Web-based remote learning of communication systems: a successful experience

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Abstract A web-based on-line framework has been created to augment an undergraduate course in communication theory aimed at Spanish telecommunication engineering students. Its aim is to enrich the students' understanding on basic topics such as analogue and digital communication systems, information theory, random signals and noise, as well as to provide remote support, additional information and interactive tools. As an ultimate goal, it tries to contribute to a redefinition of the role of the student as the principal actor of his or her own learning.

Keywords communications; modulation; noise; random signals; WebCT

Traditional methods and resources in teaching activities such as board, slides, etc., if properly employed, constitute a valuable tool in the transmission of knowledge, motivation and encouragement of students in higher education. It is no less true that the tools available nowadays, thanks to the information and communication technologies, open an enormous field of potential teaching and learning opportunities that can efficiently complement these traditional procedures. To name but a few: interactivity, instantaneous access to edited materials, new ways of presentation of the course material with a more visual and intuitive approach (multimedia simulations, didactical games, etc.). The remote availability of this kind of resource acquires even more importance taking into account the flexibility (even at an international level) that should be present in the curricula of our students. As the introduction of these techniques is advisable in every discipline, it seems even more essential to those studies aimed at future electrical and computer engineers, so that they can start to assimilate the new technologies as an integral part of their learning experience.

The Spanish Public University of Navarra is relatively young (it was established in 1987) so that it has shown itself to be very dynamic at incorporating changes, and this new environment is no exception. In fact, in 2000 the Office of New Technologies and Educative Innovation was created, supporting faculty to promote initiatives in this field. One of the degrees offered to our students (since 1989) is telecommunication engineering. As in other Spanish universities, such a degree is traditionally close in concept to electrical engineering degrees in Anglo-Saxon countries, yet with notable differences. In particular, emphasis is put on signal and system theory, electronics, transmission media, computer architecture and networks, at the expense of topics closer to mechanical engineers, such as materials science and control theory, as detailed in Ref [1]. But obviously among the main subjects treated

are communication systems, both analogue and digital. The inclusion of various mandatory courses covering such topics at the Public University of Navarra is an implicit recognition of the relevance of these topics to the engineer's background. Concerning this fundamental subject, the renovated curricula in telecommunications engineering at the Public University of Navarra now include a course entitled 'Communication Theory' and designed for juniors that covers the main aspects of analogue communications as well as the fundamental aspects of random signals and noise. The prerequisites are a junior course in linear systems and a mathematics background including Fourier transforms, statistics, and vector calculus. Digital communication systems are treated in a coordinated fashion in another simultaneous course.

The author being teacher of this course since 2000, and funded by the Office of New Technologies and Educative Innovation, he created a web framework based on WebCT software (see Ref [2]). This framework provides a structured set of resources to the students as well as communication tools like chat, newsgroups and e-mail, aimed at complementing the course on communication theory and increasing the student's opportunities to access course materials and remote teacher support.

Course context

The course on communication theory at the Public University of Navarra, in which the aforementioned lab experiments are introduced, has a total of 60 contact hours assigned. The main topics treated are:

1 Linear modulations and frequency multiplexing;
2 Angular modulations;
3 Random signals and noise;
4 Analog pulse modulation;
5 PCM, digital baseband transmission and time multiplexing;
6 Information theory, coding, and cryptography.

As can be readily noticed, although many topics are studied, the main core of the course is analogue modulations and noise in communications systems, which are studied at length. When the student faces this course, he or she has already received a sound basis in signal and system theory (60 hours), statistics (60 hours), analogue and digital electronics (300 hours), as well as basic courses in mathematics and physics. On completion of the course, the student should have an adequate understanding on which modulation method best fits a certain application, how can it be generated and detected and how noise influences signal transmission.

Available resources and support

As mentioned before, the aim of this work was to provide the course communication theory with a framework where the student had a set of tools available which he or she could access through the internet with a web browser. The tools that have been implemented in the WebCT environment are cited below.

Communication tools

- Off-line tools
  - — Calendar, where all the events concerning the course are scheduled.
  - — Newsgroups on different topics of the course.
  - — E-mail for private communications between teacher and students.
- On-line tools: chat. The student can ask the teacher in previously scheduled and announced sessions.

