using multimedia learning systems over Internet broadband and mobile devices. The work explores interfaces and tools based on synchronized multimedia presentations, with a main focus on video format, including video interfaces and video annotation, applied to educational environments.

Some of the mobile technology paradigms are also studied in this dissertation, exploring multimedia interfaces and tools for iPod devices (Figure 1.7) and Tablet PCs, laptops equipped with Pen-based technology (Figure 1.8). These devices allow to study and explore different paradigms of mobile technology, such as, media browsing and visualization on small screens and portable Pen-based technology.

[7] From `http://www.youtube.com/watch?v=FxoQTt-UiJw`, Jan., 2008
[8] From `http://itunes.stanford.edu/`, Jan., 2008

Figure 1.7 iPod Device

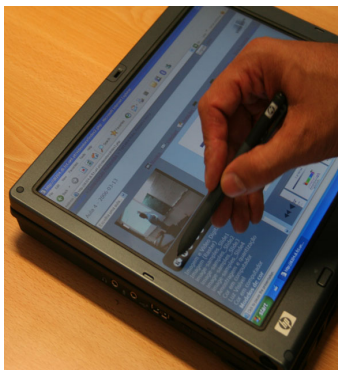


Figure 1.8 Tablet PC

1.3 Context and Background Work

The work described in this dissertation is part of two projects, the VideoStore and the mEmLearn. The VideoStore project started in 2005, as a sub-project of the main project "A Universalidade dos Saberes"(POSI), and was concluded in 2007. The mEmLearn project started in 2006, with the award of the HP Technology for Teaching Grant Initiative 2006, and is still in progress.

1.3.1 VideoStore

The main goal of the VideoStore project was to develop a Web-based learning system to store, transmit, search and share the contents of courses captured in video. The wide distribution of media documents through the Internet, using broadband, allows for new approaches in learning systems. The VideoStore explored new possibilities by providing different interfaces for learning.

The VideoStore [10, 11, 13, 14] [9] was initially developed during the author's BSc diploma project. In the end of the diploma project, a first prototype was concluded and the system architecture had reached a final form. The prototype included video, Power-Point slides and HTML synchronization with the authoring tool MS Producer 2003; video annotations, using PHP5 features and XML databases; two video interfaces and video streaming. Both, video annotations and interfaces, were integrated into the Web presentation generated by MS Producer. The

[9] `http://img.di.fct.unl/videostore/`

project also involved recorded lectures, and therefore, hardware equipment for video and audio recording was tested and chosen. Nevertheless, the VideoStore development continued and the system was tested and improved. This project was part of the project "A Universalidade dos Saberes" [10], funded by POSI (Programa Operacional para a Sociedade de Informação) with the aim to develop Internet Broadband Contents.

1.3.2 mEmLearn

The mEmLearn project [10, 11] [11] departs from the VideoStore framework to support Tablet PCs. This project has the aim to define tools that enable students to augment the course materials in an interactive way, during or after the classes, to retrieve these materials at a later stage and to share them with other students or instructors. The system includes a Web drawing interface that allows students to annotate and share course materials with the Pen-based technology. The project was initially funded by the HP Technology for Teaching Grant Initiative 2006, and among other equipment, the grant included 21 HP Tablet PCs.

1.4 Contributions

This thesis provides the following contributions:

- A Web-based system to broadcast video recorded lectures synchronized with slides.
- Interfaces and tools for video browsing and navigation, using the Internet and mobile devices.
- Interfaces and tools for video annotation, using a keyboard or a pen.

The work was published the in the following conferences:

- Mobile and Web Tools for Participative Learning. Diogo Cabral, Nuno Corrreia. IADIS, International Conference on e-Learning 2007, Lisbon, Portugal, July 6-8 2007.

[10] http://www.fct.unl.pt/universalidade-dos-saberes/
[11] http://img.di.fct.unl/mEmLearn/

- An Environment for Mobile Learning Supporting Video Lectures and Annotations. Diogo Cabral, Nuno Correia. IADIS, International Conference on Mobile Learning 2007, Lisbon, Portugal, July 5-7 2007. (poster)

- Interfaces for Video Based Web Lectures. Nuno Correia, Diogo Cabral. ICALT 2006, The 6th IEEE International Conference on Advanced Learning Technologies, Kerkrade, The Netherlands, July 5-7 2006.

1.5 Document Structure

This document is divided in five chapters. Chapter 1 has presented the importance of multimedia to communication, how it is changing in time and how it can be applied on educational environments. This chapter also summarizes the work developed, context and contributions. The projects and studies that inspired this dissertation are reported on Chapter 2, which is divided in three main areas: (1) Video Interfaces and Annotation, (2) Multimedia E-Learning Systems, and (3) Mobile Learning. The system architecture and the implementation of the projects are described in Chapter 3 and the system evaluation is reported in Chapter 4. In Chapter 5, the conclusions are presented and directions for future work are discussed.

Chapter 2

Related Work

The first Web-based multimedia learning systems appeared in the early 1990s. Among other conclusions, they showed the need to improve multimedia authoring tools and to provide better multimedia interfaces and access tools. Since that time, better multimedia interfaces were developed and multimedia authoring tools were also improved, facilitating the combination of media elements and creating new challenges for media interfaces.

Currently, the broadband Internet and mobile technology increased the sharing of multimedia content, particularly digital video. Digital video has gained popularity and has an important role on today multimedia applications. These new platforms also require new paradigms for multimedia interfaces and tools.

The usage of the most recent digital technologies in learning environments started recently. Nevertheless, a lot of work should continue to be developed in the future, particularly, focused in interfaces, which should be improved to take full advantage of these new platforms. Therefore, the presented work considers three main areas: Video Interfaces and Annotation, Multimedia E-Learning Systems, and Mobile Learning. Different projects inspired this work each one of the referred areas.

2.1 Video Interfaces and Annotation

Digital video introduced new video interfaces for browsing and searching information on video content. In addition, video annotations allow to combine other media formats with digital video, adding more information to the video content. These topics can be applied to educational environments, improving the usage of digital video by lecturers and learners.

2.1.1 Video Interfaces

The transformation from analogical to digital video introduced new ways to explore, browse and retrieve video content. These changes improved users search for video content information, which can be useful for educational videos. In the last years, this topic was quite studied and developed but there is a lot of work still going on.

2.1.1.1 VideoStreamer and CollageSpace

The VideoStreamer and CollageSpace [18] project tries to eliminate the constraints imposed by the traditional button interface for video navigation (play, pause, stop, backwards and forwards) and explores a new interface based on a 3D visualization of the video. This interface, the VideoStreamer, is formed by stacking the video frames and composing a three dimensional block, as shown on Figure 2.1 and provides a good way to visualize camera shot changes on the video (Figure 2.2). The CollageSpace project inspired a set of innovative work, which developed new video interfaces, associating visualization and navigation of video content with frame composition and layout.

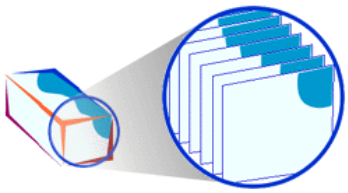


Figure 2.1 Stacking Frames as a 3D Block [1]

Figure 2.2 VideoStreamer Interface [1]

2.1.1.2 Físchlár TV

Físchlár TV [26] is a Web-based digital video system, which allows the recording of TV programs and has a set of interfaces for video browsing and navigation. A storyboard view of the

[1] From `http://lightmoves.net/videostreamer/index.html`, Jan., 2008

video is one of the simplest and most useful of them. With this interface, the user can have a global idea of the content of the video by showing a set of frames, selected by regular time intervals (subsampling), as presented on Figure 2.3, or by detection of different camera shots (automatic video segmention). The selected frames can be shown as a set in chronological order (storyboard) (Figure 2.4), one by one (slide-show) or in a drill-down mode with different levels of hierarchy (hierarchically) .

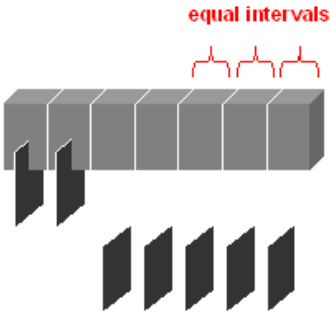


Figure 2.3 Frame Selection for Video Thumbnail

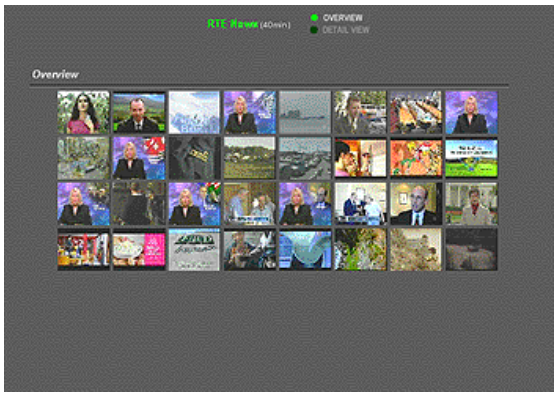


Figure 2.4 Físchlár Thumbnail Interface

Besides the set of interfaces, other features were developed, such as, personalization and program recommendation, automatic recording, Short Message Service (SMS)/Wireless Application Protocol (WAP)/Personal Digital Assistant (PDA) alerting, searching, summarizing, among others. The system is available at the Dublin City University campus (computer labs and residences) since early 2000 and has the capability of streaming to over 200 users simultaneously. In 2002 the system had more than 1500 registered users. This project uses Moving Pictures Experts Group (MPEG) video encoding, eXtensible Markup Language (XML) and MPEG-7 video descriptors. The client was developed using Cascading Style Sheet (CSS), Javascript, Java Applets and the streaming video player plug-in Oracle Video Player.

2.1.1.3 uBase

The video storyboard interface is also included in the uBase project (Web-based Image and Video Navigation) [28], but in a more advanced perspective, introducing other methods of frame selection besides the order in which they appear on the video. The defined methods are frame selection by pre-defined categories (Figure 2.5) and frame selection by similar content (Figure

2.6). This project had the aim to develop a web-based image and video browser for a content-based image retrieval (CBIR) system, integrating several types of video interfaces, including relevance feedback based navigation and hierarchical browsing. The system was tested by six users, with ages between 21 and 23, with an average experience of search engines. The tests showed that users would like to have more control over the system to have better results, which remarked the trade-off between simplicity of use and the excess of features giving more power to the users. The system uses Java Applets and Java Servlets, which form a Web client-server architecture.

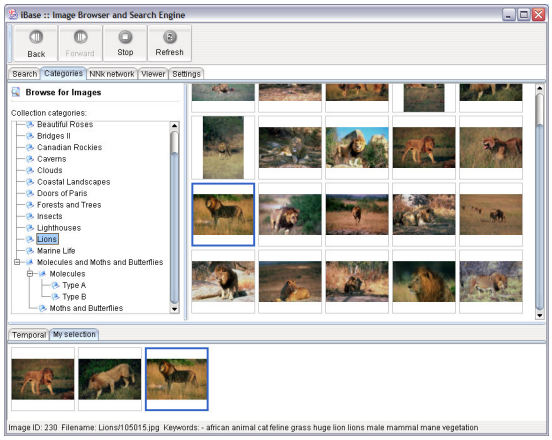


Figure 2.5 uBase Frame Selection by Categories

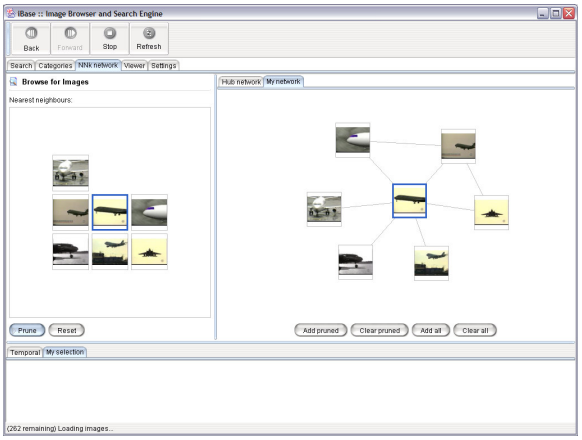


Figure 2.6 uBase Frame Selection by Similar Content

2.1.1.4 Discussion

The availability of digital video foster the development of video interfaces and methods to browse information. Some projects have an approach based on frame content and video processing, others explore semantic concepts included in the video stream. This dissertation explores frame based interfaces, some of them combined with information about users behavior, in order to reduce users participation in classification tasks.

2.1.2 Video Annotation

The ability to combine different media elements in digital platforms, resulted in a new perspective for digital video, the *video annotation*. This concept of augmented video, with different

types of media associated, and made by one or multiple users, has been developed on different projects in the last decade.

2.1.2.1 Experimental Video Annotator (EVA)

The EVA (Experimental Video Annotator) [27] system is one of the oldest digital systems with the ability to combine annotations and video. The system had the aim to solve the need to capture and record researchers impression of events as they occurred. EVA uses a NTSC video source, camera or player, and a workstation developed as part of the project Athena, which gives the ability to tag video segments, with keywords or time stamps, in real-time or after the event. The workstation was composed by a DEC MicroVax or a IMB PC/RT systems running either Unix or X Window System. The system was developed in the Athena Muse language, for interactive multimedia applications. In addition, the Argus system allows to write simples rules to identify different tags, among other features.

2.1.2.2 Annotations in Video (AntV)

The AntV (Annotations in Video) [15] is a video annotator that can be used to add or edit annotations in video streams. The annotations can be text, images, or even video. It is possible to link the annotations to a video using time intervals or space positions, and each user has associated a set of annotations. The system is composed by an annotation video player and an annotation set editor. The main purpose of the project is to enrich existing materials with new content, made by users. The Figure 2.7 shows the different components of the system.

The AntV [15] was partially developed in the scope of the Unibase [12] project, which had the aim to provide a distance multimedia interactive environment, at the Universidade Aberta (Portuguese Open University) and at the Universidade de Lisboa (University of Lisbon), that would keep the students motivated and help them to learn more.

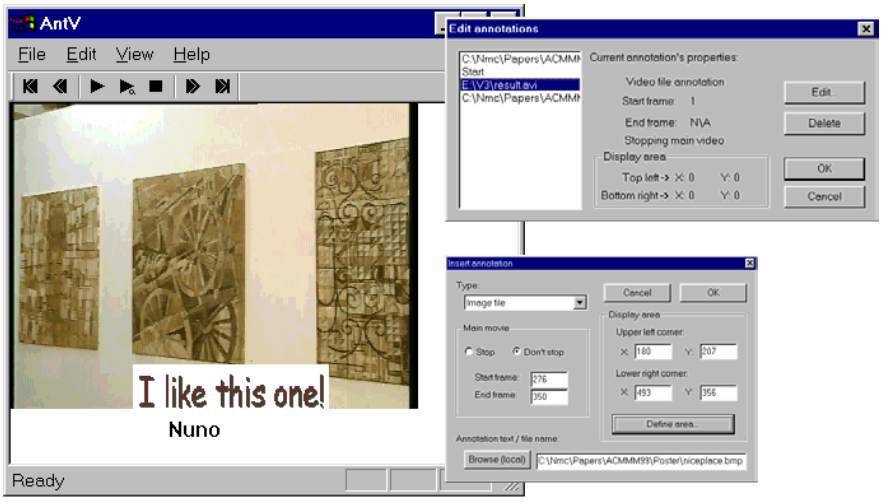


Figure 2.7 Antv Video Player and Annotation Editor

2.1.2.3 Microsoft Research Annotation System (MRAS)

The Microsoft Research Annotation System (MRAS) [8] is based on a client-server Web framework, which allows the association of a segment of a media element with an other segment of any other media element. Therefore, with this system it is also possible to create annotations linked to different types of media formats (Web pages, 3D virtual reality simulations or audio recordings). The MRAS interface was specifically designed for streaming video annotations (text or audio annotations) on the Web. A user can access a web page, which contains the video, and send annotations to the system server, using an ActiveX interface and the Simple Mail Transfer Protocol (SMTP), as shown on Figure 2.8.

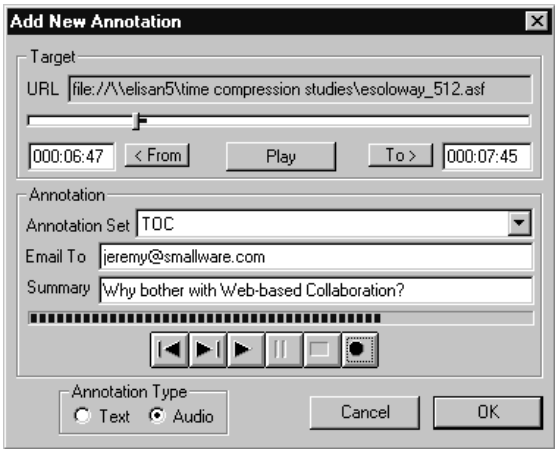


Figure 2.8 MRAS Add Annotation Interface

The MRAS Annotation Server manages the Native Annotations Content Store and the Annotation Meta Data Store, where the annotations and the meta data associated with it are respectively stored, using the Microsoft SQL Server 7.0. The MRAS Annotation Server retrieves the annotations to the users using the HyperText Transfer Protocol (HTTP), through Microsoft Internet Information Server (IIS). Figure 2.9 presents an overview of the system architecture.

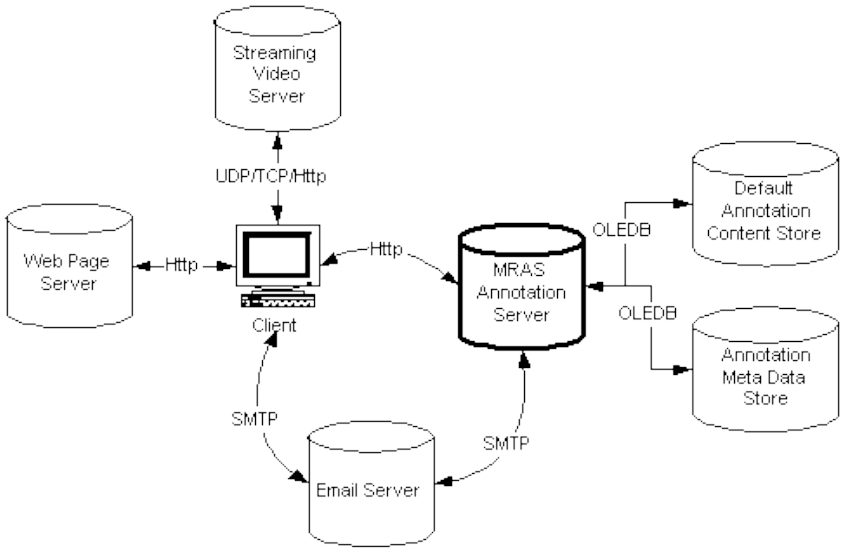


Figure 2.9 MRAS System Overview

The MRAS was tested in two ways. In the first one, six intermediate and advanced Microsoft Windows users used the system for personal note-taking and all preferred MRAS over pen-and-paper. The second, added more eighteen users to the first test and was focused on the benefits of sharing notes (Text-Only, Audio-Only and Text-and-Audio notes). In this second test, fourteen of eighteen subjects made more comments and questions using the system then in a live lecture. The precise position of annotations was not a real problem and the annotation tracking was quite used by the users for shared notes.

