Asynchronous On-Line Learning in Higher Education, a Case Study: Design and Implementation of a Neural Networks Course

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ABSTRACT:

The aim of this tutorial is to present the challenges and opportunities that online education offers our Universities today, and to illustrate them with the description of the design and implementation of an online course in neural networks.

There are many issues involved in the process of providing traditional courses from different disciplines using the Internet; the majority of current online courses are based on html-text and have had a limited successful. However, new technologies in multimedia content delivery over Internet are opening new for format options in the teaching-learning process in higher education environments. Universities such as Stanford and many others have adopted the video delivery of lectures over Internet based on streaming systems. These courses provide reliable academic success, unlike their text-based counterparts.

In the academic area of Neural Networks, there are a wide range of available courses, including the course Adaptive Neural Networks of Widrow [1] at Stanford University, the course Introduction to Neural Networks and Applications of Daglis [2] at University of Missouri-Rolla, and in our national scope, we offer the course Artificial Neural Networks and their Applications, in the Basque Country University [3].

The streaming of the traditional format lectures includes two important academic properties: delivers the existing knowledge that the teacher exhibits during the traditional class; and students expect the delivery of knowledge in a time-format familiar to them, and which they can easily schedule.

Even when the possibilities were many, the first implementations of these online lectures did not achieved the desired results for reasons that include the little time and effort dedicated to the integration of the computer as the main communication and teaching tool.

ON-LINE HIGHER EDUCATION & INTERNET

The relatively recent advances in multimedia transmission via the Internet, and the greater availability of inexpensive high-speed network access have had a direct impact in the development of online education programs and services. This services are provided not only to professionals in their companies, but throughout the educational system of colleges and universities, and increasingly in high schools as well.

For decades colleges and universities provided continuing and distance education programs using several distribution formats, including the very successful method of videotaping their traditional classroom lectures.

The logical tendency of using the new methods of distribution provided by Internet to modernize and expand the traditional vide-tape based distance education programs offered by these universities met with the technological limitations of Internet.

Although it is true that the quality associated with video transmission over the Internet historically has been associated with a modest or marginal quality, recent advances in narrow-band video applications, as well as wide spread availability of inexpensive high speed network access are providing a positive environment for the successful delivery of online courses and programs over the Internet [4, 5].

In addition to these traditional distance education programs, now using new distribution methods, these changes in technology are at the source of the creation of new university programs specifically created to offer an alternative educational environment to the classical teaching/learning methods.

The development of this alternative educational models requires not only the services provided by today's technologies and Internet, but the development of new pedagogical methods, new technical resources, and a well defined set of goals and objectives in the overall strategy defined by the administration of universities.

The world of online education is in a permanent state of change, growth, and self-definition. It will be required the efforts of academics, administrators, and technical developers to meet the challenges set forth in this area during the coming years. A list of the main tasks to be performed, obstacles to be overcome, and best strategies to be adopted are being identified and proposed in the specialized publications [6-18].

STREAMING SYSTEM

Streaming is the general name used to describe the technology which has made possible the transmission of multimedia content via the Internet. We understand by streaming the ability of distributing multimedia content via a digital network, with the special characteristic of allowing access to these contents as they are need it, without the need of a previous pre-load. This technique provides the user with many advantages compared with earlier methods, but at the same time it requires of the network and the systems providing streaming services a set of challenging technical and protocol demands. In particular, in a packet-switched network, such as the Internet, the transmission of multimedia content is highly affected by network performance factors such as bandwidth, packet delay, and packet loss probability.

The different applications involving techniques of streaming can be classified into two different groups:

a) Those applications involving the interaction between two or more users, such as IP voice transmission or video-conference;

b) Those applications mainly dedicated to the distribution of multimedia content, where the main goal is the transfer of content (usually audio and video) to a set of multiple destinations. These later applications include both live broadcasting as well as distribution of content on demand.

Table 1 includes some typical examples using this technology, including the application which will be proposed and described in this tutorial.