Resources

- Course contents. All the course chapters both in HTML and PDF formats.
- Interactive simulation programs, providing an intuitive approach to complex concepts.
- Didactical games, trying to evaluate the knowledge of the student.
- Problem sheets. Interactive sheets of problems proposed to the students.
- Solved exams. Previous exams and their solutions.
- Additional material: application notes, links to other related sites, etc.

The simulation programs developed try to provide a more intuitive approach to certain concepts such as modulation and noise, whose characteristics lead very naturally to their learning using an interactive tool. An exhaustive description of all the simulation programs developed is not presented due to lack of space. However, for instance, Fig. 1 shows the main screen of one of the programs developed, aimed at the study of different types of random signals and noise. The student can select between simulated Gaussian noise, uniform noise, and sinusoidal waves with random initial phase. The program generates such signal continuously, and estimates the main statistical averages (mean, variance, etc.) every N samples, N being an integer value chosen by the student. It also calculates the amplitude histogram corresponding to these samples. For doing so, it just divides the amplitude range into M intervals (bins) selected by the student and counts the number of samples falling into each bin. The resulting bar diagram corresponds to the histogram. When the range cannot be limited (e.g., Gaussian noise) a range of $\pm 3\sigma$ is selected, σ being the standard deviation calculated before. The successive histograms obtained are continuously averaged. The resulting averaged histogram is integrated and normalised to a maximum value of 1, leading to a good estimation of the distribution function. Once derived, we get the estimated probability density function (PDF), as shown in Fig. 1.

Didactical games are introduced in order to motivate the students to evaluate themselves. One of the programs developed is a quiz game with questions related to the course contents. After an initial screen where the student configures some settings (difficulty, maximum time per question, maximum number of errors, etc.), the main screen shown in Fig. 2 appears. After throwing the die, he or she advances. Then, a window appears with a multiple-choice question (Fig. 3), concerning a certain theme among those included in the course syllabus, which is determined by the colour of the corresponding square. When the questions corresponding to the