2.1.2.4 VAnnotator

The VAnnotator [16] application has a different perspective of a video annotator, as it allows to describe the content, by adding metadata to it. To each video stream, a set of descriptors can be added. The layers of annotation are stored accordingly to the MPEG-7 standard, allowing interoperability with other annotation tools. The project also introduces the concept of video

lenses to provide interpretations of the multimedia content and give different perspectives of the information. The VAnnotator [16] was developed in the scope of the Vizard [40] project, which had the aim to define a new paradigm for video navigation, annotation, editing and retrieval. The Vizard [40] project had the contribution of users from production/archiving and consumer electronics areas, which helped to define and validate the annotation requirements and functionality.

2.1.2.5 Intelligent Video Annotation Server (iVAS)

An other approach for a video annotation system is presented in Intelligent Video Annotation Server (iVAS) [47]. The system analyzes video content to acquire cut/shot information and color histogram. Then, it automatically generates a Web document that allows the users to edit the annotations (Figure 2.10), which are stored in an Annotation XML database.

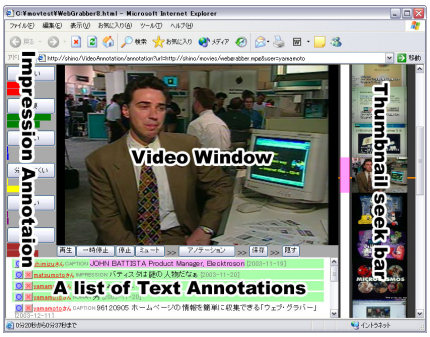


Figure 2.10 iVAS Annotation Editing Page

The annotations are divided in two categories, text and impression annotations (Figure 2.11) and an automatic evaluation method of annotation reliability was implemented on this system. The project also presents two application systems based on the annotations: video retrieval and video simplification.

Figure 2.11 iVAS Impression Annotation

The system was tested by thirty college students and the video content included news, drama, variety and cooking programs. The subjects considered the application “easy-to-use” and wished to use the system in the future.

2.1.2.6 LEAN

The LEAN [38] project explores video browsing, visualization and annotation using Pen-Based technology. This system explores the Pen-Based interface, including sketches, gestures and pressure features, as tools for video navigation and video annotation. The Figure 2.12 shows the system running on a Tablet PC.

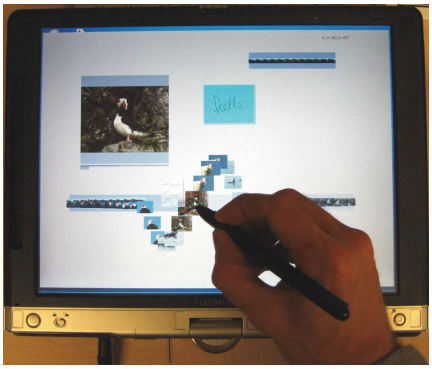


Figure 2.12 LEAN System Running on a Tablet PC

The PVslider is an interface that explores video navigation, changing the playback velocity with the distance between the video window and a tapped point with the pen. The playback velocity is directly proportional to the defined distance. An other developed interface was the Twist Lens Slider or TLslider, which was based on the fish-eye lenses and has two modes. One mode (Figure 2.13) enlarges the current frame in a film strip, focusing the attention on that particular frame.

Figure 2.13 Film strip mode of TLslider Interface

The other (Figure 2.14) morphs the linear layout of the frame strip to an s-shape, which depends on the pressure applied by the pen to the screen. This interface focus the attention not in a particular frame, but in a small segment of frames.

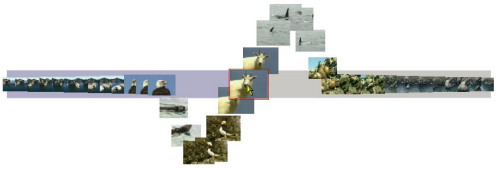


Figure 2.14 S-shape mode of TLslider Interface

The LEAN [38] system also allows to draw annotations, using the pen, in a workspace around or over a video frame, and video navigation by linking the same note to different frames, as presented on Figure 2.15.

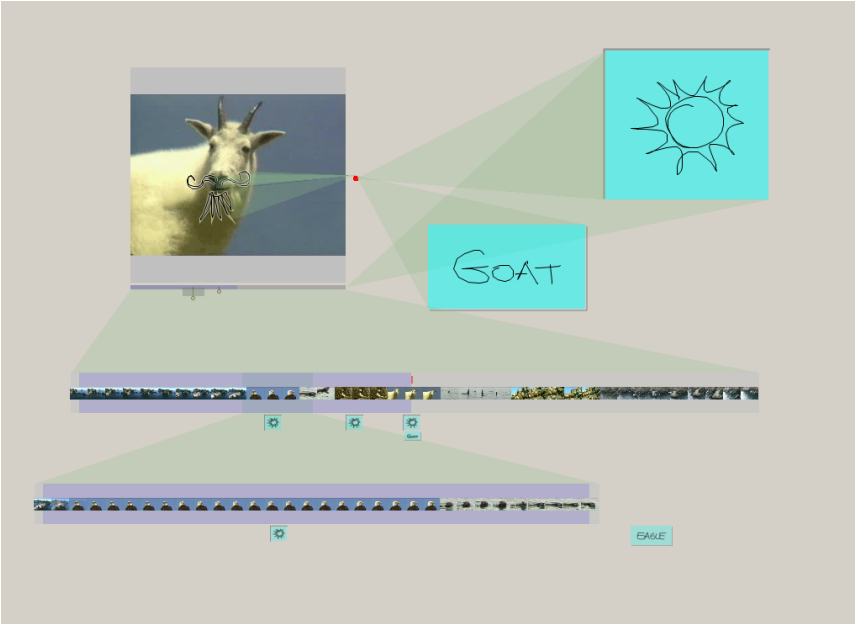


Figure 2.15 A LEAN Session with Annotations

Due the hardware limitations of the Tablet PCs, the system was tested using higher-end workstations equipped with digitizer tablets. Six users tested the system, some had previous experience with pressure sensitive digitizer tablets and all were inexperience users of video editing systems. After fifteen minutes of use, trying to understand the pressure and gesture controls, all users easily became familiar with the features of the system. The most natural and useful interface tested by the users was the PVslider.

2.1.2.7 Discussion

Video annotations can help video analysis and browsing. The first projects had a simple approach by associating keywords, written using a keyboard, to a particular instant of a video stream. After, other approaches were tried, such as annotations placed over the video content, collaborative annotations and annotations rating. More recent work uses pen-based annotations over video content. Similar approaches are studied and implemented in the scope of this thesis.

2.2 Multimedia E-Learning Systems

The ability to combine different media elements and the possibility to share it using computer networks, particularly over the Internet, increased the use of multimedia in education. Some research projects studied and explored these abilities in learning environments.

2.2.1 Classroom 2000

The Classroom 2000 [1] project integrates different media elements used and recorded during lectures and puts it available on the World Wide Web. This three-year research project introduced automated support for lecture capture in a learning and teaching university environment. The project had two main goals, (1) to study the design issues of an ubiquitous computing application with the ability of capture and access rich live experiences, and (2) to study the effort needed to produce a robust, ubiquitous computing application whose impact can be evaluated for a long period of time. The system was used to capture parts or all of sixty courses at the Georgia Institute of Technology, which included graduate and undergraduate courses, from Computer Science, Electrical Engineering and Mathematics.

The first prototype of Classroom 2000 was composed by a Xerox Live Works LiveBoard, pen-based computer with a 67-inch screen, and regular Tablet PCs, all using a Visual Basic application, called ClassPad, which had the aim to show slides enriched by lecturer notes to the students. Some students have also used this platform during class, writing their own notes on

the slides. These annotated slides were converted to HTML, using Perl scripts, and together with an audio recorded lecture. The lecturer annotated slides were available on the Web, after the class (Figure 2.16).

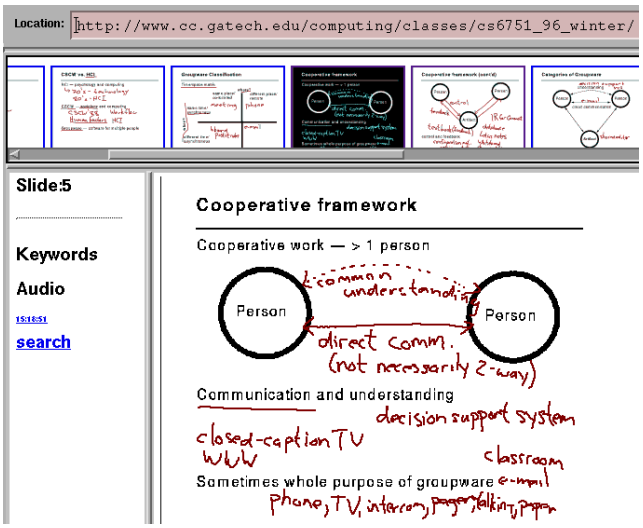


Figure 2.16 Classroom 2000: Web Interface with Annotations and Audio Links

The second prototype was improved with video lecture recordings. It was also used the same Liveboard but with a different application, the Zen* (zen-star), client-server Java application to support multiple and simultaneous captured sessions, in different locations. A post-production application, the StreamWeaver, was also developed with the aim to generate an HTML interface, linking individual pen strokes to audio.

On the final report [1] of the project it is mentioned the need to integrate student notes with public lecture notes to encourage students to take more notes in the class. On this report it is also shown the importance to study and explore the access tools and interfaces on this type of systems.

2.2.2 Authoring on the Fly (AOF)

The main goal of the Authoring on the Fly (AOF) [31] project is to "capture the live experience" of an event. All the media elements are captured in a way to reproduce the live sensation to be in an auditorium. This project combines three main tasks: teaching in the class, telepresentation and multimedia authoring. The AOF [31] replays, on real-time, audio, video and

whiteboard action streams captured during a presentation. The system introduces the notion of SRM Media, sets of media streams which are synchronizable, allow random access and contain a master stream. The multimedia documents are automatically integrated into SRM Media, making all system streams instances of SRM Media. The system is composed by a set of tools, the AOFwb for preprocessing (preparation of presentation-related materials), the aofSheel for presentation and recording (annotation and verbal explanation), MBone net and tools for telepresentation (transmission and remote presentation of all captured media streams), the aofpack for postprocessing (final editing) and aofSync for replay (playback and navigation). The system was mainly used for university lectures of algorithms and data structures (forty lectures, with twenty-ninety minutes length) from the computer science area, but other experiences were tried, such as the exchange of lectures between universities and lectures from other areas, like chemistry and history, forcing the integration of 3D models in the system. The feedback from students was positive and, even though the resulting documents of the system were not as good as other documents produced by regular authoring systems, they can capture the classroom experience as much as possible with the highest possible quality. The AOF [31] was developed in the context of the the research initiative V3D2 ("Distributed Processing and Delivery of Digital Documents").

V3D2 also supported a technology [21] which explores access tools and interfaces for recorded lectures (audio) and presentations (slides with pen strokes), presenting an improved time line interface called *elastic panning*. The original interface of the system offers two ways of lecture navigation, one by slides thumbnails and an other by a time-based slider. Both of these interfaces are limited to show information on linear or static modes. The *elastic panning* explores a more realistic approach for media browsing, by studying a non-linear navigation interface. This interface adds the possibility to click in any point of a time line, moving the time marker from its initial point to the clicked point with different velocities. The distance between the time marker and the clicked point changes the marker velocity: with a long distance the marker goes fast and with a short one the marker goes slow, as shown on Figure 2.17.

This interface allows to replay the recorded content in a non-linear way, faster if it has less information and slower if it has more information (Figure 2.18). The first feedback from

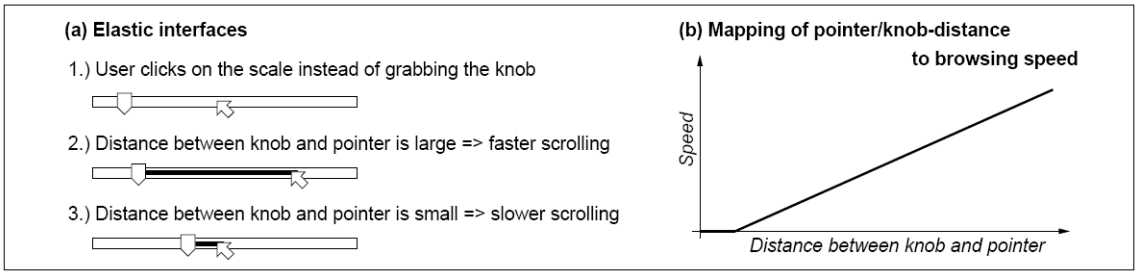


Figure 2.17 Elastic Panning Approach

users about interaction and visualization experiences was very positive. The subjects highly valued the smooth scrolling behavior compared to the original interface. The ability to browse a document at any speed is an advantage for recorded lectures with handwritten annotations.

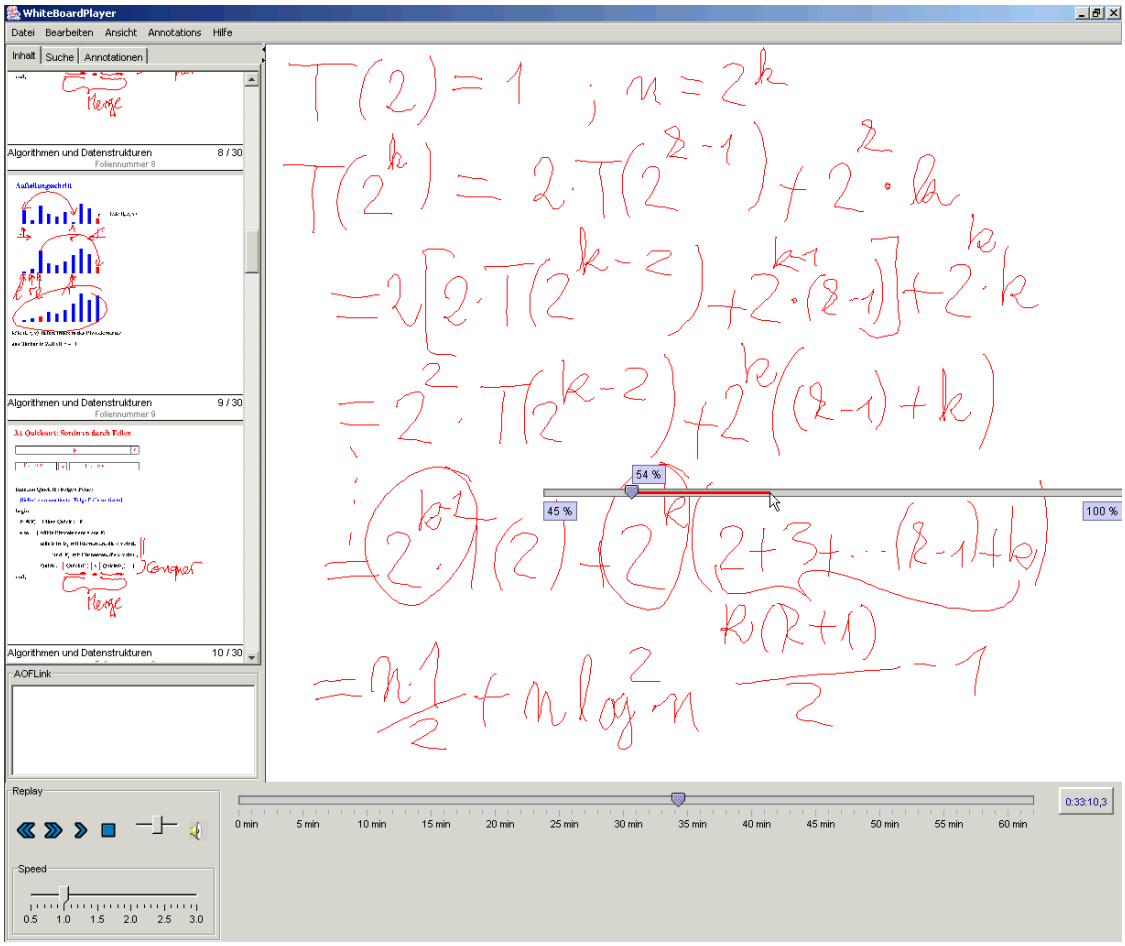


Figure 2.18 Lecture Player with Elastic Panning Interface

2.2.3 ePresence

The ePresence [6, 7, 39], a recent project, allows to participate interactively in real-time Webcasted (Web-based streaming) events and gives the possibility to view archived events. This last feature also permits user to browse and search for a specified content. The system is implemented in .NET technology and is based on a client-server architecture. The server software runs under Windows or Linux (using the Mono software application). The client can use Linux, Windows or Mac and the Web browsers developed for these platforms (Internet Explorer, Mozilla or Safari). The live streams can be seen using Real Media or Windows Media and the archives may be produced in Real Media, Windows Media and MPEG4 formats. The system uses a mobile station, called ePresence Mobile Station, for live media capturing and encoding. The recorded streams (video, slides or event data) can be updated and published for CDs or for the Web, using the ePresence Producer application. The live webcast interface (Figure 2.19) allows one to watch the video (with audio) and slide live streams, and to chat, in public or private, using written text.

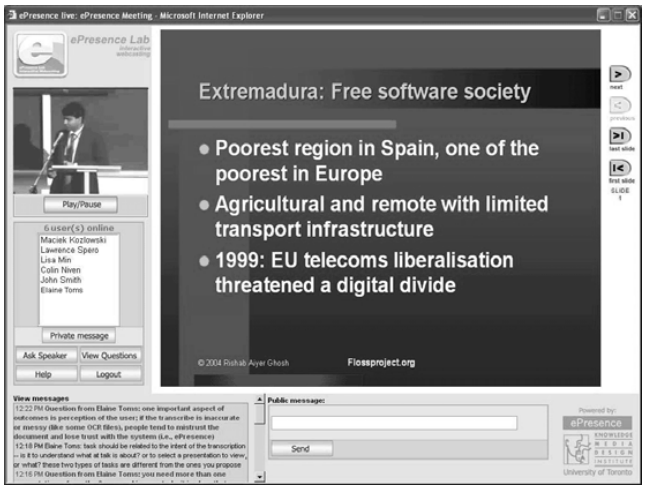


Figure 2.19 ePresence Live Cast Interface

The archived events interface (Figure 2.20) shows also the video, audio and slide streams, but replaces the chat interface by a navigable table of contents and a time-line interface.