Content	Applications		
	Interaction among users	Distribution	
		Live	On Demand
Sound	Audio Communication	Radio Broadcasting	Music Promotions, Internet Radio
Video	Communication using Webcams	Video Broadcasting	Music Videos, Movie Promotions
Multimedia	Virtual Room Videoconferencing System	Lectures	Lectures

Table 1.- Streaming Applications

What are the main development phases involved in the implementation of this technology? What groups participate in these phases? What hardware and software resources are required for their implementation? Obviously, in these phases we will find tasks involved in the creation of multimedia content (text, audio, images, data, video, etc.), tasks involved in the streaming or transfer of the content, and the operation of the network environment used for its transfer, the Internet. Table 2 includes a list of these phases in which the people involved, the goal of each phase, and the resources required for their implementation are listed. This table is followed by Figure 1, which graphically illustrates the streaming system and the physical location within the system of the different phases. The basic tasks involved in multimedia delivery over the Internet include: the creation of the content, or Authoring; the transformation of this content into a format appropriate for distribution (usually data reduction through compression algorithms), or Encoding; the delivery of the content via the Internet, or Streaming; and finally, the observation of the multimedia content, or Playing.

Phases	Function	Human Resource	Resources
1	Content Creation	Professor	PC, Camera, Recorder, Microphone, SW: Recorder
2	Content Encoding into Streaming Format	Technician	SW: Producer HW: Compressor
3	Server Distribution	Technician	SW: Server Streaming, HW: Server
4	Content Reproduction	Student	SW: Player

Table 2.- Phases in the Streaming Process

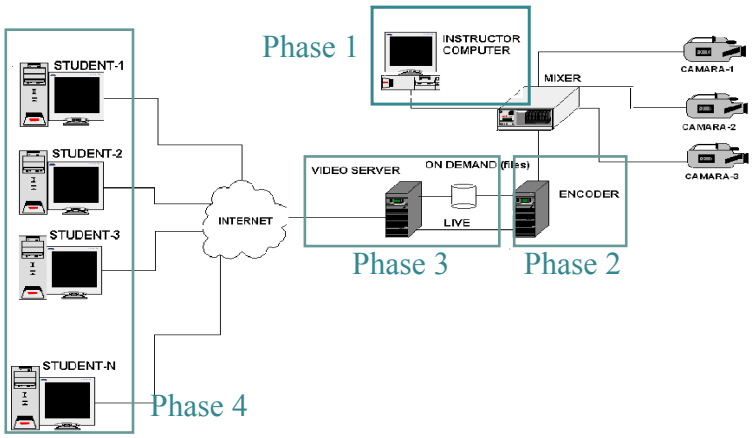

Figure 1 .- Generic Streaming System

Phase 1.- Multimedia Content Generation

The value and potential academic impact of the model proposed in this tutorial is base on the pedagogic quality of the multimedia content created by the professors. Currently, there are available in the market sets of hardware-software tools that help professors in this process of content creation for the delivery of academic courses. These contents do not have to necessarily be limited to text documents. On the contrary, they can include any combination of the different multimedia formats: text, audio, images, video, etc.

The first attempts to use streaming techniques for the distribution of course lectures included the video recording of traditional classroom lectures taught by the professor, and through the process of encoding, making these video lectures available in streaming format. These first models have been followed by others in which additional elements were integrated with the original video lectures. These included class notes and transparencies used in the lectures, index and direct access to the main sections of the lecture, etc. This model is what we call Analog Model (due to the analog nature of the original video signal of the lecture). Figure 2 illustrates with an example [19] this model.

Figure 2.- Analog Model

The design of the lecture video screen includes three parts, class window, index window and slide window, as illustrated in Figure 2. The class window is in the upper left corner and students see and hear the professor presenting the lecture. The index window, below the class window, allows the student to address the part of the lecture desired avoiding sequentially access. The large window to the right corresponds to the slide zone. The design aspects of the screen have been selected considering many technological, audiovisual and pedagogical characteristics in order to facilitate the learning process.

This model requires that the lecture event in the classroom was recorded by a set of cameras. An operator selected the appropriate video input based on the activity of the professor. An additional video signal was obtained from the instructor's monitor to provide access to his notes or his use of computer programs in class. This kind of audio/video creation required an important infrastructure (cameras, operator, classroom, etc.), however the final video product, once it was resized and encoded, did not offer an image quality according to the efforts realized and resources utilized. Simply putting lecture videos online was not the adequate answer to online teaching. The quality was enhanced by the addition of the images of whiteboard's notes synchronized by SMIL language.

