

GAIALAB: A WEBLAB PROJECT FOR DIGITAL COMMUNICATIONS DISTRIBUTED LEARNING

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ABSTRACT

This paper presents GAIALAB, a Web lab project for digital communications distributed learning developed at the University of Granada (Spain). This initiative has been funded by a University program to improve teaching quality. The project addresses problems of teaching and learning innovatively and effectively by enabling the user interaction with the simulation engines through a web browser. Our Web lab project provides an interface with JAVA applets that have been developed and integrated in the system. The Web lab project enables simulating digital communication systems and analyzing the results obtained through the Web. Moreover, all the applets that are included in the system have been designed to allow the modification of the simulation parameters, thus enabling a better understanding of the algorithms. The system also permits evaluating the experimental work developed by the students.

1. INTRODUCTION

While the Web offers a cost effective, accessible and reliable medium and has provided pedagogical advantages in the hands of creative users, it has certain limitations that pose challenges to faculty who would repurpose a course using this new concept. Information and communication technologies contribute to the quality of education and training. The purpose of electronic learning (eLearning) initiatives is to enhance the use of new multimedia technologies and Internet to improve the quality of learning by facilitating access to resources and services as well as remote exchanges and collaboration. As an example, the eLearning programme [1] focuses on a set of actions in high priority areas, chosen for their strategic relevance to the modernisation of Europe's education and training systems. The Internet is an ideal medium for distributing information. Its ubiquity and protocol standards make data communication and graphical user interface (GUI) easy to implement. The use of the Internet in remote education can be enhanced by adding an experimental component, *i.e.*, conducting experiments over the Internet [2].

Several university courses in electrical and computer engineering have used on-line resources to improve the quality of learning for their students [3, 4]. The introduction of computer-based visualization tools into the educational process facilitates the student work and learning key concepts that are difficult to describe with just text through a Web browser. A good example in the field of digital signal processing (DSP) is the discrete convolution — an algorithm used to compute the time-domain response of a linear system to a signal. Several demonstration applets implementing graphically the convolution operation between two discrete signals have been developed at Mississippi State and Johns Hopkins universities [5, 6, 7]. These initiatives are now being extended to other topics and learning environments. A virtual, remote, and distributed laboratory for teaching communication systems is being used at the Javeriana University [8]. It was based on physiological and psychological models of how the brain carries out the capture and retention of knowledge, facilitating the process of learning, reducing the time of assimilation, and achieving a longer retention of the assimilated material. The Investigator[®] project at the University of Florida [9] is an inquiry-based learning paradigm that provides undergraduates with an understanding of core DSP concepts using authentic hands-on technology. A Web-based educational software tool for showing the basics of hidden Markov model (HMM)-based speech recognition [10] is being used at Arizona State University through the J-DSP initiative [11]. Other tools to help automating the process of learning over the Internet are arriving among which, WebCT [12] is a good example of a tool gaining widespread acceptance at the university.

This paper describes a new Web lab project developed at the Department of Signal Theory, Networking and Communications of the University of Granada (SPAIN) for digital communications distributed learning. The main objective of this project is to develop a virtual laboratory for digital communication systems and other on-line learning courses in information and communications technologies. This Web lab project is based on the Ptolemy project (<http://ptolemy.eecs.berkeley.edu>) [13, 14], developed during the last decade at the University of California at

Berkeley, which facilitates the development of JAVA applets for visually designing, modeling and simulating heterogeneous systems.

2. MOTIVATIONS

The communications and digital signal processing industry continues growing and being in need of trained engineers. Preparing students for their careers as engineers has historically been the role of higher education. Trying to comply with this responsibility we have developed this project trying to fuse eLearning principles with the available technology for integrating demonstration experiments over the Internet. This Web lab project is supported by the University of Granada under a program to improve the quality of teaching. Our work addresses problems of teaching and learning innovatively and effectively by enabling the user interaction with the simulation engines through a Web browser. With this tool the students of the University of Granada could decide when and from where they log in the platform and conduct their experiments and home works depending on their schedules. The aim of the proposed learning environment is to take advantage of the available technology for defining interactive systems with a graphical user interface. The development of this valuable tool will enable students of Electronics, Computer and Telecommunications Engineering to conduct laboratory experiments through simulation engines running signal processing and communication systems over the Internet as well as to enable the grading process for instructors. The experiments are planned to consist of parametric functional blocks, so the operation of the system is fully controllable by the end user. This fact will allow a better understanding of the systems and to evaluate the effect of a given parameter on the response of the system and its performance. On the other hand, the instructor will be able to formulate questions and to evaluate the students by their results and home works.