The ePresence [6, 7, 39] was tested in conferences (University of Toronto), computer science learning (University of Trento and Instituto Superior Técnico) and in medical learning (University of Toronto).

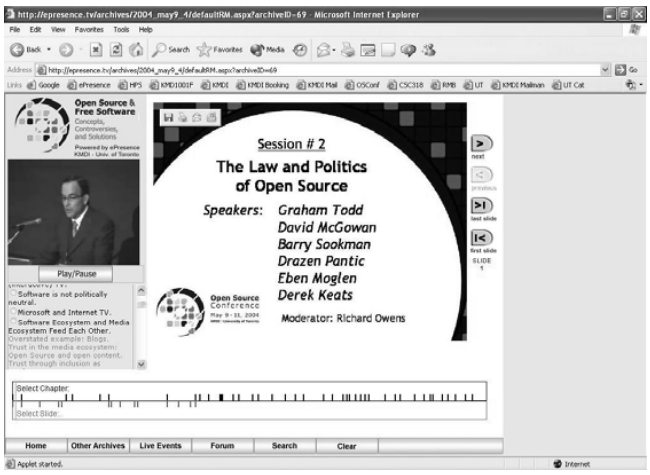


Figure 2.20 ePresence Archived Interface

2.2.4 Östlund & Svensson Study

In [42], the authors propose an inductive approach to bridge the gap between information systems design theory and the educational context where the design is to be implemented. The study used the DISCO system, which divides a course into modules, and a recording studio equipped with a Sony DV camera, a microphone, a document camera and a computer with MS Windows XP. The Microsoft Producer authoring tool was also used in this work, which integrates, captures, synchronizes and publishes (for the Web, local computer or CD) video, audio, MS Power-Point slides and HTML documents. This application uses CSS to define the Web-Lecture final layout. Some courses had Teacher On-Line (TOL) sessions to answer students questions, either via e-mail or using the groupware application Marratec. Some lectures were broadcasted, in real-time, using Integrated Services Digital Network (ISDN) video conferencing and others were only published later on the Web. This study was conducted at the department of Economics and Informatics of a Scandinavian university college with approximately 1000 students and 500 staff members. This study provided a clear view of the problems, that can be found presently, on using and developing a multimedia e-learning system.

2.2.5 Discussion

The use of multimedia can help students and teachers to share knowledge and ideas. The support provided by digital platforms improves the combination of media elements, like, images or

presentation slides, sound and video. The Internet allow distance sharing of these elements, which can be done in an after event scenario or in a real-time situation. The work reported in this dissertation explores the sharing of presentation slides and recorded video lectures.

2.3 Mobile Learning

Currently, mobile technology is very common and popular worldwide. Mobile learning applies this technology to learning environments, giving the ability to learn everywhere and at anytime. Devices like mobile phones, PDAs and iPods are very small and light, therefore, very easy to carry out but have some constrains, such as short battery duration, small screen size and limited computational power. Tablet PCs and laptops, are less mobile but still portable, particularly because the overweight and the oversize, and have more computational power. This dissertation focuses on the use of iPods and Tablet PCs, combining both paradigms.

2.3.1 iPods

Besides the popularity of the iPod devices and their mobile characteristics, they can be considered excellent devices to playback multimedia formats, like digital audio, photographs and video.

2.3.1.1 Stanford on iTunes

The Stanford on iTunes [36] project broadcasts, on the iTunes system, audio and video lectures (Figure 2.21), formal meetings and debates, that happened in this university. This project allows common users to download and play the recorded events, freely, on their own PCs or iPod devices. This project was made in collaboration between Stanford University and Apple, and shows the relevance that podcasts and broadcasted video are gaining in education and in the society in general.

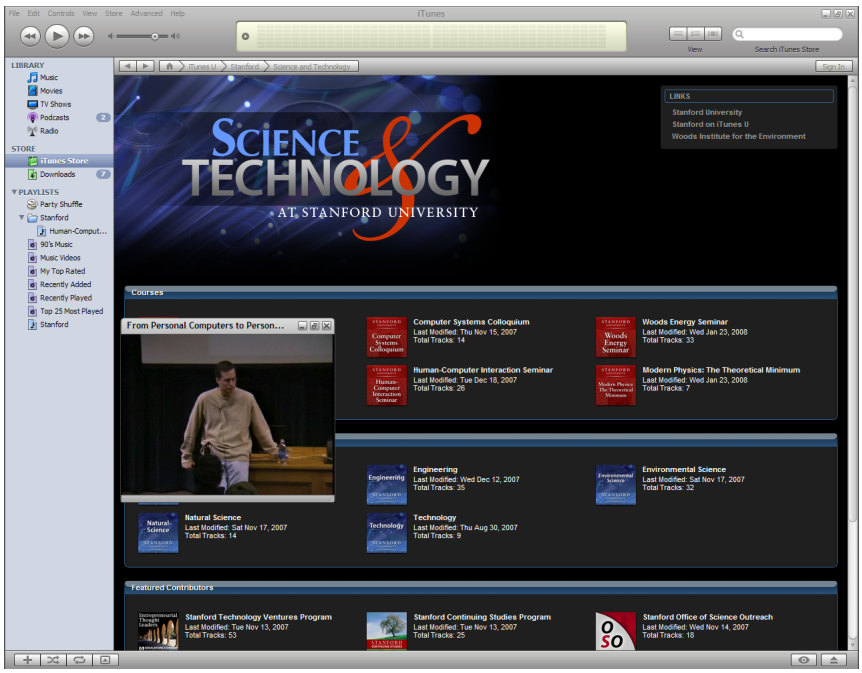


Figure 2.21 Stanford on iTunes: The video can be transferred to iPod devices

2.3.1.2 Duke University iPod First-Year Experience

The Duke University initiative [9] to massively distribute iPod devices to students and podcast university courses had quite positive results. The project distributed iPod devices, each equipped with Belkin Voice Recorders, to over 1600 entering first-year students. The students academic uses of these devices include course content dissemination, classroom recording (audio data), field recording (audio data), study report and file storage/transfer. The project included a diverse set of courses, such as English, Music, Spanish, Info Science/Info Studies, Theater Studies, among others. The final year report [9] comments the benefits and the difficulties of using this technology on a wide population of university students, with a very positive feedback. The benefits include, more independence of physical course materials, spatial and time access independence to the materials, effectiveness and easiness on using digital audio recording, student engagement and interest in discussions and enhanced support for individual learning. On the other side, the barriers included difficult integration of multiple broadcast systems with some particular infrastructure, software license limitations, limitations of the iPod device, limited documentation, insufficient quality of the recordings for some contexts and lack of knowledge about device functionalities.

2.3.1.3 Ketter, Mertens, Morisse & Vornberger Study

The advantages and disadvantages of using mobile technology in learning environments are discussed in this interesting study [25]. The study describes a prototype implementation of a workflow to support e-learning content on different mobile devices. The article presents a set of requirements and facts for e-learning on mobile devices, which includes the short usage times, the fast and precise access to learning material, the easiness of use, the media support and the additional benefit perspective, by augmenting e-learning environments. The study also describes three main purposes for using mobile devices on education, which can be organizational, communication and learning purposes. The article presents a media production chain using the Web as a medium to broadcast high quality lectures and as a platform to broadcast lectures for different mobile devices. The study combines the virtPresenter, PowerPoint-based application for recording lectures, with podcast technology, creating an automated workflow for a multi-channel lecturer recording.

2.3.1.4 Discussion

The iPod and other mobile devices can help students learn by allowing them to access lecture material when and where they want. This material can be recorded audio or video, or presentation slides. The small screens, which is a characteristic of theses devices, lead to improvements of multimedia interfaces and visualization. This dissertation explores how can the iPod devices can be used to view video recorded lectures.

2.3.2 Tablet PCs

The Tablet PCs (using Pen-Based technology) are not new, but presently have the same design and physical characteristics of laptops, making this technology quite portable.

2.3.2.1 MIT iCampus

The MIT iCampus [22] project is a partnership between MIT and Microsoft Research with the aim of transforming the high education practices using and developing information technological tools. The use of Tablet PCs on the International Design Contest (IDC) [30] and the two sub-projects, the iLabNoteBook [23] and MagicPaper [3, 37, 41], from the iCampus [22] initiative, are good indicators that this technology has a lot to explore and contribute. The IDC [30] is a robot design competition, that in the 2002 edition gave 100 Acer TravelMate Tablet PCs to the participants, helping them in the collaborative and creative design process. The iLabNoteBook [23] project had a similar aim by using Tablet PC technology on laboratories, giving scientists and students an easy way to access and record digital media, including sketches made with Pen-based technology, on their workspace. In a different perspective, the MagicPaper [3, 37, 41] is a software tool to understand natural interaction, such as sketching, gesturing and talking in a natural way. In this project, traditional digitizing tablets were used, a Wacom tablet with an LCD-display drawing surface, and a Mimio whiteboard system. The system was tested by thirteen individuals, including computer science graduate students, computer programmers and an architecture student. The users evidenced that the system was easy to use, efficient and has a more intuitive approach. A positive aspect reported by the subjects was the ability to draw shapes with curves and lines without changing tools, while the system successfully recognized basic shape forms.

2.3.2.2 Moovl

The Moovl [32, 46] project shows that Tablet PCs are not restricted to university educational environments. This is an online drawing application with dynamic properties, allowing images to move according to simple rules of physics, as presented on Figure 2.22.

This application was programmed in Java and was tested in a primary school in inner-city of Bristol, by thirty one children of Year 3 (aged 7-8) and by thirty children of Year 1 (aged 5-6). The application was used to teach science and to develop “problem solving” skills in children. The children were highly engaged and motivated by using this application and delighted with

Figure 2.22 Moovl Interface

the possibility to animate their own drawings. The system interface was easy to understand, however, it needed some small corrections and all of the subjects recognized how to use the stylus on the Tablet PC. This prototype was developed for younger children and demonstrates the new possibilities open by the use of Tablet PCs in education (Figure 2.23).

Figure 2.23 Moovl Running on a Tablet PC

2.3.2.3 Classroom Presenter & Ubiquitous Presenter

The Classroom Presenter [4] and Ubiquitous Presenter (Web version) [45] applied the Pen-based technology on University educational environments for mobile and collaborative learning practices. Using the Classroom Presenter [4] students and professors can share solutions and answers during lectures, both using Tablet computers. The problems are presented to the students with Power-Point slides, which they use to solve it, as presented on Figure 2.24. The professor

receives all students responses and selects one or more to show to the classroom, and the lecturer has also the possibility to annotate the answers using the Pen-Based Technology. The system was tested on junior and senior undergraduate Computer Science courses, which included, Algorithms, Data Structures, Software Engineering, Digital Design and Human-Computer Interaction, and on one graduate level seminar. On the experience 20 HP TC1100 Tablet PCs were used. Most of the students gave a very positive feedback of the system, especially considering the ability to participate and contribute for the problem solving in a anonymous way, reducing the fear of being wrong.

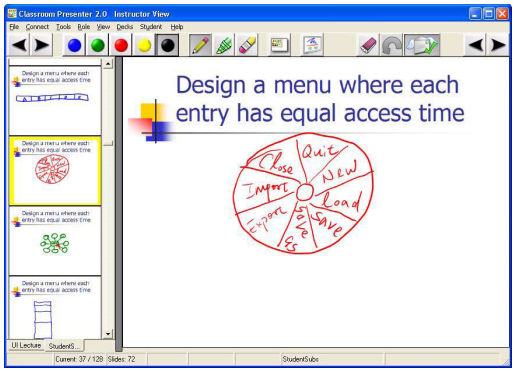


Figure 2.24 Classroom Presenter Interface Showing Exercises Solved by Students on Slides

Since the Classroom Presenter works over a specific network protocol, this causes a very restrict usage of the system. Therefore, the Ubiquitous Presenter [45] was developed with the aim to use a Web based network protocol which allows a wider access to the system. This Web extension allows one to access and annotate Classroom Presenter [4] materials using a Web browser. This application is based on a client-server architecture, programmed in PHP and Javascript, and can be accessed using the most popular browsers including, Internet Explorer, Netscape Navigator and Mozzila. Both applications, Classroom Presenter and Ubiquitous Presenter are synchronized using Simple Object Access Protocol (SOAP) remote procedure calls and the PHP GD library is used for composing ink with the slides. This application allows the students to make their slides submission via HTTP POST commands. In a recent article [19] related to the Ubiquitous Presenter, the Web is also presented as a mean to cross different platforms, like personal computers, laptops, Tablet PCs, PDAs, mobile phones and whiteboards.

2.3.2.4 Discussion

The Tablet PCs allow a more free and natural interaction with computer technology, particularly for computer sketching or writing. Pen-based technology helps students on tasks that involve problem solving, creative skills and on the understanding of their environment. This thesis explores pen-based annotations, using Tablet PCs, associated with media elements, like images or video.

Chapter 3

Architecture & Implementation

The system has a client-server architecture and allows different ways of access and interaction, with the aim to reduce temporal and physical constraints and foster the user participation. The implementation is divided in two projects, the VideoStore and the mEmLearn, both with Web and mobile developments. This chapter resumes both projects, describes the developments made on the different phases of each project and how the two are combined.

3.1 System Overview

The developed work has a client-server architecture complemented with a data module (Figure 3.1). The data module is composed by three submodules: (1) presentation slides, (2) video content and (3) annotations. The server is a single module to process the data. The client module is also divided in three submodules: (1) desktop, (2) iPod and (3) Tablet PC. All the client submodules are Web-based, with the aim to have an easier and wider access by the users. The Tablet PCs can give more freedom of writing and foster the interaction by the usage of pen-based technology. In addition, the iPod permits more temporal and physical independence by allowing the students to watch video lectures where and when they want. The desktop and iPod modules were developed on the scope of the VideoStore project and the Tablet PC as part of the mEmLearn project.

The annotations linked to video content, can be made using a desktop or a Tablet PC. The pen-based annotations, developed on the scope of the mEmLearn project, are divided in two types: (1) annotations over still images and (2) annotations over video content. The first type

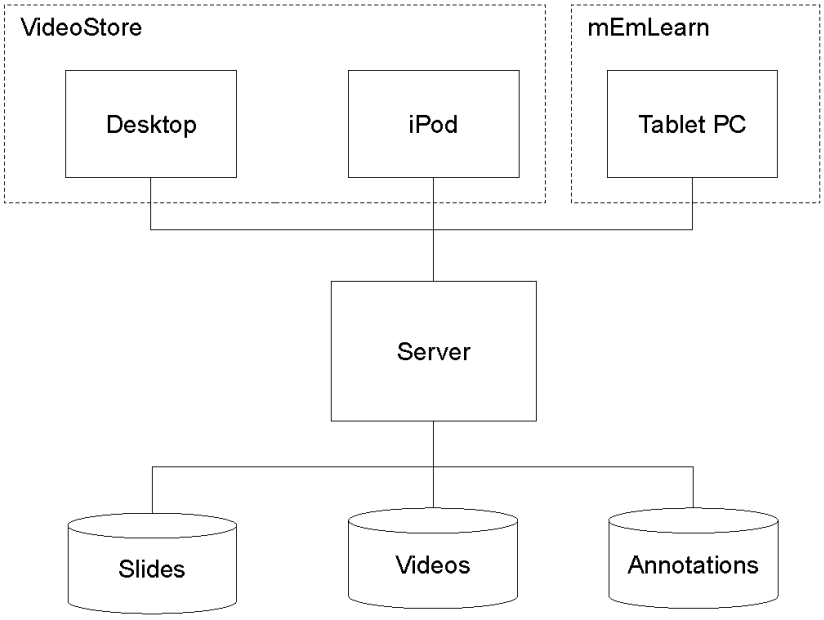
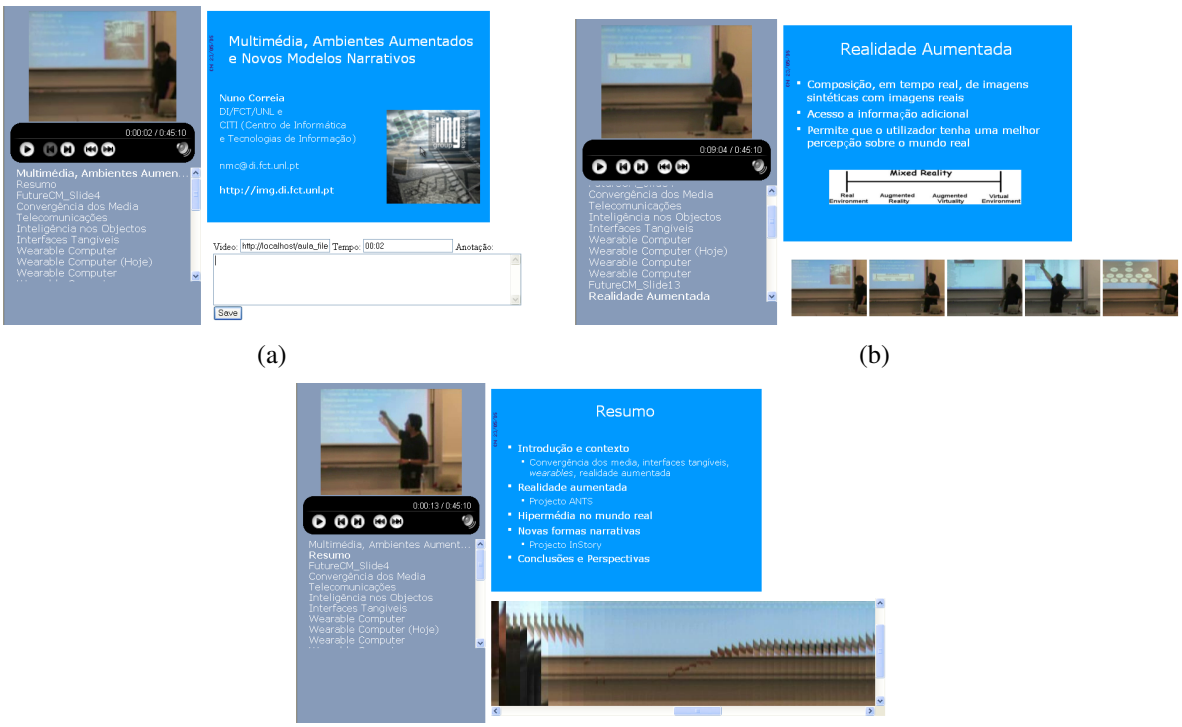


Figure 3.1 System Overview

was integrated with the VideoStore system and the second, due to technological constraints (see Section 3.3.3), were developed in a separated way. The video annotations and some of the video interfaces integrates information provided by the users promoting their interaction with system and fostering participative learning.