The next proposed model, which we call Digital Model [20], has as its goal the elimination of the main aspect of the video quality degradation: that is the analog to digital conversion required to capture on the computer the analog video recorded in the classroom. Why not use the video digital quality directly from the PC? For this the solution is to use the computer as the only and main creator of the source content. The computer allows the use of any application available in the market without restrictions, such as applications for graphic design, mathematical calculus, simulators, word processor, whiteboard, media players, etc.

For this purpose is necessary a software product that records screen activity as videos, edits the clips, and publishes the finished presentation in standard formats. There are many authoring and edit tools for create and product streaming content based on the screen capture software [21]; they are widely available, easy to use and highly efficient. The software product choose Camtasia Studio™ [22], is a set of products which includes a screen camcorder, a video production tool, an effects tool, a menumaker tool and a player. The Camtasia Recorder is used to record screen activity as a moving desktop video. The selection of the capture input options (screen, window, region or fixed region) before recording allows us to define the area and type of video capture. Recorder saves the action as an AVI file. This is a series of frame captures that record all movement and actions on the computer screen; also it can add sound with a microphone as the recording is performed. Moreover, for broadcasting live events Recorder can also act as a software camera feed to live productions.

The model proposed in this tutorial focuses on the role to the multimedia content generated by the professor. This content is created by the professor, prior to class, in his/her office, using the computer as the main content creation tool. The computer allows professors to use any software, such as powerpoint, word, matlab, mathcad, neural simulator packages, whiteboard, etc. to be an integral part of the class. Camtasia Recorder captures all the video and audio activity in the computer, including the tablet input from the professor. The multimedia content is later presented in the format of a high video/audio quality document where the professor delivers the content of the class.

The design of the lecture video screen includes three parts, prologue, index menu and class window, as illustrated in Figure 3.

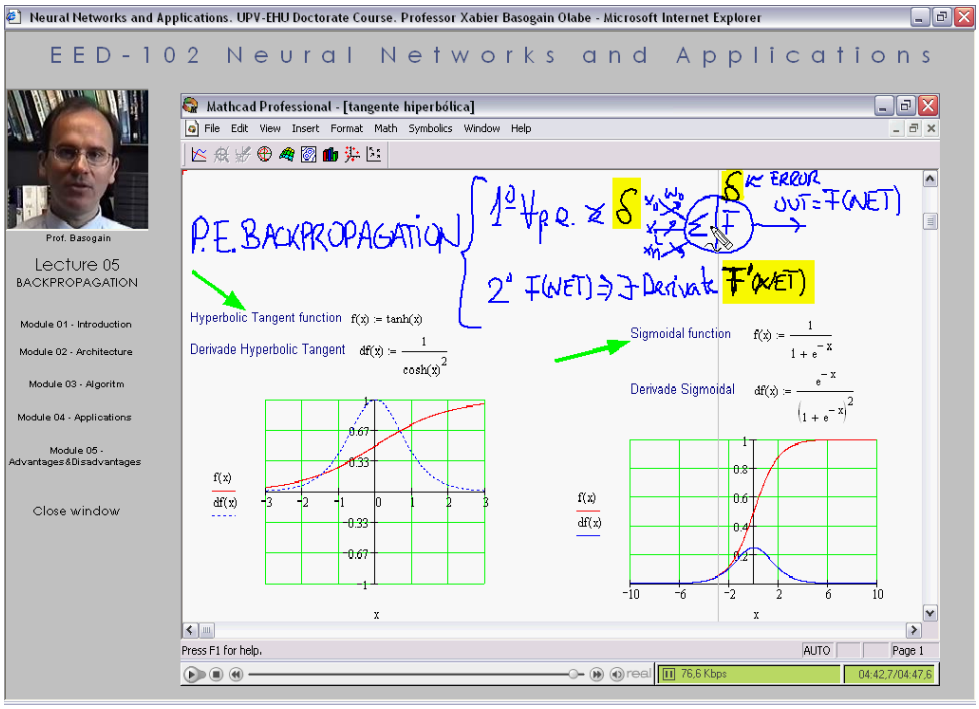

Figure 3.- Digital Model

The prologue is accessible by clicking the professor's picture and is a short video where the professor introduces the topic of the current lecture. The index menu is on the left side, and allows the student to address the corresponding section of the lecture. Each section has associated with it an streaming file that is presented in the class window. The large window on the right corresponds to the class zone where the students see and hear the multimedia content based on the computer screen activity created by professor. At the bottom of the window, the control buttons to provide video and audio control to the viewer. Table 3 summarizes the main differences between both streaming methods.