3. DEVELOPMENT PROCESS

Learning digital communications requires conducting laboratory experiments and system simulations in order to better understand its fundamentals and applications. Matlab is an excellent tool to carry out these computer experiments since it provides specialized blocks for communication systems and simulation tools. However, its use is limited to workstations and, at this time, it has no direct support for exporting simulation models to a Web platform. The Ptolemy project at the University of California at Berkeley has developed tools for this purpose. The software tool Vergil [14], included in the Ptolemy software package, provides the necessary framework for developing heterogeneous system models for simulation with the clear advantage of being directly exportable as JAVA applets

suitable for being incorporated to a HTML Web project. The process of developing a simulation engine for our laboratory consisted of the following steps:

- i) definition of the application environment,
- ii) development of the necessary functional blocks for each system,
- iii) integration of all the blocks into the system,
- iv) exportation of the XML models for the JAVA-based simulation applets.

Once all the simulation engines were built and exported as JAVA objects, the Web interface was built in order to include all the necessary background information needed to conduct and understand the operation principles for each experiment.

4. EXAMPLE EXPERIMENTS

The Web lab project enables simulating digital communication systems and analyzing the results obtained through the Web. The system is installed on a server which includes the Web interface and the JAVA-based simulation engines to enable the operation of an interactive laboratory for distributed learning. All the applets that are included in the system have been designed to allow the modification of the simulation parameters, thus enabling a better understanding of the algorithms. Among the communication systems that can be simulated using the Web lab are:

- i) the propagation of signals through a channel with linear or non-linear distortion,
- ii) the multipath effect for square and noisy signals,
- iii) PCM modulation,
- iv) delta modulation (DM), and
- v) different line coding schemes for digital communication systems.

The graphical user interface (GUI) is built over JAVA applets and the digital communication systems being studied are defined using available library blocks and others specifically developed for this project.

Fig. 1 shows an example of a system included in the Web lab to simulate different line coding schemes [15] for digital communications. Fig 1.a. shows the block diagram of the system that consists of:

- ❖ A random bit generator. A uniform distribution random source is used being its output compared to zero. If it is greater than zero a "1" bit is generated, otherwise a "0" bit is produced.
- ❖ A Polar/On-off line coder.
- ❖ A Gaussian noise source.
- ❖ A spectrum analyzer consisting of an averaging FIR filter.

The results of the simulation are shown in Fig. 1.b. The line coding used is shown in the first *ArrayPlotter*. Note the effect of the Gaussian noise source on the values of the pulse train. The power spectral density is shown in the second *ArrayPlotter*. The system allows selecting the line coding scheme (polar or on-off) to be used and to modify the noise power. The user selection will affect the power spectral density of the transmitted signal.

Fig. 2.a shows the block diagram of raised cosine pulse shaping [15] simulation systems for a digital communication system. The system consists of the following functional blocks:

- ❖ A random bit generator similar to that used in the previous experiment but masked to better present the simulation model.
- ❖ A raised cosine line coder.
- ❖ A Gaussian noise source.
- ❖ A spectrum analyzer consisting of an averaging FIR filter.

The results of the simulation are illustrated in Fig. 2.b through a Web browser. The first *ArrayPlotter* shows the pulse shape for transmitting the random bit patterns. The second one shows the sequence of bits being transmitted while the third one shows the power spectral density of the raised cosine pulse train.