3.2 VideoStore

The VideoStore [10, 11, 13, 14] project had the aim to develop a Web-based learning system to store, transmit, search and share the contents of courses captured in video. The project was initially developed in the scope of the author BSc diploma project. In the end of the diploma project, a first prototype was concluded and the system architecture has reached a final form. The prototype included video, Power-Point slides and HTML synchronization done with MS Producer 2003, an authoring tool which generates a Web presentation; video annotations, using PHP5 features and XML databases; two video interfaces, VideoMosaic and VideoSpot; and video streaming. Both, video annotations and interfaces, were integrated, using PHP and Javascript, into the Web presentation generated by the MS Producer (Figure 3.2).



(a) (b)

(c)

Figure 3.2 VideoStore Initial Interface and Features: (a) Video Annotations (b) VideoMosaic (c) VideoSpot

Other technologies, like SMIL or the Camtasia Studio, were tested with the aim to integrate slides and video on the Web. The tools to produce SMIL material were complex and limited to expert users. The Camtasia Studio had a different approach by converting the slides into a video stream, which was not a flexible solution. The MS Producer 2003 proved to be the best solution, allowing to synchronize video, slides and HTML to integrate the system features on a final Web presentation, using Javascript. This tool also had a user friendly interface allowing less expert users to produce their own presentations (Figure 3.3).

The project also involved recorded lectures, and therefore, hardware equipment for video and audio recording was tested and chosen. With the aim to record lectures, a Canon MVX35i digital video camera and a wireless microphone pack Sony UWP-S1 were used. The wireless microphone had the aim to reduce the physical restrictions on the teaching process. A server machine, a Pentium 3,6GHz, with 4 GigaBytes of Ram and two harddisks with 250 GigaBytes each, was also used.

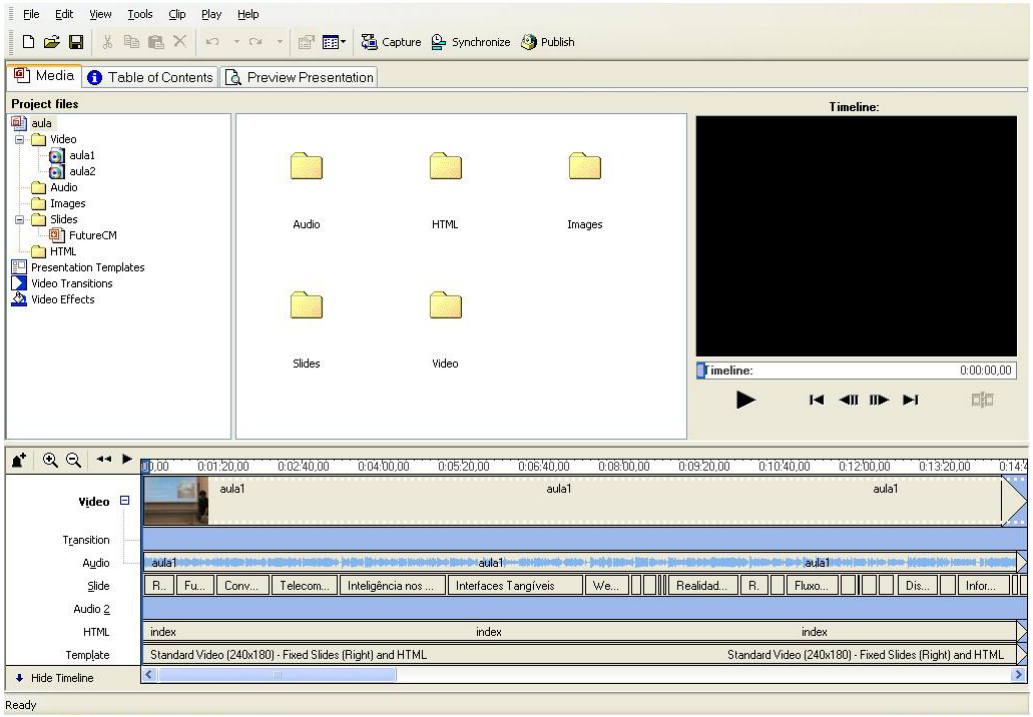


Figure 3.3 MS Producer 2003

3.2.1 Video Interfaces

The traditional VCR controls, like "rewind/fast-forward", are hard to use and do not provide any hints to find the content, therefore, an important focus was given to the video interfaces during the development of the system. Two interfaces were developed, the VideoLog and the Slide Thumbnail and an other two were improved, the VideoMosaic and the VideoSpot. The first two allow to browse the video based on external information, which can be related to its content, and the last two use frame content. All interfaces are synchronized with the video and the presented slides, which allows a user to click on the interface, corresponding to a particularly part of the video and to play it from that moment.

3.2.1.1 VideoLog

The VideoLog interface shows a graphical representation of the most watched moments of a video. When a user watches a video lecture, the streaming server registers which part of video the user watched. An application was developed to parse the log files generated by the server and retrieve the videos access times. A numerical map with the most watched seconds

of the video is created and transformed to a graphical representation (Figure 3.4). The colored columns represent the most watched parts of the video and the black columns the less watched. This interface allows a user to browse the video based on the content visualized by other users.

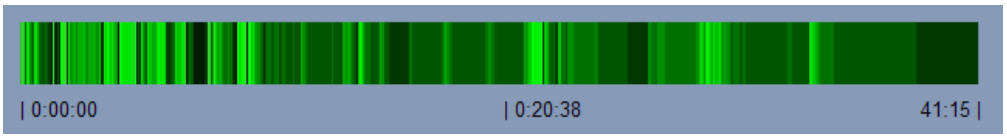


Figure 3.4 VideoLog Interface

3.2.1.2 Slide Thumbnail

The Slide Thumbnail interface shows all the slides presented in lecture. This interface displays a preview of the presented slides and allows to browse the video content based on the moments that each slides appears on the video (Figure 3.5).

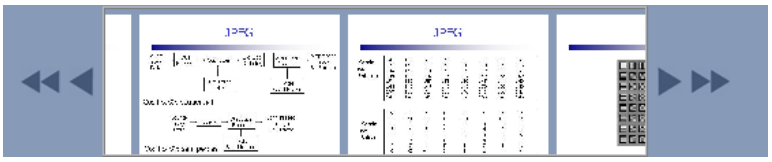


Figure 3.5 Slide Thumbnail

An application was developed to parse the Javascript files generated by MS Producer 2003 and retrieve the instants when each slide appears on the video. The Slide Thumbnail interface is generated by matching the slide, in the JPEG format, and the times retrieved from the Javascript files, using the images filename and their system path. In addition, an horizontal scroll mechanism with the images was developed, allowing the users to browse the slides from the beginning to end (right-to-left) and vice-versa, at two different speeds. This mechanism has the aim to provide to the users a more comfortable visualization of the interface.

3.2.1.3 VideoMosaic

The VideoMosaic interface is composed by sampling the video frames with equal time intervals, giving a global perspective of the video (Figure 3.6).

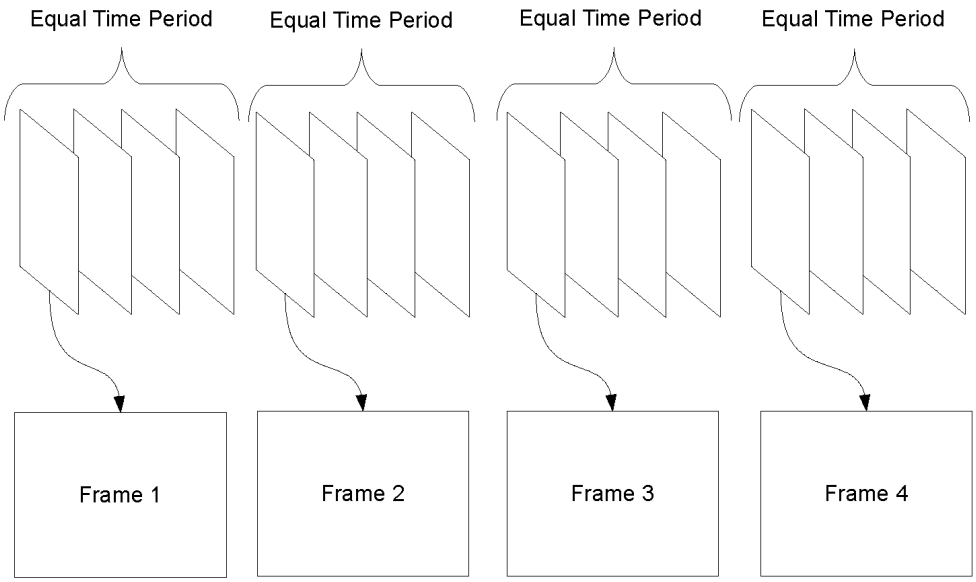


Figure 3.6 VideoMosaic Composition

The VideoMosaic was improved from the initial prototype (Figure 3.7) by the possibility to change the number of frames of the sample and by the changing the frame format, from the uncompressed BMP to the JPEG compressed format.

Figure 3.7 VideoMosaic Interface: Initial Prototype

These changes allow a better exploration of the video content by increasing the number of frames in the sample, reducing the occupied harddisk space and recuding the amount of data to transfer through the Web. In addition, the horizontal scroll mechanism referred in Section 3.2.1.2 was also implemented with the still images (Figure 3.8).

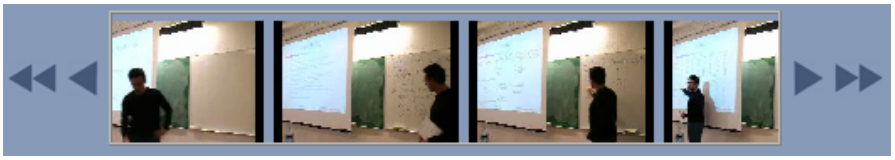


Figure 3.8 VideoMosaic Interface: Improved version

3.2.1.4 VideoSpot

The VideoSpot interface was inspired by the VideoStreamer[18] and has the goal to improve the visualization of video content changes. This interface is composed by a set of columns taken from the middle of each frame and placed together side by side (Figure 3.9).

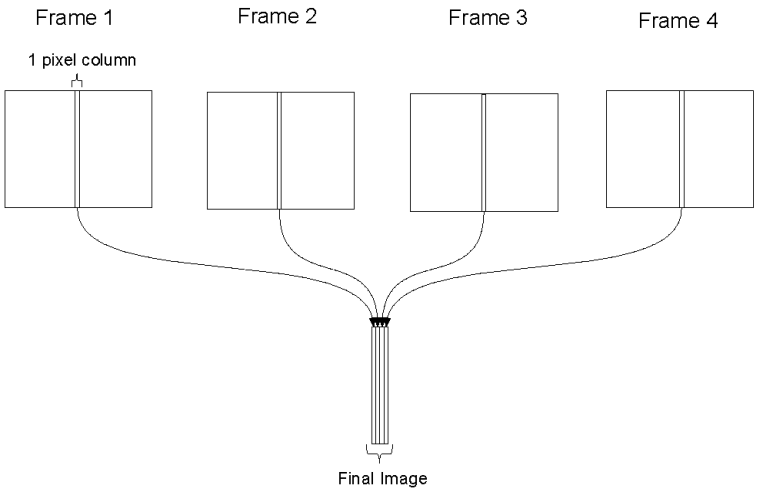


Figure 3.9 VideoSpot composition

The VideoSpot was improved from the initial prototype (Figure 3.10) by reducing the size of the columns to a width of 1 pixel and the final image was saved on JPEG compressed format.

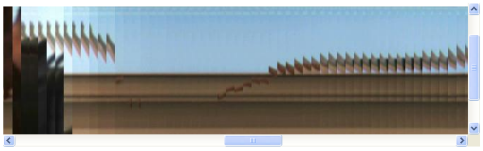


Figure 3.10 VideoSpot Interface: Initial Prototype

Due to image processing library constraints of creating images with large dimensions, the final image was divided in a small set of images and displayed together side by side. In addition, the horizontal scroll mechanism referred in Section 3.2.1.2 was also implemented with the final images (Figure 3.11).

Figure 3.11 VideoSpot Interface: Improved Version

3.2.2 Video Annotation

The Video Annotation system allows the users to make notes and link each note to a specific moment of a video. The annotations are HTML based, allowing also annotations with images and hyperlinks, and are associated with a video by a time period (Figure 3.12). In addition, other features were introduced, including documents upload, sharing of annotations among system users and the ability to remove annotations.

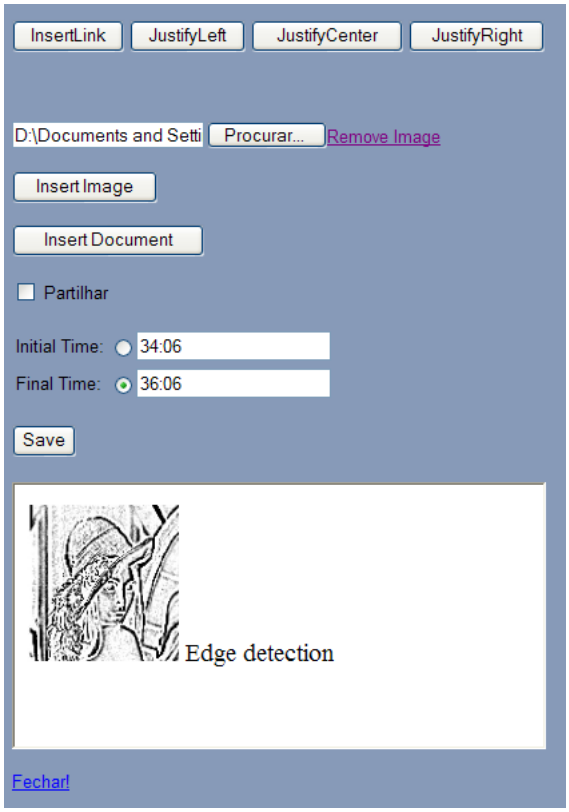


Figure 3.12 VideoAnnotation Interface

The interface is composed by a Javascript/Internet Explorer feature that allows to create HTML documents on Internet Explorer browser and by three sets of buttons, (1) to define an annotation time period, (2) to upload documents and images and (3) for text editing. The begin time of the period is set by default with the value of the video current time. The system has

two modes to visualize the video annotations: unsynchronized and synchronized. With the unsynchronized mode, the system shows all the annotations associated with the current video (Figure 3.13).

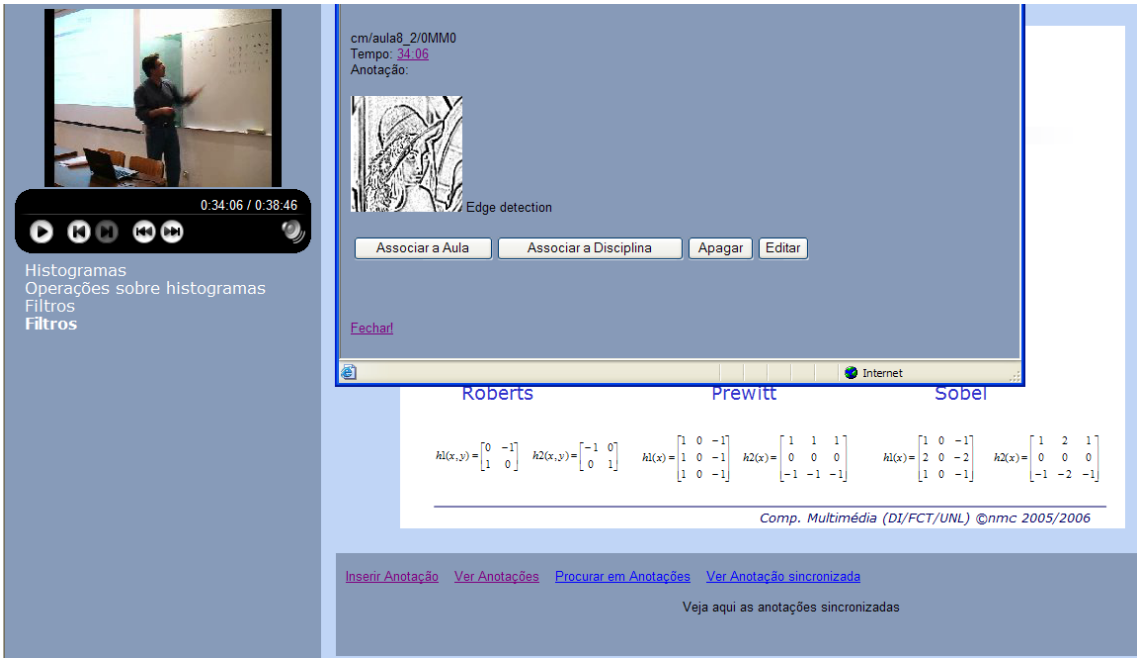


Figure 3.13 Unsynchronized Video Annotations

The synchronized mode shows the video annotations associated with the different moments of the video, while it is playing (Figure 3.14).

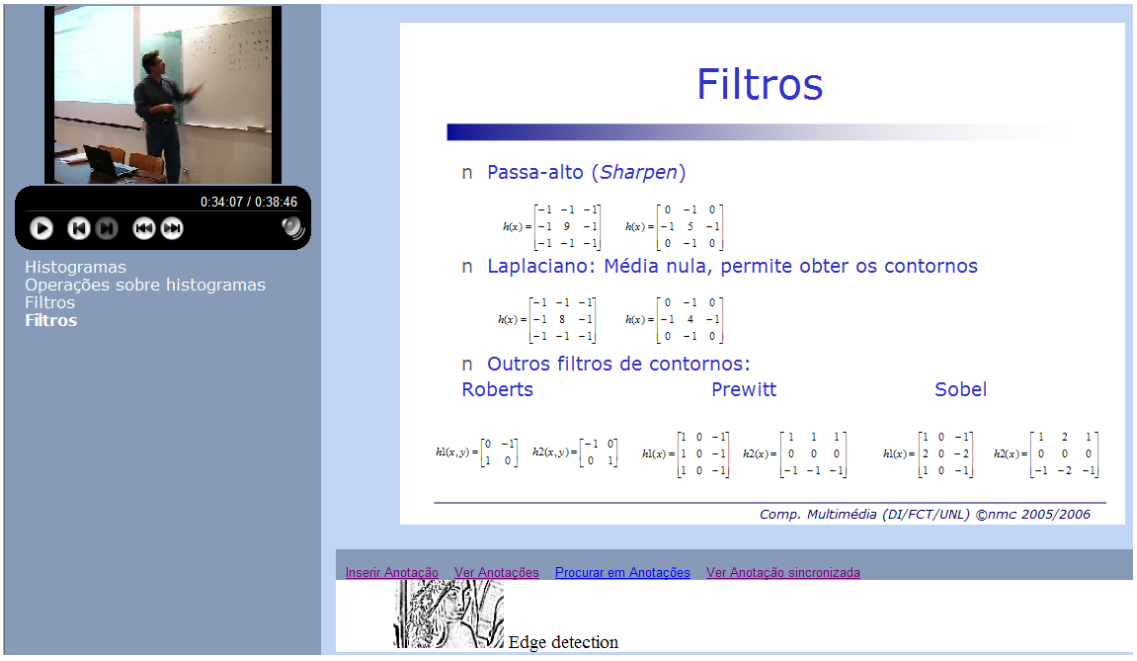


Figure 3.14 Synchronized Video Annotations

It is possible to search information on the video annotations using keywords (Figure 3.15 and Figure 3.16). The annotation system also support annotations associated with a lecture or a course, allowing the users to create notes independently of the video and linking to it at a later time. All annotations are associated with a given user and stored on native XML databases.