	Analog Model	**Digital Model**
Place	TV Studio	Office
Requirements	Video Cameras + Producer Microphone + VCR Recorder	PC + Camtasia Recorder Microphone + Tablet
Final Product	VCR Tape	AVI File
Post-production	Transparencies->jpeg Realpix, Realtex	
Multimedia Integration	Smil Language	Html Language

Table 3.- Comparison Analog and Digital Models

Phase 2.- Encoding into Streaming Format

The encoder is the software which will generate the video and audio files to be stored in the server to be later made available as media on demand, and it is also the software that creates in real time the stream signal which is directed to the server for its immediate broadcasting. This piece of software is of critical importance since a good encoding and compression processes will allow the creation of high quality files, while dramatically reducing the bandwidth requirements for its transmission. This software requires fast and powerful processors for the real time and high quality of video encoding and compression.

The format of the video encoding process must support streaming capabilities. The main established types of streaming formats include: rm, wmv, mov, which include the three main streaming platforms in the market. The software selected for the implementation of the encoding process is Camtasia Producer: it can open the AVI files to remove unwanted frames, change the sequence of events or timing, and splice together the pieces into a longer presentation. Producer also allows to save the video file in the final output form (.avi, .swf, .camv, .rm, .mov, .asf, .wmv, .gif).

The technical personnel in charge of the encoding process is able to adjust the encoding parameters of the multimedia contents according to a set of criteria which includes: Target Audience (target bitrate audience, audio target settings, Video Options (preroll, keyframe, framerate, size), Audio Options(format, codec, bandwidth). Figure 4 illustrates this process of parameter control.