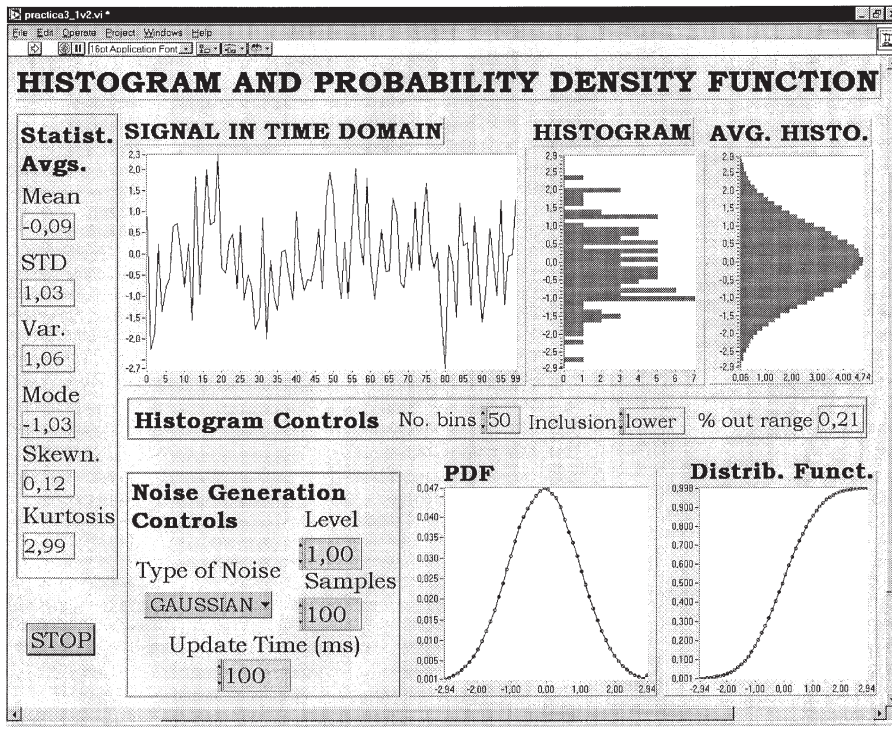

Fig. 1. *Front panel of program for random signals and noise experiments.*

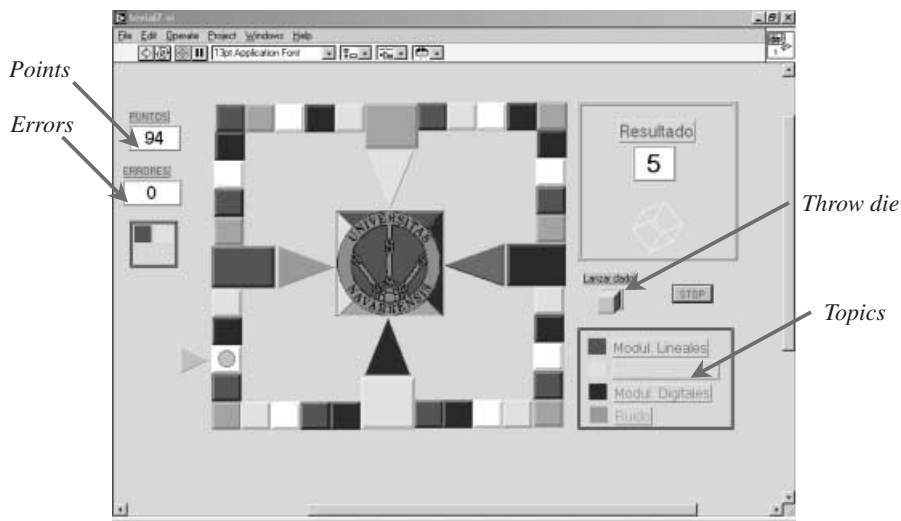

Fig. 2. *Main window of the quiz game.*

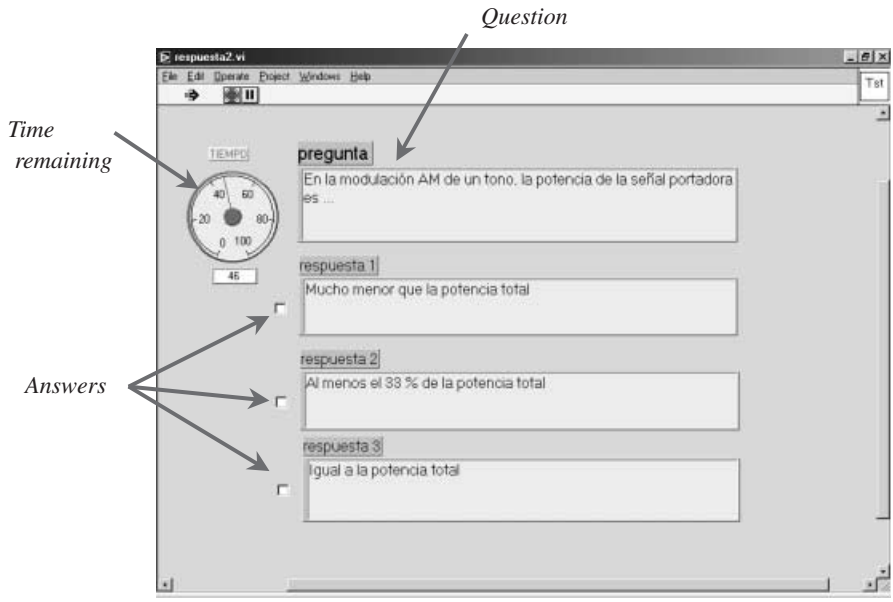

Fig. 3. *Question window of the quiz game.*

TABLE 1 Statistics of use of the web tool (Spring semester 2002)

Parameter	Value
Number of accesses to the Web tool	1367
Number of students employing the tool	124
Percentage over the total number of students enrolled in the course	63%
Average number of accesses per student	11
Number of newsgroups created and active	6
Total number of hours of online teacher support (chat sessions)	8.5

four larger squares are correctly answered, five final questions are posed to the student, who has to answer at least three to win. The program is very modular, so that it suffices to change the database with the questions to adapt it to another course.

Conclusions

The web-based framework described in this paper offers students the possibility of experiencing the fundamental concepts of analogue modulation and noise simultaneously with their theoretical study and in a distance-learning hands-on environment by using interactive programs and games, and by accessing additional material they have available. Moreover, the communication opportunities with the teacher and among the students themselves have been significantly augmented. Such an envi-

ronment has been working for two years now and the experience of the author is very positive. He has found the students to have a deeper grasp of the concepts of noise and modulation, as well as more motivation and encouragement for acquiring the basic concepts involved. The acceptance of the tools incorporated has been very good, as reflected by the statistics of use of the resources shown in Table 1, corresponding to the Spring semester of 2002.

Acknowledgements

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References

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2 WebCT home page: http://www.webct.com.