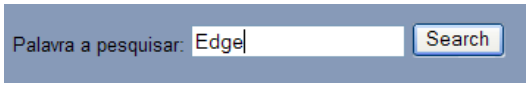


Figure 3.15 Video Annotations Search: Text Box

Figure 3.16 Video Annotations Search: Results

3.2.3 Video Podcast

The Video Podcast is a mobile approach of the VideoStore project and has the aim to podcast recorded video lectures. This feature allows the users to transfer recorded video lectures to an iPod device and watch them anywhere and anytime. However, the simple conversion of the recorded videos to the podcast format would cause an information loss, particularly of the slides presented by the lecturer (Figure 3.17), thus, an application was developed to combine the presented slides and the video stream (Figure 3.18).

The application uses the timestamps and the images of the slides, provided by the Slide Thumbnail interface (Section 3.2.1.2), and integrates the slides into the video. When a slide change occurs, the image slide appears on the video replacing the original video frames, during a certain period of time (Figure 3.19). Due to the usage of the WMV (Windows Media Video) format there were some constraints on the video editing process, which caused frame and audio gaps on the iPod video format.

Figure 3.17 Lecture Podcast: The Lecturer

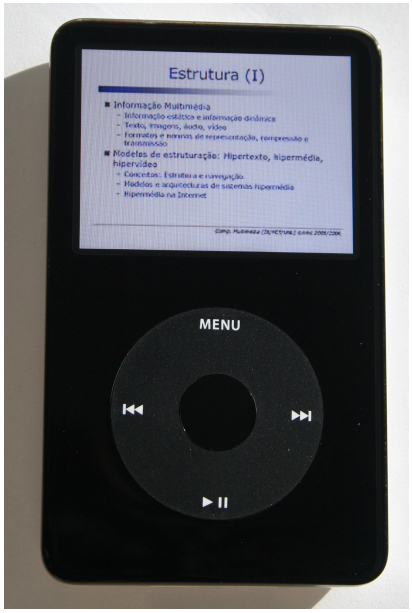


Figure 3.18 Lecture Podcast: Slide Image

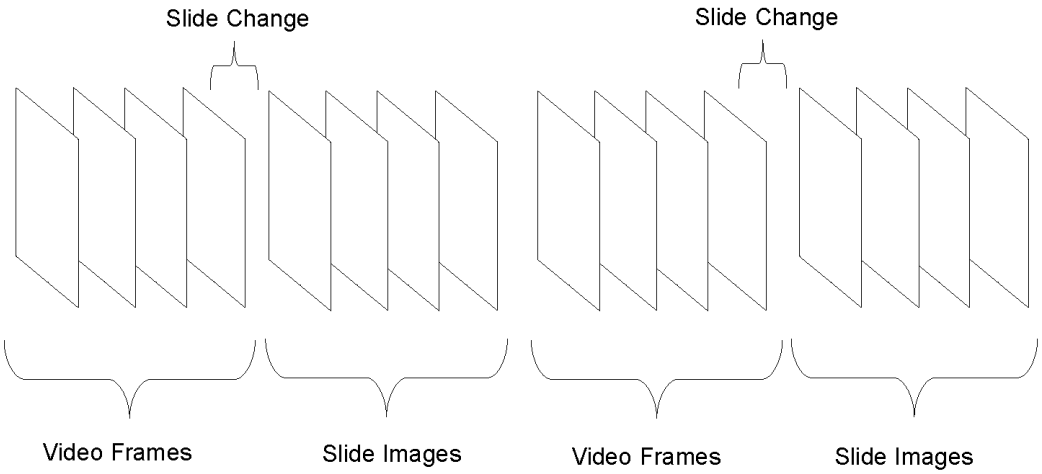


Figure 3.19 Podcast Video Composition

3.2.4 VideoStore Architecture and Modules

The VideoStore architecture is stable and it has enough flexibility to introduce future changes and new features. The system has a client-server architecture and the server has four modules: (1) data (video data, slides presentations and annotations databases), (2) data processor (authoring tool, hypertext generator and video processing applications), (3) web server and (4) streaming server. The videos and slides presentations are provided by the system administrator, which also manages the data processor module. The client has two modules: a web browser, a video player and the iTunes application (Figure 3.20).

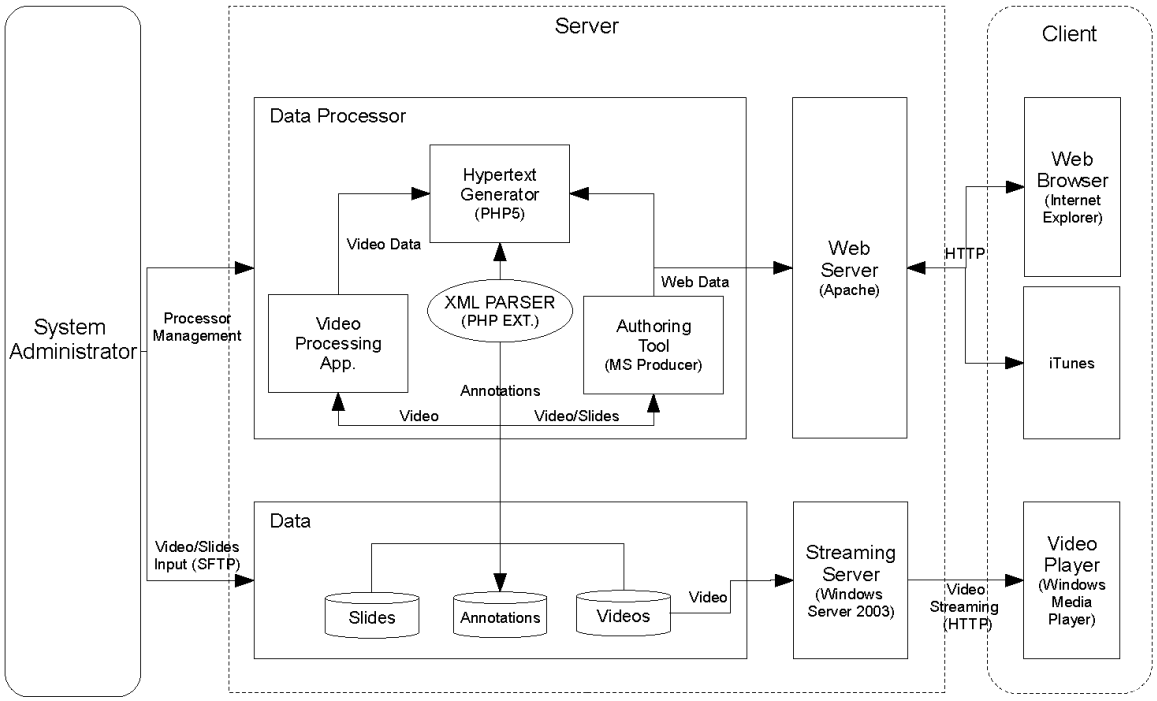


Figure 3.20 VideoStore Architecture

The lectures were recorded using one digital camera and a wireless microphone, as mentioned on Section 3.2. The camera was still during the lecture, to avoid disturbing the students and the lecturer. After class, video content was synchronized with the presented slides provided by lecturer, using the MS Producer. The media limitations of the architecture are caused by the use of Microsoft Producer, which generates a Web presentation, based on Javascript and DHTML. Most of the limitations are on the video format, the WMV, and on the users' browser, Internet Explorer or Netscape. Besides the synchronization between video and slides, the Microsoft Producer allows to synchronize HTML files, creating a way to integrate new features in the system. The design of the Web presentation generated by this authoring tool is supported by CSS (Cascading Style Sheets). The interfaces were developed in PHP 5 and Javascript in order to interact with the Microsoft Producer Web presentation. Video processing applications were developed with Microsoft .NET/DirectShow/Windows Media Services platform, to directly access the media files, and were combined with the OpenCV API for image format conversions and with the GD2 PHP extension to create Web graphical representations. The annotation system was implemented using XML and HTML trees. The XML tree allows the link between users, videos/lectures/courses and video annotations. Appendix A shows the XML schema for

the annotation structures. The recent PHP 5 features for XML were used, including the Object-Oriented parser called SimpleXML and the extensible DOM classes to manage the annotation system. Nevertheless, the XML extensions of PHP5 had some restrictions related to the insertion and the removal of data from XML files. Due to these constraints, three XML files are associated with each user, corresponding to video annotations, lecture annotations and course annotations. An extra XML file is used to save shared annotations.

The data is transferred from the server to the client by a Web server and a Streaming server. The system uses the Media Services of the Windows Server 2003 for the streaming broadcast and the Apache server for HTTP services. Due to network restrictions HTTP was also used as the streaming protocol (HTTP Encapsulated). The client can also the iTunes system to download, play and transfer the video to an iPod device.

3.3 mEmLearn

The mEmLearn project [10, 11] departs from the VideoStore framework to support Tablet PCs. This project has the aim to define tools that enable students to augment the course materials in an interactive way, during or after the classes, to retrieve these materials at a later stage and to share them with other students or instructors. The system includes a drawing Web interface that allows students to annotate and share course materials with Pen-based technology.

This section reports the tests and developments of the project, with the aim to explore the Tablet PC technology and the handwriting/drawing capabilities over media elements. The developments are divided in ink annotation over images and ink annotation over video, both on the Web.

3.3.1 Ink Annotations over Images

This feature allows a user to draw notes over images, on the Web. It is composed by two layers, the background layer and the foreground layer. The background is defined by the image where the user wants to add information and the foreground is the set of ink strokes, which compose

the annotation. The user can upload an image, draw notes over an image, using an HTML form, and save the annotation on the server (Figure 3.21). It is also possible to change the color of the ink and to remove all the ink strokes at once.

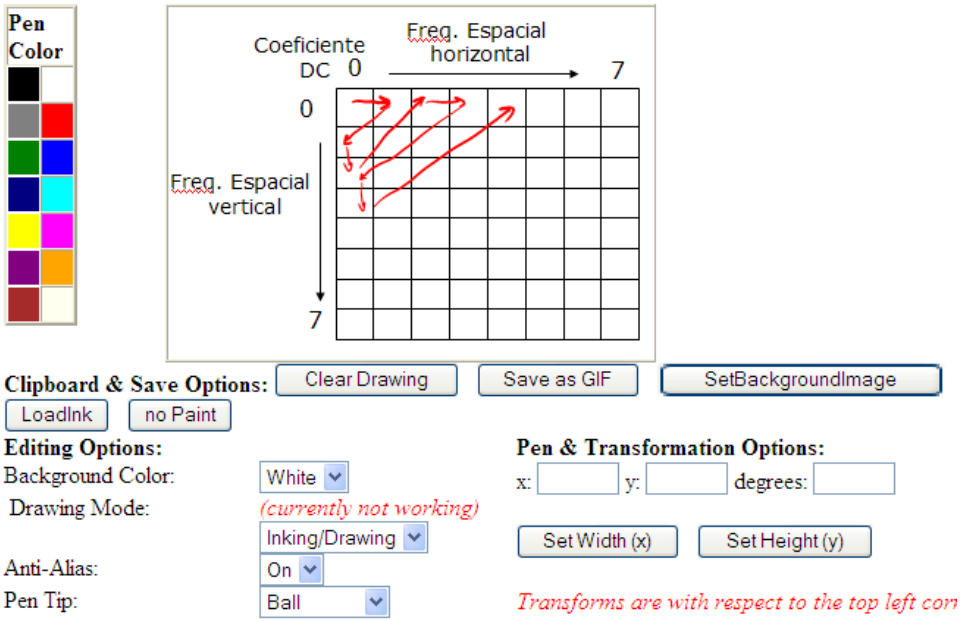


Figure 3.21 Ink Annotation Over an Image

3.3.2 Ink Annotations over Video

This feature allows a user to draw notes over a video, on the Web. The usage of video may introduce a dynamic perspective, which differs from the annotations over static images, based on time and motion. Nevertheless, the reported developments do not yet explore this dynamic perspective. This feature is also composed by two layers, the background layer is defined by the video where the user wants to add information and the foreground is the set of ink strokes, which composes the annotation (Figure 3.22). In addition, it is possible to remove all the ink strokes at once and to change the color of the ink. Currently, the video stream is provided by the system administrator, but in the future it should be provided by the users.

Figure 3.22 Ink Annotation Over a Video

3.3.3 mEmLearn Architecture and Modules

The mEmLearn project also has a client-server architecture and the initial prototype used the VideoStore platform. The server is divided in four modules: data (images, videos and annotations), data processor (hypertext generator and authoring tool), web server and WebInkControl. As mentioned, the videos are provided by the system administrator, which also manages the data processor module. The client is composed by a web browser (with Flash Player) (Figure 3.23).

The WebInk/Drawing Control [1], a C# application based on the Microsoft Windows XP Tablet PC Edition SDK 1.7, was embedded on the VideoStore system as an HTML form. The WebInk/Drawing Control allows one to draw annotations using pen-based technology and the application was changed to permit annotations over images. The ink strokes, which compose an annotation, and the filename of the background image are stored in a XML file. Nonetheless, the C# cannot integrate video on the Web. Considering this restriction, other technology was adopted, Adobe Flash CS3, with the aim to develop an application which allows to draw annotations over a Web video.

[1] `http://www.codeproject.com/KB/mobile/webinkctrl.aspx`

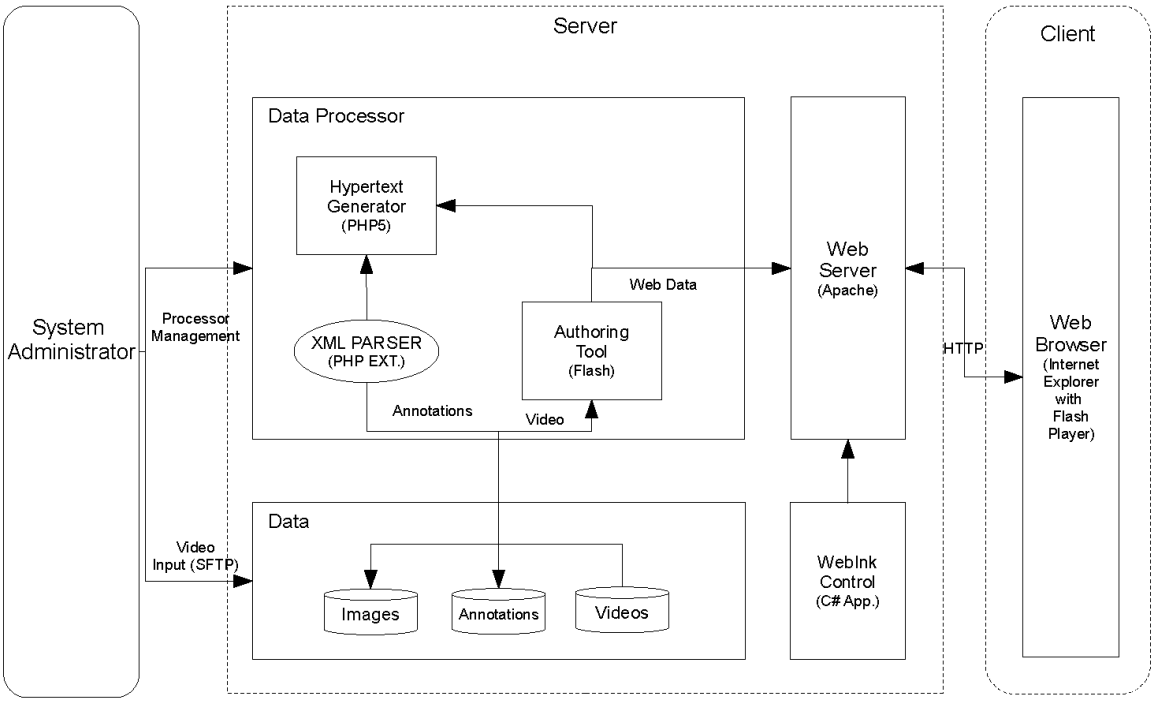


Figure 3.23 mEmLearn Architecture

The first Flash developments had good results, consequently this technology is the primary development platform to the mEmLearn project. Nevertheless, other technologies maybe needed for further developments.

Chapter 4

Evaluation

The evaluation was divided into two tests. The first test focused on students evaluation about using the VideoStore system on a Masters course and the second test focused on the evaluation by a diverse group of users of both systems, VideoStore and mEmLearn.

4.1 Students Evaluation

On the first test (see Appendix B and Appendix C for questions and results), questionnaires were made to thirty-six students of the Multimedia Computing Masters course of which 75% used the VideoStore system against 25% that preferred not to use it (Figure 4.1).

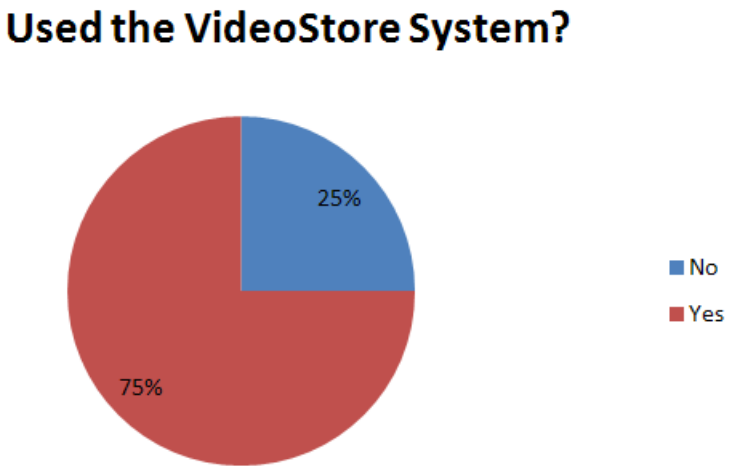


Figure 4.1 VideoStore Usage on the Multimedia Computing Course

For the 27 students that used the system, 3,7% used it just for following lessons against 77,8% that used it just for studying for the exams and 18,5% that used it for both activities (Figure 4.2).