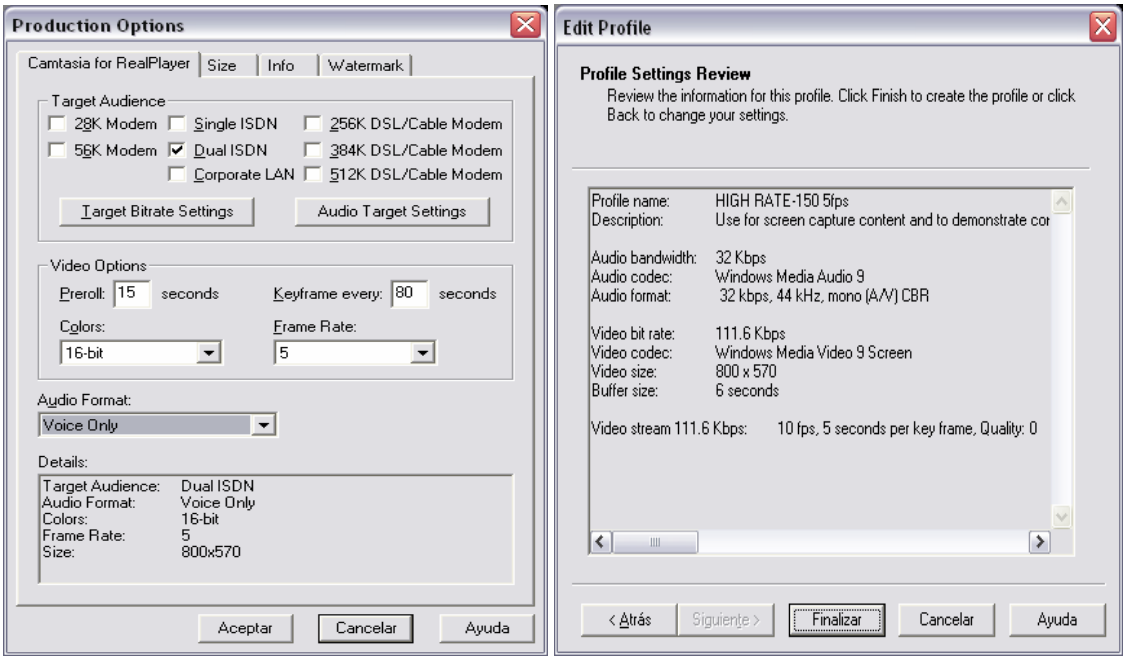

Figure 4.- Encoding Parameters

Phase 3.- Server Streaming Distribution

The server is a fundamental element in the distribution system of multimedia content. It implements the main communication tasks, including accepting connection requests from remote users, and the corresponding establishment of the connection for the media delivery. To implement this distribution there are different techniques and configurations which will determine the performance of the established

connections, allowing the optimization of resource allocation in the network. The selection between the main different methods of distribution (unicast, multicast, splitting, etc.) are tasks corresponding to the communications technicians, and are beyond the scope of this tutorial.

Table 4 describes the three main streaming platforms in the streaming market. Each platform includes its own encoders, servers, and players, as well as their own video file formats and even their communication protocols. It is notable that the server Helix, from RealNetworks, can be described as an universal server since it supports the distribution of media content from all three platforms [23].

Logot	Name of Platform	Name of Company	File Extensions	
	RealVideo	RealNetworks	Videos: .rm	Pointer: .ram
	Windows Media	Microsoft	Videos: .asf , .wmv	Pointer:.asx
	QuickTime	Apple	Videos: .mov	

Table 4.- Streaming Platforms

A streaming system based on the model client/server is the most scalable solution and the most popular. The streaming server software is installed onto the web server to manage and distribute the requested files; it is recommended for high traffic video network because gives the most control over who is watching and what is being sent supported by new streaming protocols as RTP and RTSP. Of course, this model is more complex, more difficult to implement and more expensive than an streaming system based on the server-less model which does not use server software(instead it works solely on HTTP streaming, and simply encodes a file and then places it on a web server where one normally puts other HTML pages and web images).

The files encoded in streaming format are later stored in the server computer according to a predefined directory structure which includes criteria for organized access to the different multimedia elements, as well as the criteria for the organization of the academic content of the course.

Phase 4.- Reproduction of Multimedia Content

The last phase in this streaming system based on the client/server model corresponds to the client/user, or student in the academic environment, who requests a connection for the reproduction of the multimedia content stored in the streaming server. To this end the user, in addition to having access to the network, must have installed in his/her computer the corresponding Player software. This software is of free distribution, and allows the communication with the server to request the transmission of a video file, as well as the interchange of commands for the selection of preferred segments of the video. The Player, which includes the corresponding codec, implements the task of decoding the encoded signal providing the final audio and video signals.

The student can access the multimedia content using the basic Internet protocol HTTP from a web page, or directly through a pointer included in a special file, such as a .ram or .asx file. In addition, the design of the lecture video screen is based on a HTML page with frames where the left frame shows the class index divided in sections and the right frame shows the embedding presentation in the web page, rather than launching the Player as a separate application.

UPV-EHU A CASE OF STUDY

The University of Basque Country UPV-EHU, the only Public one in the Basque Country Autonomous Community, and the one with the widest range educational offer, which almost reach one hundred qualifications. In its thirty faculties and university schools, placed though the campus of Alava, Bizkaia and Gipuzkoa, we work, study and investigate more than 60,000 students, 3,500 lectures and a thousand professional staff.

This a modern and an active University, in a constant change. The University's anagram, wich was designed by the sculptor Eduardo Chillida, is joined to the motto "Eman ta zabal zazu", "Bear fruit and make it known". This is the leading principle of all our activity.

In the spirit of our University's motto and also the evolution experienced by a great majority of Universities elsewhere, the UPV-EHU created in 1997 its own Virtual Campus [24]. This Campus uses technologies of information and communication (TICs) with the goal of offering the university's community the tools for remote or distance education. This new format of education provides new opportunities, including reaching a greater number of students, facilitate students access to continuing education, and the improvement of the academic quality.