5. CONCLUSIONS

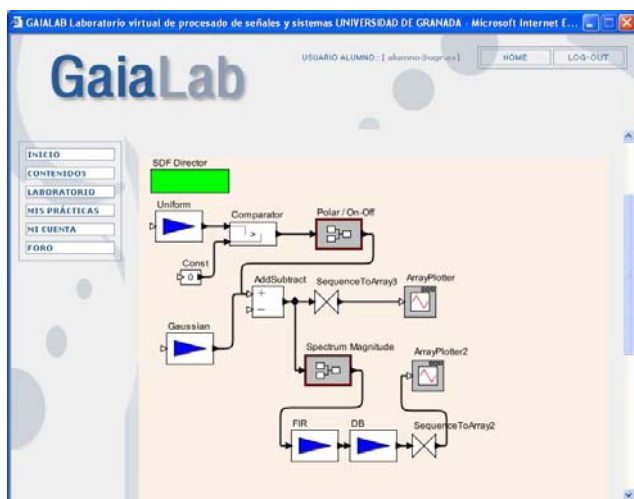
This project began in September 2003 with the support of the University of Granada under a teaching innovation program. As a starting point, we considered the development of a simulation environment for a lecture on digital communications for undergraduate students in Electronics Engineering. This project will be available to students for next course and we will get a valuable feedback from the users that will influence our future work. This work has demonstrated to provide a very interesting framework for digital communications distributed learning. The role of students is not limited to just view the results of a given simulation experiment. The experiments are designed using parametric functional blocks so the operation of the system is fully controllable by the end user. This fact allows a better understanding of the problem and to evaluate the effect of a given parameter on the response of the system and its performance. On the other hand, the instructor can formulate questions and evaluate the students by their results and homework. This Web lab will be used in the future as a complement for theoretical lectures with the purpose of making the learning process more amenable to students and to propose activities or home-works the students can develop under the guidance of an instructor.

6. ACKNOWLEDGEMENTS

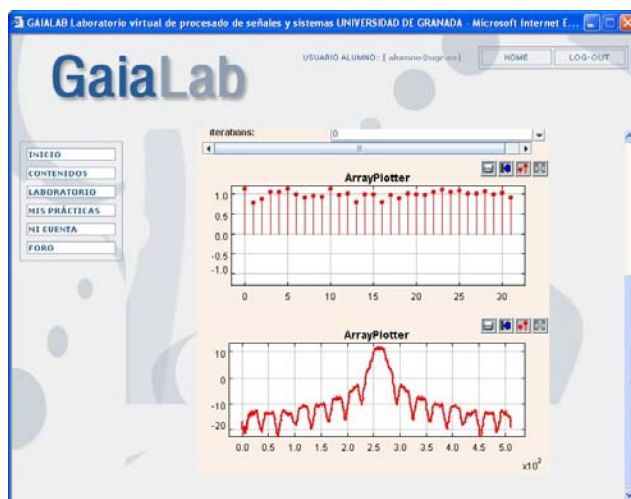
We would like to thank the University of Granada for supporting this innovation project for improving teaching quality in Electronics Engineering.

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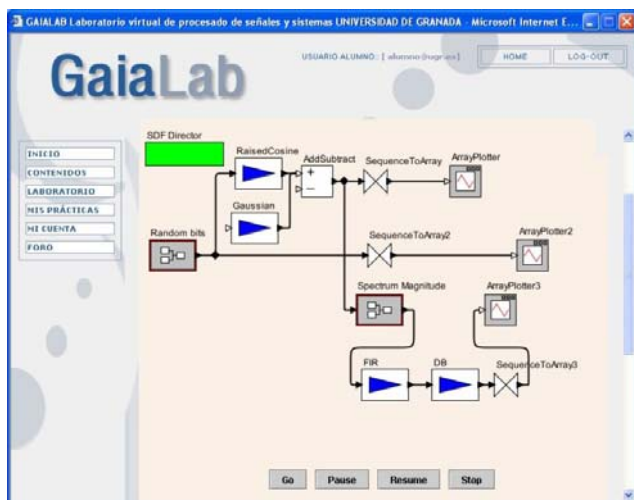


a)

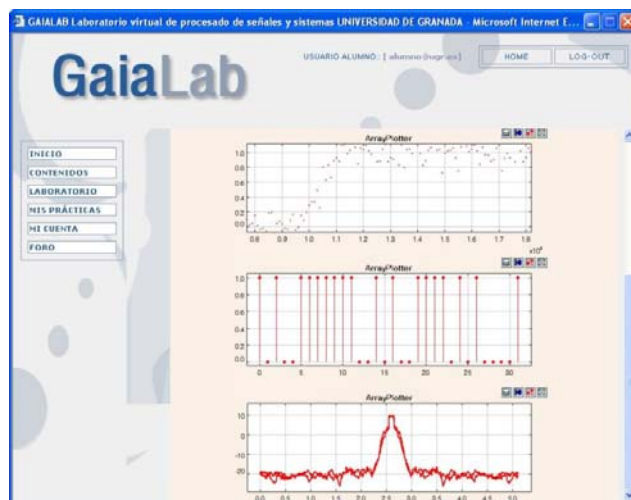


b)

Fig. 1. Polar/on-off line coding.



a)



b)

Fig. 2. Raised cosine pulse shaping.