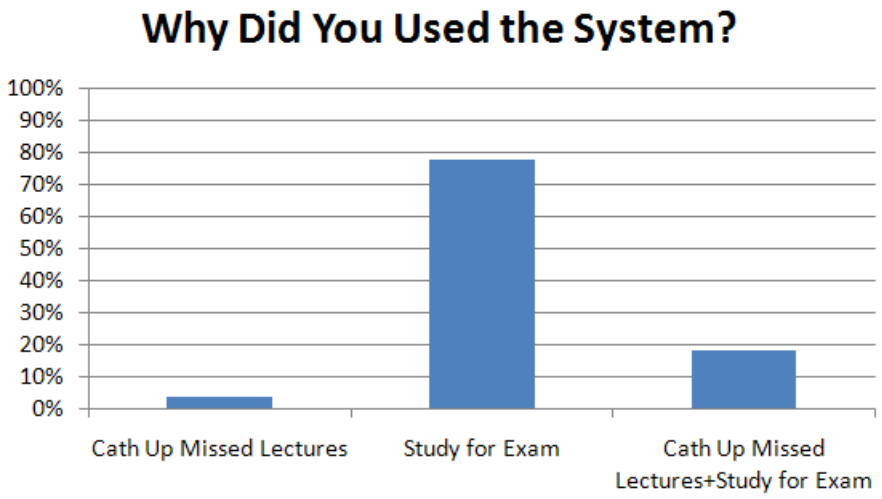


Figure 4.2 Why Did the Students Use the System

The most popular interface was the Slides Thumbnail, with 74% students using it and all rating it between reasonable to highly functional. The other interfaces attracted between 14,8% and 33,3% of the users (Figure 4.3). The preference for the Slide Thumbnail indicates that the video content and the video interfaces should be improved in the future.

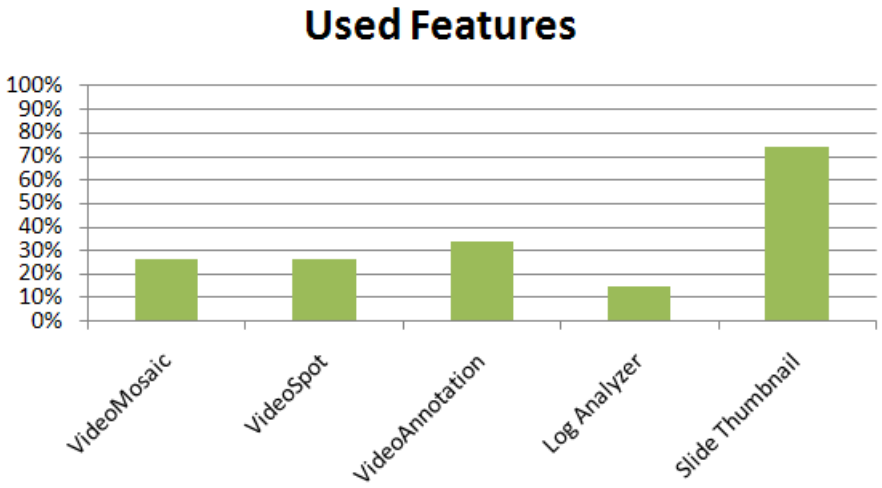


Figure 4.3 Features Used by Students

Most students, 70,3%, accessed the system from home, while the accesses using the different university networks were between 37,6% and 48,1%. It is interesting to observe that the wireless university network had more success, with 48,1% of the students using it, while the two wired university networks had 40,7% and 37,6% of the users (Figure 4.4). These results show the importance of the development and the use of mobile learning technologies.

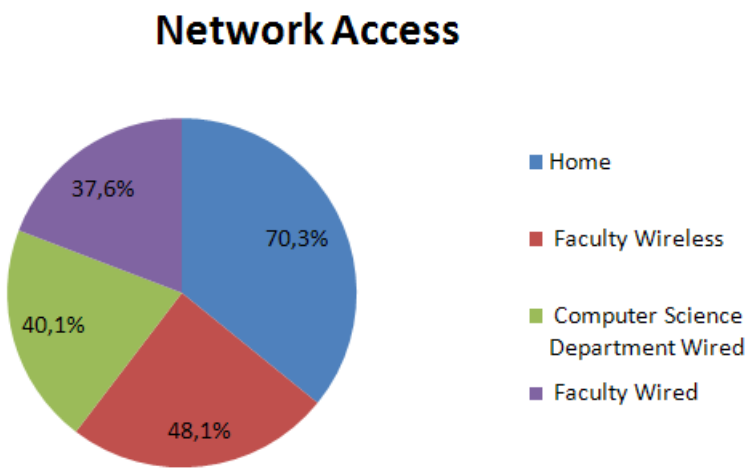


Figure 4.4 Network Access

Regarding the quality of the audio and video, 48,1% of the students gave a good score to the video quality and 44,4% gave a reasonable score to the quality the audio. There was some problems with the audio quality on the first lectures, but on the second half of the semester the problem was corrected.

The Internet Explorer was the most used browser, with 77,8% of the students using it against the 22,2% of the students that used Mozilla Firefox with the Internet Explorer Tab extension. The use of Internet Explorer is a constraint imposed by Microsoft Producer 2003, and the possibility to use Mozilla Firefox was available only at the end of the semester. Therefore, a new evaluation can provide more precise information about this issue. When asked how positive was the contribution of this system to the learning experience, 66,6% of the students answered between very and highly positive and 25,9% answered just positive (Figure 4.5).

It was asked the students for free opinions about the system and the most common request among the users, with 33,3%, was to register the lecture notes made on the board during class. This board usually appeared on the video lecture but without enough detail to be read. The difficulty to see the board on the video can be a strong reason for the low usage of the video interfaces. This problem should be solved by using a SmartBoard on future lectures, as described in the last section of the dissertation.

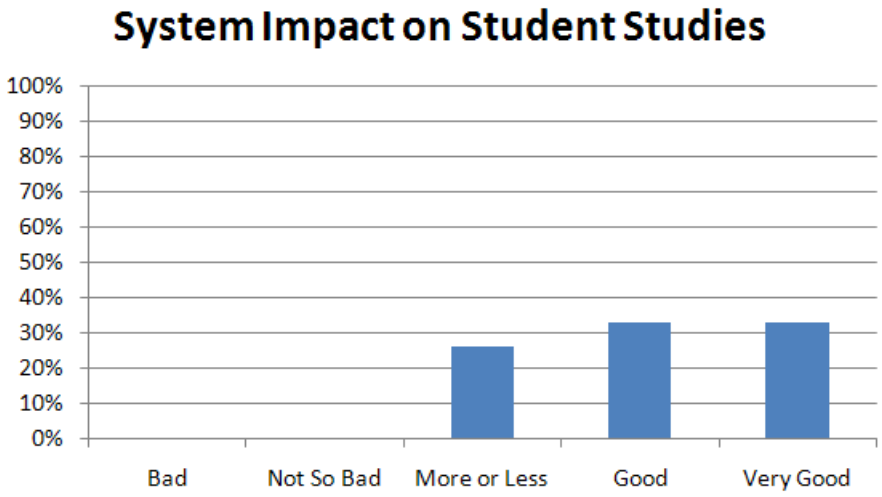


Figure 4.5 VideoStore Impact on Student Studies

4.2 Global Evaluation

In the second test, 10 diverse users (with different ages and with different professional activities) also answered a questionnaire, evaluating features from both systems, which included the interaction using pen-based technology (see Appendix D and Appendix E for questions and results). The user ages were between 21 and 37 years old, with 90% in the range from 21 up to 29. Half of the users were male, all of them were right-handed and at least half had no experience with pen-based technology.

Most of the users, 70%, frequently take notes at meetings, seminars or conferences and 80% watch videos on the Web, which shows the importance of Web video and video annotation. More then half of the subjects, 60%, watch videos on the Web related with their professional activities with some regularity against 30% of them that almost never and 10% that never watch this type of videos. Three tasks were proposed to the users, two related with video interfaces and one related to video annotation. It was also requested the use of the pen from the Tablet PCs as much as they could.

On the first task, it was asked to the users to find a specific information on a recorded lecture using the VideoStore system. Half of the users intuitively chose the slide topics, generated by MS Producer, to try to find the information. The evaluation of the results of the search using this interface were controversial, as 60% rated good against 40% which rated quite bad. Some

of the users, 30%, chose intuitively the Slides Thumbnail interface for the same task and all of them classified the results as good or excelent (Figure 4.6).

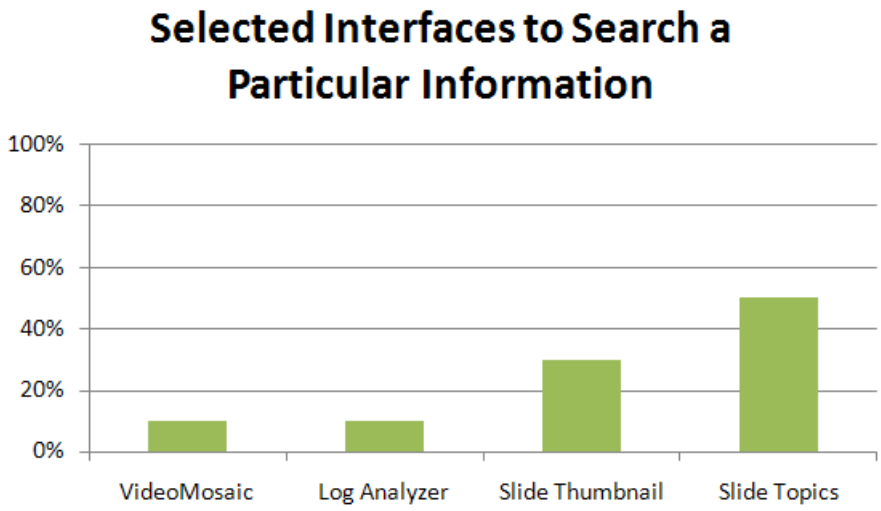


Figure 4.6 Selected Interfaces to Find a Specific Information

When it was asked to the users to use the VideoMosaic interface for this task, 70% of them evaluated the results as bad and quite bad (Figure 4.7).

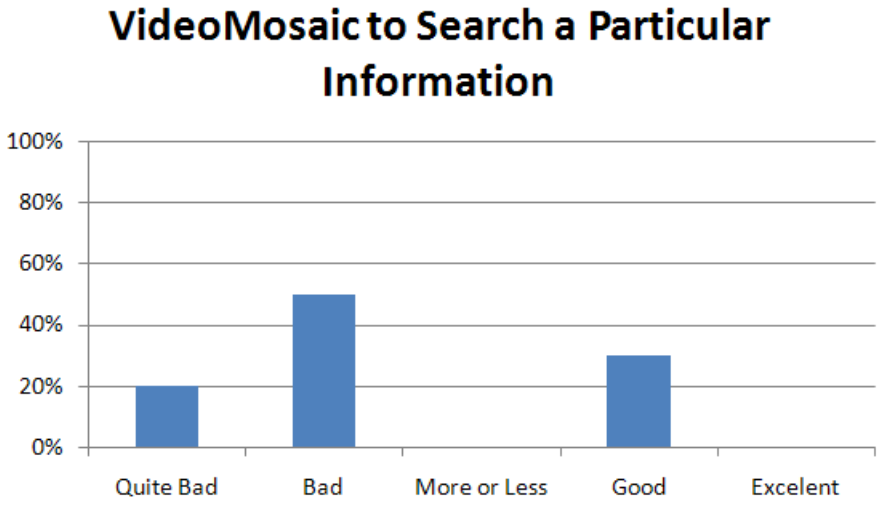


Figure 4.7 VideoMosaic to Find a Specific Information

The usage of the Slide Thumbnail interface for the same task gathered very positive results, 70% of the users classified the search results using this interface as good and excellent (Figure 4.8). 40% of the subjects did not find any difficulty to accomplish this task and 40% found difficulties in using the interfaces. The results of this task can be related to the video content,

which was very static, resulting on the users need to have additional information to browse the lecture content.

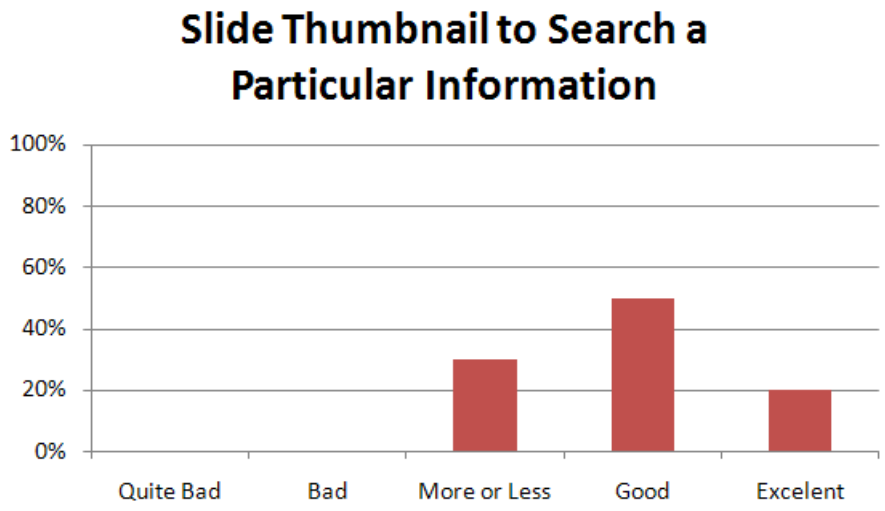


Figure 4.8 Slide Thumbnail to Find a Specific Information

After, it was asked the users to find the lecture highlights, 40% of the users intuitively chose the Log Analyzer interface, 20% the MS Producer slide topics and 20% the VideoMosaic (Figure 4.9). All users were satisfied with the results of each of the chosen interfaces.

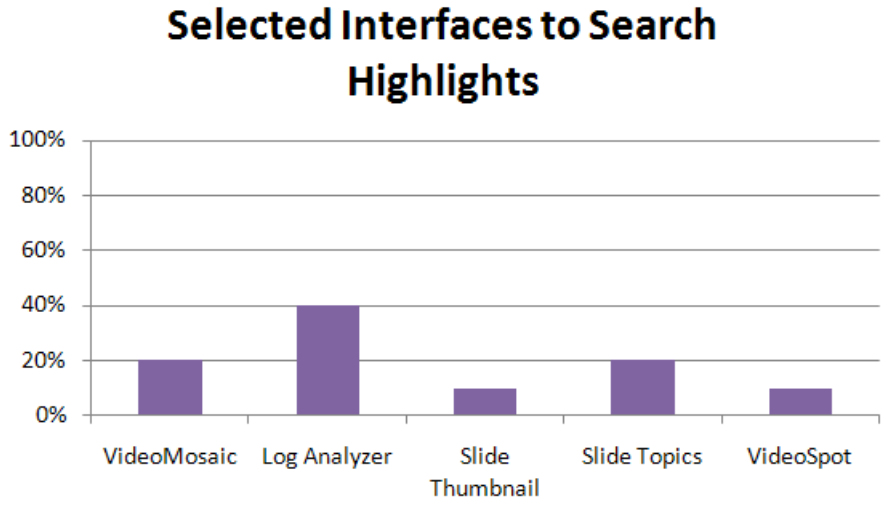


Figure 4.9 Selected Interfaces to Find Highlights

When it was asked to use the VideoSpot interface for the same task, all users classified the results as bad, with 40% of the users rating it as quite bad (Figure 4.10).

The Log Analyzer interface was classified as the best interface for this task, with 90% of

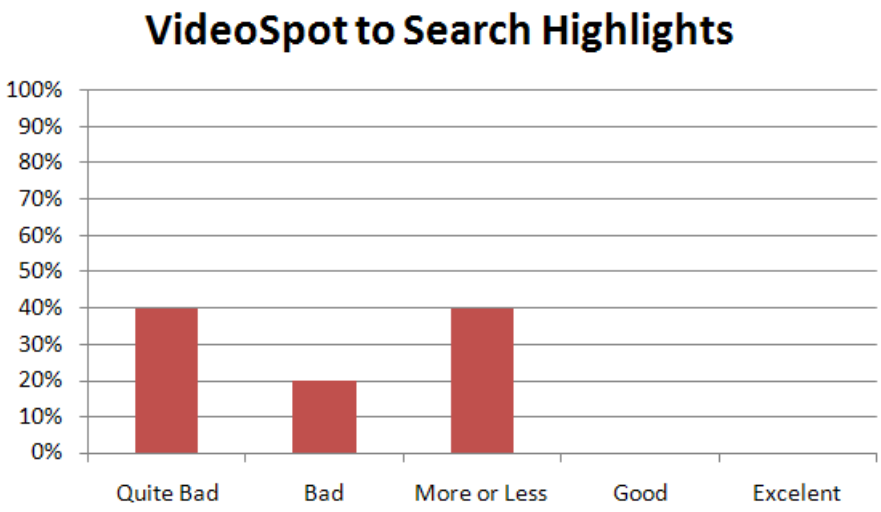


Figure 4.10 VideoSpot to Find Highlights

users satisfied with the results (Figure 4.11). It was also asked to the users to suggest other methods that could be useful to find the video highlights: 40% of them suggested a text based search, 20% would like to have more content rating (e.g., slides rating) and 20% said that the combination of the different techniques could help on this task. The results of this task denote the importance of content rating and keywords to find content hightlights and showed the difficulty to understand the information retrieved by the VideoSpot interface.