The proprietary platform of the Virtual Campus, named CV, is similar to other commercial e-learning platforms, such as WebCT [25], Blackboard [26]; these software reside on a server and using a web browser, such as Internet Explorer or Netscape, users can gain access to it. In addition it enables the instructor to make changes to his/her course readily from any point of the Internet and to make these changes available to any user at the same time. All of them offer a set of tools designed specifically to accomplish different goals considered in a course design, such as assignments, calendar, chat, content, assistant, content module, discussions, glossary, goals, image, database, mail, my grades, my progress, quiz, search, self test, student homepages, student presentations, syllabus, and whiteboard.

The Virtual Campus has experienced a progressive evolution during its short life. The current academic offer of the Virtual Campus for the academic year 2002-03 includes 70 courses corresponding to elective courses of different majors, complement aid to traditional courses, and doctoral and professor education courses. The number of professors currently participating in the Virtual Campus is over one hundred, serving about 4000 students.

Our research group, the Multimedia Group, GM, begin its work in the area of e-learning during the academic year 2000-01 with the offering of the e-course 'Artificial Neural Networks and their Applications' based on the technological (RealServer) and academic infrastructures (WebCT) that integrate the video transmission of lectures over Internet and a support educational environment. This course, based on the Analog Model, constituted the first experience of streaming based education implemented in the UPV-EHU [27]. The e-course 'Artificial Neural Networks and their Applications' has been designed using as a reference course imparted in a bimodal mode (in the classroom and over Internet) at the School of Engineering of Bilbao. The table of contents describes the field of neural computation as a serious alternative method in those applications where the classical computational methods do not achieve success results. In this sense, it requires leaving out areas of interest included in more comprehensive programs of other universities.

The tools selected for e-course ANN are grouped in the following areas: a) course materials, b) communications, c) evaluation and d) video- lectures as shown in Figure 5.

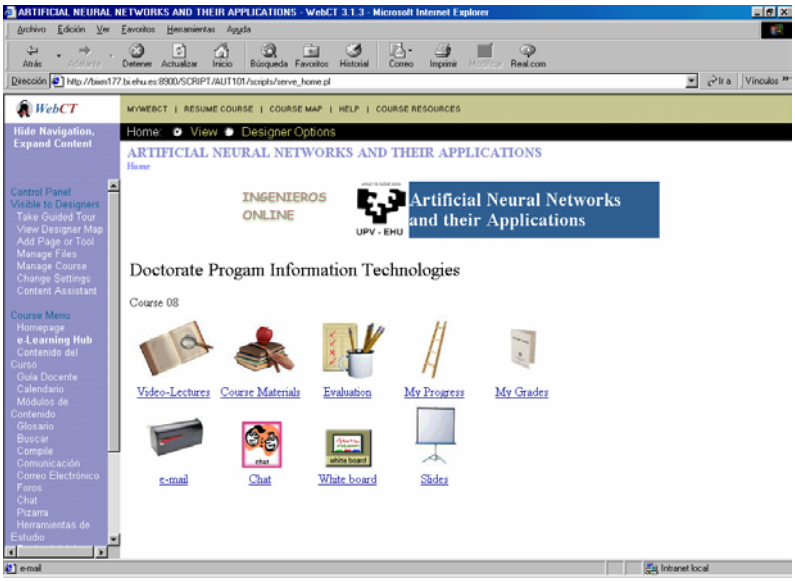

Figure 5.- ANN course Homepage

The course materials offer the students the syllabus, the module content, the notes and slides, the software for design and simulation and finally a calendar. The commonly used method to communicate with the student is the e-mail, and for appointed sessions the chat, discussion, and blackboard tools are used. In order to help the learning of the topics in the course, there are available ten self-test with more than two hundred question of multiple choice.

The Virtual Campus of the UPV-EHU learned about the work developed by the GM and decided to create the streaming infrastructure necessary for to incorporate the ANN course as part of the CV platform. Beginning in the academic year 2001-02 the ANN course is offered as part of the CV. This event was the catalyst for the creation of a formal relation of collaboration between both groups.

During this time, the multimedia group GM has continued its work with the development of new e-learning models based on streaming of multimedia content. During the academic year 2002-03, the GM has offered a doctoral course, "Modeling and Simulation of Communication Systems", using the Digital Model described in the previous section.

Project VCCV: Multimedia Courses – High Quality Video – 2003/04

The Virtual Campus of the UPV-EHU and the GM established in the Fall of 2002 a formal relation of collaboration in the area of creation and transmission of multimedia content in high-quality video format. The two groups collaborate en the development of the VCCV project.

This project was created with the main objective of creating the technological, administrative, and academic infrastructures for the integration in the CV of the UPV-EHU of teaching methods based on multimedia content with a high-quality video format.

The general objective of this project is translated into concrete goals with the definition of the following outcomes: a) Guaranteeing the academic success of the created courses and the successful participation of students in this new format of virtual education; b) Establishing a group of Professors proficient in the creation of courses using this technology; c) Creation of 10 courses based on the Digital Model. These courses are scheduled to be offered during the academic year 2003/04; d) Establishing a methodology for the evaluation of the students progress; e) Establish the technological infrastructure to achieve these

outcomes; and f) Propose standards by which the University promotes and rewards academic activity in this area.

The project was designed not to be a mere academic experience as it is often the case in the area of e-learning. For this purpose, the planning, development and evaluation of the project aim at making of this work an experience that will be later translated into a formal reference to be used to integrate in a systematic way throughout the entire scope of the UPV-EHU the methodology of virtual education using high-quality video.

There are two factors that have been identified as essential in the success and usefulness of this project: the number of created courses, and the scope of the participating academic group. To address the first factor, it was decided to define a wide and comprehensive group of academic disciplines (See Table 5). Each of these different areas knowledge brings its own intrinsic characteristics which will be reflected in the process of creating multimedia content. Also, this diversity allows the representation of the many academic areas which are part of the UPV-EHU. To address the second factor, the group of Professors responsible for the creation of the selected courses was created with a clear mission of collective and cooperative work. This group has become an e-community which uses the CV platform in its activities of creation and sharing of results and experiences. There is a continuing participation, via forums and discussions, in a dialog which addresses the creation process of multimedia content, evaluation of students progress, use of communication tools (e-mail, chat, discussion boards).

Course	Degree	Campus
Modelado y Simulación I	Ingeniero en Automática y Electrónica	Bilbao
Economía Política II	Diplomatura en Empresariales	Bilbao
Sistemas de información Geográfica	Licenciado en Geografia	Gasteiz
Pedagogía del Tiempo Libre	Educación Social	Bilbao
Anatomia Klinikoa	Licenciatura de Medicina	Leioa
Introducción al Scilab	Físicas/Ingeniero en Electrónica	Leioa
Derecho Penal	Licenciado en Derecho	Donostia
Proyectos 5	Arquitecto	Donostia
Semiología: Lenguajes del Arte	Licenciatura en Bellas Artes	Leioa
Ingenieria Asistida por Ordenador	Ingeniero Industrial en Mecanica	Gasteiz
Gráficos avanzados en Ingeniería	Ingeniero Industrial	Bilbao

Table 5.- Courses of the VCCV Project

In addition, the directors of the project closely work with the technical staff of the Virtual Campus in the implementation of the streaming system, and the integration of the courses using the Digital Model in the CV´s platform.

During the academic year 2003/04 the e-community will offer the created courses. This will be followed by a formal external evaluation of the students, the e-community, and the technical staff. The evaluation will determine the degree in which the set goals were attained, and it will indicate the level of improved quality in the learning process. This evaluation will eventually determine the viability of the integration of this methodology throughout the UPV-EHU.

The results of this project can be summarized in the following points:

1.- Multimedia Courses: Set of course based on a set of multimedia files lectures that present the following characteristics:

- a large window with a high quality video corresponding to the pictures, hand-writing, simulator pictures, text and designs created by professor.

- the audio signal of the professor, corresponding to the oral presentation of the class, offers the students a comprehensive explanation of the material which is lacking in traditional text-based online methods.

- a lecture screen design, which includes a video prologue, an comprehensive lecture index and the control buttons enhance the introduction and viewing of the lectures.

The model proposed accomplished the goals of improving the academic success of courses based on video streaming of recorded lectures in the classroom.