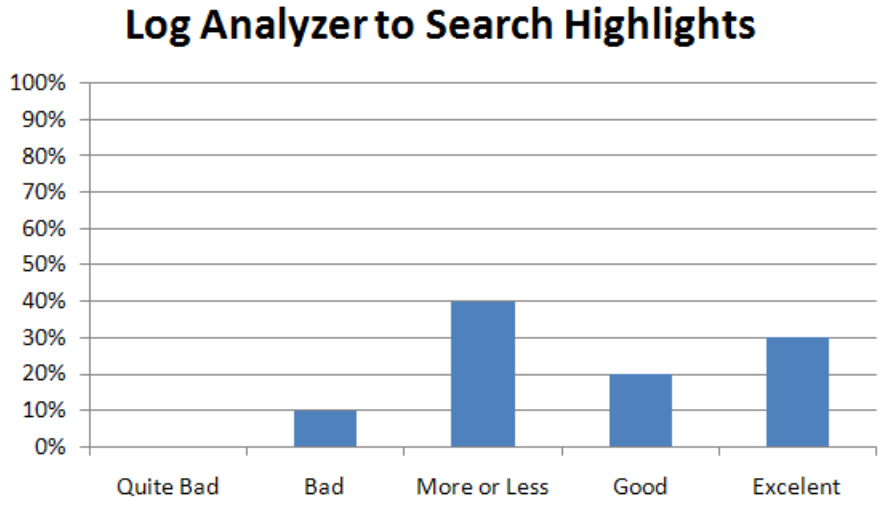


Figure 4.11 Log Analyzer to Find Highlights

On the last task, it was asked to the users to input annotations in the system in three different ways, (1) using the keyboard, (2) using the pen over a static image and (3) using the stylus over a

video recorded lecture. This task had the aim to evaluate the annotation system and the usage of pen-based technology as an interface to input information. All users found no difficulty on the keyboard based annotation and 30% denoted some inexperience using the pen to annotate over image and video. Most of the users, 80%, gave a positive feedback using both input interfaces, keyboard (Figure 4.12) and pen.

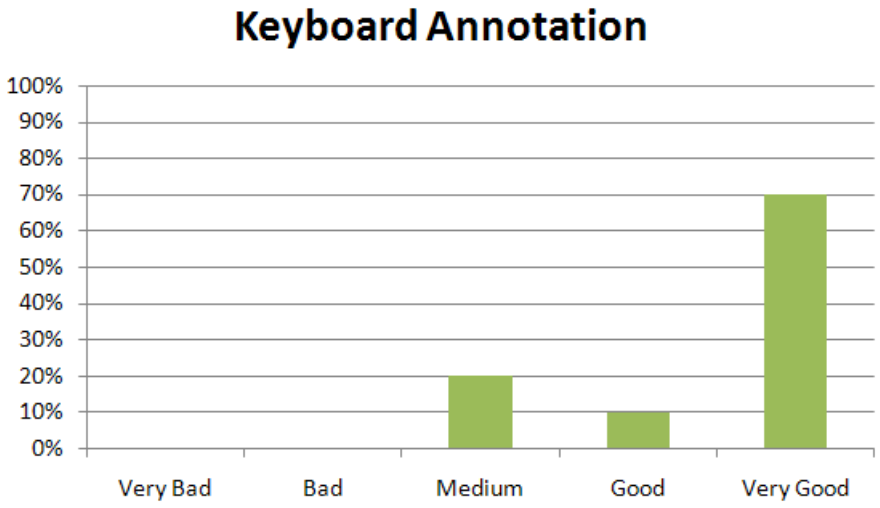


Figure 4.12 Evaluation of Keyboard Annotations

Nevertheless, 70% of the users rated the keyboard interaction as very good and only 40% gave the same classification to the pen (Figure 4.13), which can be explained by the inexperience with this last technology.

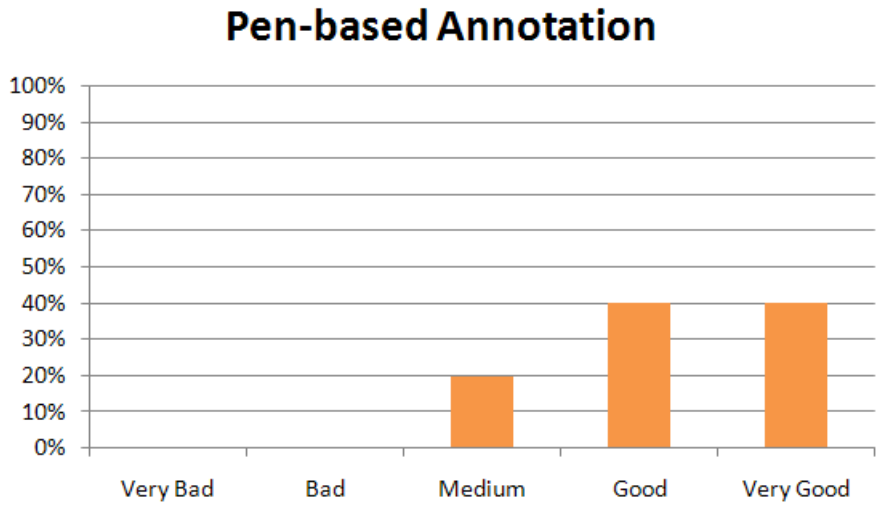


Figure 4.13 Evaluation of Pen Annotations

When the users were asked if they would like to share annotations among them, 70% said they would do without imposing any restriction, 20% suggested users restrictions and 10% recommended annotations restrictions. The users were asked to suggest extra features for pen-based annotations and 20% of them said that they would like to have the ability to remove parts of the annotations (like a common rubber) and 20% said that they would use more the annotations over the image. This task showed that the users liked to use the pen as an input interface (even though they presented some inexperience with this technology) and the importance of a good policy of note sharing.

On a global evaluation of both systems, most of users, 70%, totally agreed that it was easy to learn and use the system and most of them, 80%, found the information retrieved by the system useful. Almost all users, 90%, enjoyed the aesthetic of the system interface and most of them, 80%, thought that the pen-based technology improved their interaction with the system. All users said that they would use this system on their work and almost all, 80%, will use the pen-based annotations over images and video.

During the evaluation process it was observed that most users tried to use more than one interface for the same task and the constant changing of two pens (one digital and one regular to answer the questionnaire) can lead to some mistakes. After the tests, some informal discussion was made with the users, which revealed that most users correctly understood the Log Analyzer interface, the brighter green representing the most watched moments. Some users would also like to have dynamic interfaces, particularly the Slides Thumbnail and the Log Analyzer, which would move synchronized with the video content. A timeline interface was also suggested as a way to navigate through the lecture content. The users reported some inexperience with pen-based technology, nevertheless, they gave a positive feedback using this technology, particularly on cases in which the use of the keyboard or the mouse make the task difficult, such as, free sketching or writing mathematical formulas. In this informal discussion all users said that they would like to access all their courses using this system.

Chapter 5

Conclusions and Future Work

This dissertation shows that the developed tools can achieve a high percentage of usage because they are perceived as being very useful to catch up on missing lectures and to study for exams. This success makes clear the importance to continue developing these technologies and provide better and more effective interfaces. The VideoStore project was concluded and a system prototype has reached a final form, giving a stable base for further projects.

The recording equipment was sufficient for the project needs and had the advantage that it could be managed only by a single person. Nevertheless, two restrictions can be reported regarding this hardware. The video recorded by the digital camera, directly to a memory card, facilitates the transfer process but presents a low-resolution, and the wireless microphone power batteries can end in the a middle of some lectures, causing its interruption or the loss of audio data.

The Microsoft Producer 2003 is considered a good tool to produce and synchronize media elements but introduced some technological constraints in the project. The MS Producer 2003 forced the use of the WMV video format and the Internet Explorer browser, thus reducing the number of tools that could integrate the project.

The usage of a native XML database was a good solution to store the data and the time response of the system was not a problem. Nevertheless, it is always possible to migrate from this technology to a database server with SQL. The extensions of PHP5 to manage XML files, simplified the parsing but introduced some constraints on adding and removing elements of the existing structure. These restrictions caused the need to split the data in different files, which should be simplified by using a single file associated to each user. The improvement of the PHP5 extensions can simplify the system.

The video interfaces should be further studied in the future, with the aim to explore better ways to browse and search information on a video stream. The interfaces are implicitly linked to the content: to know what users want to watch and want to search is crucial to improve both the content and the access interfaces. The answers to these questions also depend on the video context. In this work, the recorded content was very static and its most relevant parts were related to the presented slides, the lecturer speech and his notes. The most popular video interfaces were those which combined the video content with other types of information. In the case of the Slides Thumbnail interface, the video content is browsed on the presented slides and the Log Analyzer allows to navigate the video based on what other users have watched previously. The video content could be improved by using a SmartBoard to record the lecturer notes written on the board. Due to logistical problems it was not yet possible to integrate this technology on the VideoStore project.

The video annotations can be very useful but the interfaces should have less constraints. The interface improvement tried to reduce these restrictions but some still remained. The video annotations should work off-line and should not be limited to written text using a keyboard. The usage of pen-based technology in this matter can play an important role.

The podcast of video, combined with slides, can be a good feature for students as the evaluation indicates the high percentage of accesses from home and the high percentage of usage of wireless networks. The resizing of slide images for the iPod screen caused a loss of information, making some slides unreadable. Therefore, it is important to use slide sizes and text fonts that can be understood in small screens. The video format used plays also an important role and it can restrict the video editing tools and increase the complexity of the editing process.

In the mEmLearn project different technologies were used. The Microsoft Windows XP Tablet PC Edition SDK 1.7 presents limitations for Web features and the Adobe Flash CS3 is a better platform for this type of developments. Nonetheless, both technologies should be combined in the future, reducing the constraints of each. The mEmLearn first prototype has some limitations, but it can be considered a good platform for future developments. The ability to use pen-based technology can reduce the keyboard restrictions and allows to control and add information to video content in a more natural way.

The evaluation made on this work gave initial users feedback and helped to understand some of their problems and needs when using the system. The users from both evaluation tests found the VideoStore and mEmLearn applications useful and relevant. Features like the usage of a SmartBoard, video podcasting, a good policy for sharing annotations and pen-based technology can improve the system. Even though the users are more used to the keyboard, they found that the usage of pen-based technology can give them more freedom, particularly, for mathematical formulas and free sketching.

Future developments and tests should include other types of video content, with the aim to test other scenarios and the user feedback on each one. Future work should also involve pen-based video annotations with attributes, such as, a time period associated, motion tracking, replay, partial removal (rubber feature) of ink strokes, and dynamic video interfaces. On future evaluations, the users population should also include left-handed people, with the aim to study their feedback on using pen-based technology, and older people, who are known for having difficulty on the interaction with computer technology.

Annotations linked to media elements can promote participative learning, but to accomplish this aim, it is important to give the users the ability to express themselves in a more natural way and with less restrictions.

Bibliography

[1] ABOWD, G. D. Classroom 2000: an experiment with the instrumentation of a living educational environment. *IBM Syst. J. 38*, 4 (1999), 508–530.

[2] ALESSI, S. M., AND TROLLIP, S. R. *Multimedia for Learning, Methods and Development (3rd edition)*. Allyn and Bacon, 2001.

[3] ALVARADO, C. J., AND DAVIS, R. Preserving the freedom of paper in a computer-based sketch tool. In *Proceedings of HCI International 2001* (New Orleans, Louisiana, USA, August 2001), Lawrence Erlbaum Associates, Inc, pp. 687–691.

[4] ANDERSON, R., ANDERSON, R., CHUNG, O., DAVIS, K. M., DAVIS, P., PRINCE, C., RAZMOV, V., AND SIMON, B. Classroom presenter: A classroom interaction system for active and collaborative learning. In *Proceedings of the 1st Workshop on the Impact of Pen-based Technology on Education (WIPTE 2006)* (West Lafayette, Indiana, USA, April 2006), D. A. Berque, J. c. Prey, and R. H. Reed, Eds., Purdue University Press, pp. 21–30.

[5] BACKON, J. Student minds and pen technologies: A wonderful pedagogical marriage. In *Proceedings of the 1st Workshop on the Impact of Pen-based Technology on Education (WIPTE 2006)* (West Lafayette, Indiana, USA, April 2006), D. A. Berque, J. c. Prey, and R. H. Reed, Eds., Purdue University Press, pp. 1–12. Keynote Presentation.

[6] BAECKER, R., AND RANKIN, K. Open-source webcasting and media archiving software for e-learning. *ACM eLearn Magazine October 2005, Issue 10* (October 2005), 3.

[7] BAECKER, R., WOLF, P., AND RANKIN, K. The epresence interactive webcasting and archiving system: Technology overview and current research issues. In *Proceedings of World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2004* (Washington, DC, USA, 2004), G. Richards, Ed., AACE press, pp. 2532–2537.

[8] BARGERON, D., GUPTA, A., GRUDIN, J., AND SANOCKI, E. Annotations for streaming video on the web: system design and usage studies. In *WWW '99: Proceeding of the*

8th International Conference on World Wide Web (New York, NY, USA, 1999), vol. 31, Elsevier North-Holland, Inc., pp. 1139–1153.

[9] BELANGER, Y., AND MENZIES, D. Duke ipod first-year experience. Tech. rep., Duke University, June 2005.

[10] CABRAL, D., AND CORREIA, N. An enviromment for mobile learning supporting video lectures and annotations. In *proceedings of International Conference Mobile Learning* (2007), IADIS.

[11] CABRAL, D., AND CORRREIA, N. Mobile and web tools for participative learning. In *proceedings of International Conference e-Learning* (2007), IADIS.

[12] CHAMBEL, T., AND GUIMARÃES, N. Learning with video in hypermedia. DI/FCUL TR 01–16, Department of Informatics, University of Lisbon, December 2001.

[13] CORREIA, N., AND CABRAL, D. Videostore: A system to store, annotate and share video based content. In *proceedings of m-ICTE2005, The 3rd International Conference on Multimedia and ICTs in Education* (Badajoz, Spain, 2005), FORMATEX.

[14] CORREIA, N., AND CABRAL, D. Interfaces for video based web lectures. In *ICALT '06: Proceedings of the 6th IEEE International Conference on Advanced Learning Technologies* (Washington, DC, USA, 2006), IEEE Computer Society, pp. 634–638.

[15] CORREIA, N., AND CHAMBEL, T. Active video watching using annotation. In *ACM MULTIMEDIA '99: Proceedings of the 7th ACM international conference on Multimedia (Part 2)* (New York, NY, USA, 1999), ACM Press, pp. 151–154.

[16] COSTA, M., CORREIA, N., AND GUIMARÃES, N. Annotations as multiple perspectives of video content. In *MULTIMEDIA '02: Proceedings of the 10th ACM international conference on Multimedia* (New York, NY, USA, 2002), ACM Press, pp. 283–286.

[17] DAVIS, B. G. *Tools for Teaching*. Jossey-Bass, San Francisco, 1993.

[18] ELLIOTT, E., AND DAVENPORT, G. Video streamer. In *CHI '94: Conference companion on Human factors in computing systems* (New York, NY, USA, 1994), ACM Press, pp. 65–68.

[19] GRISWOLD, W. G., AND SIMON, B. Ubiquitous presenter: fast, scalable active learning for the whole classroom. *SIGCSE Bull. 38*, 3 (2006), 358–358.

[20] HILLS, P. J. *Teaching, Learning and Communication*. Routledge Kegan & Paul, 1986.

[21] HÜRST, W., AND GÖTZ, G. Interface issues for interactive navigation and browsing of recorded lectures and presentations. In *Proceedings of the AACE World Conference on Educational Multimedia, Hypermedia & Telecommunications (ED-MEDIA 2004)* (Jun 2004), C. M. Lorenzo Cantoni, Ed., vol. 2004, AACE press, pp. 4464–4469.

[22] ICAMPUS, M. http://icampus.mit.edu/, 2006.

[23] ILABNOTEBOOK. http://icampus.mit.edu/projects/ilabnotebook.shtml, 2006.

[24] JONES, M., AND MARSDEN, G. *Mobile Interaction Design*. John Wiley & Sons, LTd, 2006.

[25] KETTERL, M., MERTENS, R., MORISSE, K., AND VORNBERGER, O. Studying with mobile devices: Workflow and tools for automatic content distribution. In *World Conference on Educational Multimedia, Hypermedia and Telecommunications 2006 (ED-Media)* (2006), AACE press, pp. 2082–2088.

[26] LEE, H., AND SMEATON., A. F. Designing the user-interface for the físchlár digital video library. *Journal of Digital Information, Special Issue on Interactivity in Digital Libraries 2*, 4 (2002).

[27] MACKAY, W. E. Eva: an experimental video annotator for symbolic analysis of video data. *SIGCHI Bull. 21*, 2 (1989), 68–71.

[28] MAY, A. Web-based image and video navigation. Final year project report, Department of Computing, Imperial College London, June 2004.

[29] MAYER, R. E. *Multimedia Learning*. Cambridge University Press, 2001.

[30] MICROSOFT. Massachusetts institute of technology changes the face of education using tablet pcs. Tech. rep., Microsoft, November 2002.

[31] MÜLLER, R., AND OTTMANN, T. The "authoring on the fly" system for automated recording and replay of (tele)presentations. *Multimedia Syst. 8*, 3 (2000), 158–176.

[32] MOOVL. http://www.moovl.com, 2006.

[33] MUIRHEAD, B., AND JUWAH, C. Interactivity in computer-mediated college and university education: A recent review of the literature. *Educational Technology & Society 7*, 1 (2004), 12–20.

[34] NAISMITH, L., LONSDALE, P., VAVOULA, G., AND SHARPLES, M. Literature review in mobile technologies and learning. Tech. rep., University of Birmingham, Future Lab, December 2004.

[35] NYIRI, K. Towards a philosophy of m-learning. In *Proceedings WMTE 2002, IEEE International Workshop on Wireless and Mobile Technologies in Education* (Washington, DC, USA, August 2002), IEEE Computer Society, pp. 121–124.

[36] ON ITUNES, S. http://itunes.stanford.edu, 2006.

[37] PAPER, M. http://icampus.mit.edu/projects/naturalinteraction.shtml, 2006.

[38] RAMOS, G., AND BALAKRISHNAN, R. Fluid interaction techniques for the control and annotation of digital video. In *UIST '03: Proceedings of the 16th annual ACM symposium on User interface software and technology* (New York, NY, USA, 2003), ACM Press, pp. 105–114.

[39] RANKIN, K., BAECKER, R., AND WOLF, P. epresence: An open source interactive webcasting and archiving system for elearning. In *Proceedings of World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2004* (Washington, DC, USA, 2004), G. Richards, Ed., AACE press, pp. 2888–2893.

[40] REHATSCHEK, H., AND KIENAST, G. Vizard - an innovative tool for video navigation, retrieval, annotation and editing. In *Proceedings of the 23rd Workshop PVA 'Multimedia and Middleware'* (Vienna, Austria, 2001).

[41] SEZGIN, T. M., STAHOVICH, T., AND DAVIS, R. Sketch based interfaces: early processing for sketch understanding. In *SIGGRAPH '06: ACM SIGGRAPH 2006 Courses* (New York, NY, USA, 2006), ACM Press, p. 22.

[42] ÖSTLUND, C., AND SVENSSON, L. Designing web lectures, bridging design theory and educational practice through and inductive approach. In *Proceedings of 28th Information System Research in Scandinavia (IRIS 28)* (Kristiansand, Norway, August 2005).

[43] VAVOULA, G. N., AND SHARPLES, M. Kleos: A personal, mobile, knowledge and learning organisation system. In *Proceedings IEEE International Workshop on Wireless and Mobile Technologies in Education* (Washington, DC, USA, August 29-30 2002), IEEE, p. 152.

[44] WEHMEIER, S., MCINTOSH, C., TURNBULL, J., AND ASHBY, M., Eds. *Oxford Advanced Learner's Dictionary of Current English (7th Edition)*. Oxford University Press, 2004.

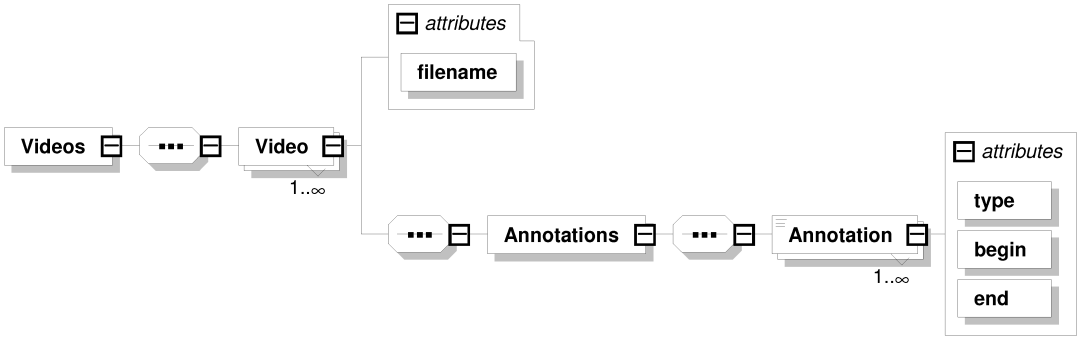
[45] WILKERSON, M., GRISWOLD, W. G., AND SIMON, B. Ubiquitous presenter: increasing student access and control in a digital lecturing environment. In *SIGCSE '05: Proceedings of the 36th SIGCSE technical symposium on Computer science education* (New York, NY, USA, 2005), ACM Press, pp. 116–120.

[46] WILLIAMSON, B. Moovl, a futurelab prototype research report. Tech. rep., Futurelab, UK, July 2004.

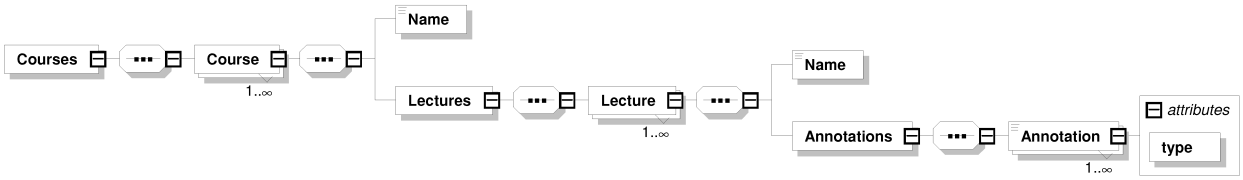
[47] YAMAMOTO, D., AND NAGAO, K. ivas: Web-based annotation system and its applications. In *ISWC2004: Proceedings of 3rd International Semantic Web Conference* (Hiroshima, Japan, November 2004).

Appendix A

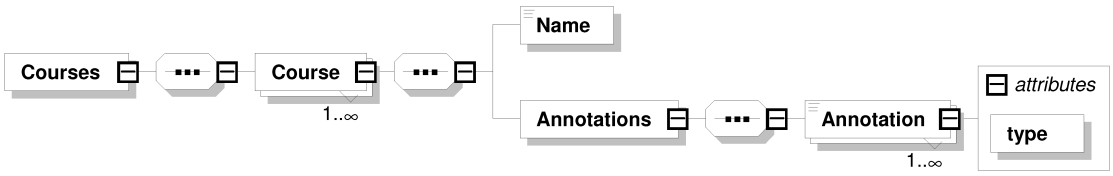
Annotation Schemas



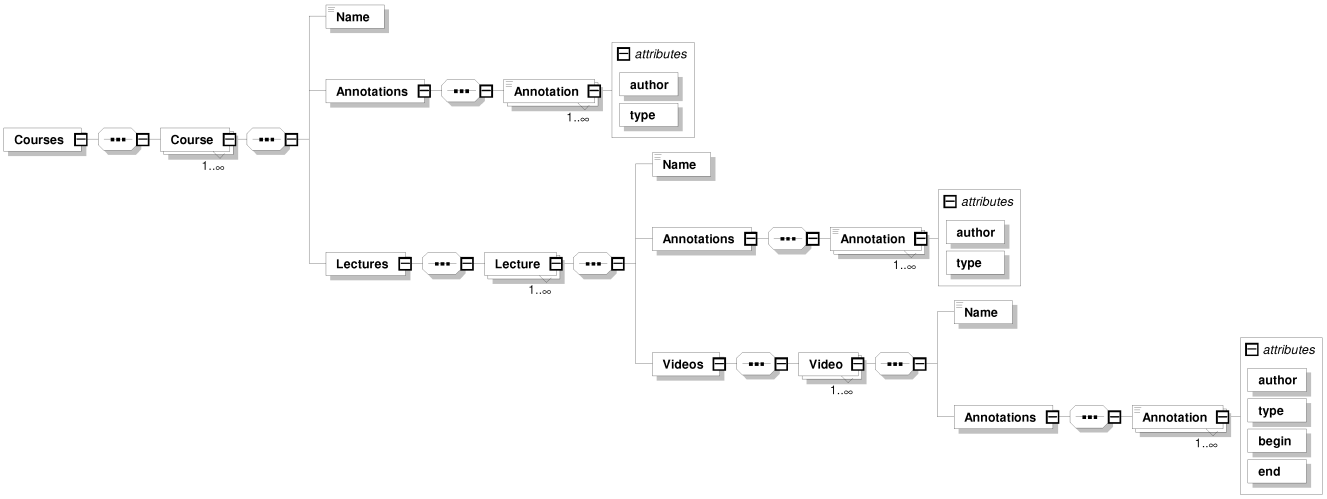
Video Annotations



Lecture Annotations



Course Annotations



Public Annotations

Appendix B

Students Evaluation Questionnarie

INQUÉRITO – VIDEOSTORE

1. Já utilizou o sistema?

   Sim: ☐
   Não: ☐

   (Se respondeu sim, continue a responder ao inquérito.)

2. Qual ou quais os objectivos de utilização do sistema?

   Acompanhamento das aulas: ☐
   Estudo: ☐

3. Das funcionalidades do VideoStore, diga quais usou e classifique de 1 (mau) a 5 (muito bom) a sua utilidade.

	Sim	1	2	3	4	5
Mosaic						
VideoSpot						
Video Annotations						
Log Analyzer						
Slides Thumbnail						

4. Das funcionalidades que usou, indique de 1 (mau) a 5 (muito bom) a sua usabilidade.

	1	2	3	4	5
Mosaic					
VideoSpot					
Video Annotations					
Log Analyzer					
Slides Thumbnail					

5. Das sub-funcionalidades das Video Annotations, diga quais usou e classifique de 1 (mau) a 5 (muito bom) a sua utilidade.

	Sim	1	2	3	4	5
Visualização Assíncrona						
Visualização Síncrona						
Pesquisa						

6. Das sub-funcionalidades das Video Annotations que usou, indique de 1 (mau) a 5 (muito bom) a sua usabilidade.

	1	2	3	4	5
Visualização Assincrona					
Visualização Sincrona					
Pesquisa					

7. Indique quais os locais a partir dos quais acedeu ao sistema VideoStore e e classifique de 1 (mau) a 5 (muito bom) os tempos de resposta do sistema em que cada um dos locais.

	Sim	1	2	3	4	5
Casa						
Rede Fixa DI						
Rede Fixa FCT						
Wireless FCT						
Outro 1:						
Outro 2:						

8. Indique de 1 (mau) a 5 (muito bom) a qualidade do vídeo e do áudio na generalidade das aulas.

	1	2	3	4	5
Vídeo					
Áudio					

9. Indique que browser utilizou, na maioria das vezes, para aceder ao sistema:

Internet Explorer	
Firefox (c/ I.E. Tab)	

10. Indique, de 1 (mau) a 5 (muito bom), até que ponto o sistema VideoStore influenciou positivamente o seu estudo e/ou acompanhamento das aulas:

1	2	3	4	5

11. Sugestões e Comentários.

_____
_____
_____
_____
_____

Appendix C

Students Evaluation Results

You used the system?	
Yes	27
No	9
Total	36

Why did you used it?	
Cath up Lectures	1
Exam Study	21
Cath up Lectures+Exam Study	5

Used Features and Functionality	***Yes***	***1***	***2***	***3***	***4***	***5***
Mosaic	7			2	5	
VideoSpot	7			3	2	2
VideoAnnotations	9		1	3	5	
Log Analyzer	4				4	
Slide Thumbnail	20		1	6	7	6

Usability	***1***	***2***	***3***	***4***	***5***
Mosaic			2	3	2
VideoSpot			1	4	3
VideoAnnotations			2	5	1
Log Analyzer			1	1	1
Slide Thumbnail			5	9	6

Video Annotations	***Yes***	***1***	***2***	***3***	***4***	***5***
Unsynchronized Visualization	4			1	3	
Synchronized Visualization	6			1	3	2
Search	1				1	

Usability	***1***	***2***	***3***	***4***	***5***
Unsynchronized Visualization			2	1	
Synchronized Visualization			3	2	2
Search				1	

Network Access	***Yes***	***1***	***2***	***3***	***4***	***5***
Home	19	3	2	4	6	4
Comp. Science Wired	11				6	5
Faculty Wired	10				7	3
Faculty Wireless	13		1	3	4	5
Other 1:						
Other 2:						

Quality	***1***	***2***	***3***	***4***	***5***
Video	2	5	2	13	5
Audio	1	6	12	6	2

Browser	
Internet Explorer	20
Firefox (w/ I.E. Tab)	7

System Impact on Student Studies	***1***	***2***	***3***	***4***	***5***
Postitive	1		7	9	9

Coments	
Record Whiteboard	9
More courses on the system	4

Not accessible links	3
Synchronization video/slides	3
Improve audio/video quality	2
Download video/audio	2
Timeline Interface	1

Appendix D

Global Evaluation Questionnarie

VideoStore/mEmLearn Application

O VideoStore/mEmLearn é um sistema que permite, através da Web, o visionamento de vídeos de aulas previamente gravadas. O sistema permite, também, a navegação, a pesquisa e a adição de conteúdos utilizando uma caneta digital.

Através deste estudo pretendemos avaliar a usabilidade do sistema. Para o efeito, pedimos-lhe que execute as tarefas abaixo indicadas e, preenchendo este questionário, nos informe acerca das dificuldades que encontrou ao interagir com o sistema e nos dê a sua opinião acerca da interface e das funcionalidades disponíveis.

Dados pessoais

Idade: ☐

Sexo: M ☐ F ☐

Lateralidade de escrita: Esquerda (Canhoto/a) ☐ Direita (Destro/a) ☐

Costuma tirar apontamentos em aulas, reuniões, seminários ou conferências?

Nunca				Sempre
1	2	3	4	5

Costuma visionar vídeos na Web?

Nunca				Sempre
1	2	3	4	5

Relativos aos seus estudos/trabalho?

Nunca				Sempre
1	2	3	4	5

Tarefas
Por favor, efectue as seguintes tarefas e descreva-nos os resultados obtidos.

Exploração da interface

Tarefa 1:

Visualize alguns minutos da aula gravada, navegue nos menus e explore as diferentes funcionalidades do sistema.

Informação sobre o menu superior:

-VideoMosaic: Conjunto de algumas frames do vídeo

-VideoSpot: Conjunto de partes de todas as frames do vídeo

-Log Analyzer Global: Os momentos mais vistos pelos utilizadores (a verde)

-Slides Thumbnail: Todos os slides apresentados na aula.

- Anotações: Inserção de anotações.

Navegação e pesquisa de conteúdos

Tarefa 2:

Utilizar as diferentes interfaces para pesquisar informação sobre "a mistura de cores".

- Utilizando uma interface à sua escolha. Qual? _____

  Como classifica os resultados obtidos?

Maus				Excelentes
1	2	3	4	5

- Utilizando VideoMosaic.

Como classifica os resultados obtidos?

Maus				Excelentes
1	2	3	4	5

- Utilizando Slide Thumbnail.

Como classifica os resultados obtidos?

Maus				Excelentes
1	2	3	4	5

Questões gerais relacionadas com as tarefas anteriores:

Quais foram as dificuldades sentidas durante a pesquisa da informação pretendida?

_____

_____

_____

_____

Tarefa 3:

Utilizar as diferentes interfaces para pesquisar os momentos (que lhe pareçam) mais importantes na aula disponível.

- Utilizando uma interface à sua escolha. Qual? _____

Como classifica os resultados obtidos?

Maus				Excelentes
1	2	3	4	5

- Utilizando VideoSpot.

  Como classifica os resultados?

Maus				Excelentes
1	2	3	4	5

- Utilizando Log Analyzer Global.

  Como classifica os resultados?

Maus				Excelentes
1	2	3	4	5

Questões gerais relacionadas com as tarefas anteriores:

Que outros métodos acharia importantes para pesquisar informação relevante?

_____

_____

_____

Adicionar conteúdo.

Tarefa 4: Adicionar uma anotação (não é necessário guardar!).

- Adicione uma anotação (com teclado).

Que dificuldades encontrou para cumprir a tarefa?

_____

_____

_____

- Adicione uma anotação a uma imagem (com caneta).

Que dificuldades encontrou para cumprir a tarefa?

_____

_____

_____

- Adicione uma anotação a um vídeo (com caneta).

Que dificuldades encontrou para cumprir a tarefa?

_____

_____

_____

Questões gerais relacionadas com as tarefas anteriores:

Como classifica a utilização do teclado para inserir uma anotação?

Muito Má				Muito Boa
1	2	3	4	5

Como classifica a utilização da caneta para inserir uma anotação?

Muito				Muito

Má				Boa
1	2	3	4	5

Gostaria de partilhar e visualizar anotações com/de outros utilizadores?

_____

_____

_____

Que funcionalidades relacionadas com a anotação com a caneta gostaria de ter?

_____

_____

_____

Avaliação da interface

Responda às seguintes perguntas fazendo um círculo em volta do número que melhor representa a sua opinião acerca da aplicação que acaba de experimentar.

1. É fácil aprender a usar a aplicação.

Discordo				Concordo
1	2	3	4	5

2. Considero a informação fornecida pelo sistema útil.

Discordo				Concordo
1	2	3	4	5

3. O aspecto estético da interface agrada-me.

Discordo				Concordo
1	2	3	4	5

4. A utilização da caneta permitiu uma melhor interacção com o sistema.

Discordo				Concordo
1	2	3	4	5

5. Eu utilizaria esta aplicação para os meus estudos/trabalho.

Discordo				Concordo
1	2	3	4	5

6. Eu utilizaria as anotações com a caneta, ligadas a formatos multimédia (imagem ou video), para escrever as minhas notas pessoais.

Discordo				Concordo
1	2	3	4	5

Appendix E

Global Evaluation Results

Personal Data		
Ages		
	21	1
	22	1
	23	
	24	1
	25	1
	26	1
	27	2
	28	1
	29	1
	30	
	31	
	32	
	33	
	34	
	35	
	36	
	37	1
Sex		
	M	5
	F	5
Laterality		
	Left	
	Right	10
How often do you take notes on lectures or meetings?		
Never	**1**	
	2	
	3	1
	4	7
Frequent	**5**	2
How often do you watch Web videos?		
Never	**1**	
	2	
	3	4
	4	4
Frequent	**5**	2
Web videos related to your studies/work?		
Never	**1**	1
	2	3
	3	4

	4	2
Frequent	**5**	

TASK 2

Search for a particular information

Selected Interface

Which?		VideoMosaic	Log Analyzer	Slide Thumb.	Slide Topics
Bad	**1**				2
	2				
	3				2
	4	1	1	2	1
Excelent	**5**			1	

VideoMosaic

Bad	**1**	2
	2	5
	3	
	4	3
Excelent	**5**	

Slides Thumbnail

Bad	**1**	
	2	
	3	3
	4	5
Excelent	**5**	2

Difficulties

	None	4
	On the Content	1
	On the Interfaces	4
	Search Text on Slides	1
	Improve Sound	1

TASK 3

Search for Highlights

Selected Interface

Which?		VideoMosaic	Log Analyzer	Slide Thumb.	Slide Topics	VideoSpot	
Bad	**1**						
	2						
	3		1				1
	4	2	1	1	1		
Excelent	**5**		2		1		

VideoSpot

Bad	**1**	4

	2	2
	3	4
	4	
Excelent	**5**	

Log Analyzer Global

Bad	**1**	
	2	1
	3	4
	4	2
Excelent	**5**	3

Other Methods to Found Highlights

	Don't Know	4
	Rating	1
	Topics	1
	Slide Topics	1
	Frames w/ Keywords	1
	Text Search	1
	Slides Rating	1
	Combined Interfaces	1

Task 4

Annotations Input

Keyboard Annotations - Difficulties

	None	10

Pen-based Annotations, over Image - Difficulties

	None	7
	Pen inexperience	3
	Remove Ink strokes	1
	Bad Caligraphy	1

Pen-based Annotations, over Video - Difficulties

	None	7
	Pen unexperience	1
	Remove Ink strokes	1
	More difficult to write	1

Classification of Keyboard Annotations

Very Bad	**1**	
	2	
	3	2
	4	1
Very Good	**5**	7

Classification of Pen-based Annotations

Very Bad	**1**	
	2	
	3	2
	4	4
Very Good	**5**	4

Sharing Annotations with Other Users

	No/None	
	Yes/All	7
	Some Users	2
	Some Annotations	1

Addiotional Pen-based Features

	None	5
	Remove Ink strokes	2
	Image Annotations	2
	Ann. w/ Video Time Periods	1

Global Evaluation
It's easy to lear how to use the system

Disagree	**1**	
	2	
	3	1
	4	2
Agree	**5**	7

The information retrieved by the system is useful

Disagree	**1**	
	2	
	3	
	4	2
Agree	**5**	8

I like the aesthetics of the interface

Disagree	**1**	
	2	

	3	1
	4	6
Agree	**5**	3

The usage of the pen allow a better interaction with the system		
Disagree	**1**	
	2	
	3	2
	4	4
Agree	**5**	4

I would used this system on my studies/work		
Disagree	**1**	
	2	
	3	
	4	
Agree	**5**	10

I would used the pen-based annotations linked to multimedia content, images or video, on my personal notes		
Disagree	**1**	
	2	1
	3	1
	4	2
Agree	**5**	6