2.- E-Community: This is group of Professors trained in the creation and teaching of courses based on this technology. This group will have a catalytic function by promoting and training in their own schools and colleges new generations of Professors in the use of this modality of e-learning.

3.- Technological Infrastructure: The Virtual Campus of the UPV-EHU will benefit from the technological infrastructure that will allow it to provide courses based on multimedia content, as well as the knowledge and experience in the tasks of management, maintenance and service provider of a streaming system.

4. Hallmark: This work will provide the results of a tested methodology which will give the Administration of the University tools and data for better plan future actions in the area of integrating systematically online education in the UPV-EHU.

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REFERENCES

[1] Widrow, B. Adaptive Neural Networks (EE373B), Stanford University http://scpd.stanford.edu/scpd/courses/academic/crseDesc.asp?crseID=119&sdID=5
[2] Daglis, C., Introduction to Neural Networks and Applications, University of Missouri-Rolla http://web.umr.edu/~dagli/emgt378winter2003/schedule.htm
[3] Basogain, X., Redes Neuronales Artificiales y sus Aplicaciones, UPV-EHU http://cv.ehu.es/campus/
[4] Perkins C., and J. Crowcoft, “Real-Time Audio and Video Transmission of IEEE GLOBECOM’96

over the Internet", IEEE Communications Magazine, pp 30-33, April 1997
[5] Jinzenji H., and K. Hagishima, "Real-Time Audio and Video Broadcasting of IEEE GLOBECOM'96 over the Internet Using New Software", IEEE Communications Magazine, pp 34-38, April 1997
[6] American Journal of Distance Education. http://www.ajde.com/
[7] The Chronicle of Higher Education. http://chronicle.com/distance/
[8] Distance Education. http://www.tandf.co.uk/journals/carfax/01587919.html
[9] Distance Education Systemwide Interactive Electronic Newsletter.(DESIEN) http://www.uwex.edu/disted/desien/index.html
[10] E-Learning. http://www.ltimagazine.com/ltimagazine/
[11] eSchool News online. http://www.eschoolnews.com/
[12] European Journal of Open and Distance Learning. http://www.eurodl.org/
[13] Interactive Educational Multimedia. http://www.ub.es/multimedia/iem/
[14] International Journal on E-Learning. http://www.aace.org/pubs/ijel/default.htm
[15] International Review of Research in Open and Distance Learning. http://www.irrodl.org/
[16] The Internet and Higher Education. http://www.scis.nova.edu/ihe/
[17] Journal of Interactive Media in Education. http://www-jime.open.ac.uk/
[18] The Virtual University Gazette. http://www.geteducated.com/vugaz.htm
[19] Basogain, Xabier; Olabe, Mikel; Olabe, J.C., 2001, "Course on Artificial Neural Networks: Digital Education", European Symposium on Intelligent Technologies, Hybrid Systems and their implementation on Smart Adaptive Systems, ENITE 2001, Proceedings: CD- ISBN 3-89653-916-7 pp. 538-543 http://multimedia.ehu.es/cast/public.html
[20] Basogain, X.,Olabe, M. and Olabe, J.C., Streaming Multimedia Content: Digital Course of Artificial Neural Networks , European Symposium on Intelligent Technologies, Hybrid Systems and their implementation on Smart Adaptive Systems, EUNITE 2002, Proceedings of EUNITE'2002 , 697-702, ISBN 3-89653-916-7 http://multimedia.ehu.es/cast/public.html
[21] HuntFor.com, Screen Capture Software, 2003 http://www.huntfor.com/web/software/screens.htm
[22] Camtasia Studio, 2003 http://www.techsmith.com/products/studio/default2.asp
[23] Helix Universal Server Administration Guide service.real.com/help/library/guides/helixuniversalserver/realsrvr.htm
[24] Campus Virtual, UPV-EHU http://cv.ehu.es/campus/
[25] WebCT http://www.webct.com/
[26] Blackboard http://www.blackboard.com/
[27] Basogain, X., Olabe, M. and Olabe, J.C., "Bimodal Education: Pilot Project at the University of the Basque Country " Proceedings of CIED2000 .Congreso: I Congreso Internacional de Educación Digital,Año: 2000, Bilbao http://multimedia.ehu.es/cast/public.html