BRAIN-LEARNING-MODEL-BASED DSP TEACHING ENVIRONMENT FOR COMMUNICATION SYSTEMS

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ABSTRACT

It is presented the description of a virtual, remote, and distributed laboratory for teaching communication systems, 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 system includes an application for diagramming, configuration, simulation, and monitoring of the practice to perform; a group of Digital Signal Processors which implements the practice; and a local communication system that allows interaction among the different modules, in addition to specific connections to real instruments and Internet, in order to command the system remotely, providing the same functionality. All features contemplated in the models mentioned have been implemented and tested in the tool, and the results show that the approach indeed eases learning processes, which motivates further study on the subject.

1. INTRODUCTION

As computers' processing capabilities, multimedia driving, and remote manipulation through Internet have increased significantly, their use in education have expanded drastically, making part of the well-known phenomenon of Information and Communication Technologies (ICT). However, in many cases, the phenomenon has consisted primarily on the migration of traditional schemes based on printed media and/or physical laboratories, bringing their limitations and historical errors to the new paradigm, therefore reducing its possibilities significantly.

At the same time, better understandings of the brain in general, facilitated by new measurement techniques, and of the learning process in particular, due to improved computational and psychological models, have allowed establishing a guide for the teaching–learning process which agrees in a more natural way with the new available technological options.

Unifying these concepts, the design of an educational system based on these paradigms was undertaken. Such system will be explained in detail in the present article. In the first place, basic concepts are given about brain and learning modeling. Later on, the laboratory is described, detailing specially the features of the user interface thought to ease learning. Finally, the results obtained are evaluated and the conclusions presented.

2. BRAIN AND LEARNING MODELS

The brain is a distributed system conformed by multitude of primary processing elements denominated neurons. Each neuron has a projection fiber or axon and a group of receivers or dendrites. Neurons are highly interrelated each other, constituting neural circuits, which, acting together, carries out information processing.

Connections among neurons are not random neither indiscriminate, but rather they follow a strongly genetic-guided pattern, even in the details that determine the specific points of contact [7]. Unlike other cells in the organism, neurons do not replace themselves, or at least not with the same speed. Due to these two facts, prior models of learning argued that it was only possible during the very first years of life, and, once that time window was close, the process of active learning was changed by one of memorizing.

Nonetheless, new facts coming from improved experiments and models have reported that learning is a never-ending process, and although it is true that neurons are not changed by new ones in huge quantities, it is true that learning is accomplished by creation [2] or reinforcement [12] of dendrite connections. Also, major shifts in learning theory point out the importance of emotion, motivation, and meaning [10] as key factors to be included in any serious model of learning. Moreover, it is necessary to be aware of the differences in the learning process during the several life stages; the cognitive processes involved in learning are not the same for a child, a teenager, or a young one [4].

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All these discoveries have motivated several authors to propose the necessity of reevaluating current educational paradigms [3] and to claim for immediate inclusion of strategies in accordance with these biological facts [6]. Knowledge should not be seen anymore as a ladder or a pyramid where low-level concepts uphold more abstract ideas; instead the symbolism of a web, where each concept is interconnected with many others is a better choice [4]. Also, learning is seen as the addition of new nodes to this web, which is carried out by connecting that node to the previous ones, being elaboration [9] and rehearsal [11] fundamental for success. To deal with such a schema, multi-approach techniques for teaching must be developed [5].

Psychophysiology experimenters are discovering that one learns a concept only when it turns to be a part of a neural circuit, expressed as changes in quantity and shape of dendrites and of protein production because of activation and or modification of DNA expression of some neurons of that neural circuit. The fine details of how these changes describe knowledge representation and manipulation are not well understood yet, but there exist indeed a strong correlation with learning [2][11][12].

Moreover, these changes are not produced is the new information being learnt has no *meaning* for the user, i.e. if he/she cannot establish *contact* with that matter, and integrate it to his/her *prior* knowledge. The purpose of tools such as the mentioned here is to promote those changes, allowing the user to *personalize* both the tool itself and the way he/she interacts with it. In this way, the user gets *actively involved* in the learning process. The idea is that he/she *enjoys* the process *and* learns quicker giving *personal significance* to what he/she is learning.

Traditionally, teachers claim that, although individualized education is very desirable, it is not possible because of the enormous time, resources, and effort it demands, then, tools like this can become a valuable help in making plausible that strategy.

3. A BRAIN-FRIENDLY LABORATORY

The learning environment proposed takes advantage of the principles enunciated before, being these the main design considerations:

- *Horizontality of concepts:* there is not path to advance from simple to complex ideas. Students are confronted with a screen showing a set or practices, any one of them popped up every time the application is opened (figure 1)
- *Personalization:* young people get involved more easily if concepts such as clan, pseudonym, and challenge are present. When using the tool, the user is allowed to choose a name from a group of heroes (chosen from music, sport, movie, and game stars), a personage, and a clan. Clans compete to obtain points; members of each clan also compete. Individuals with more points become leaders; finishing the term, real names of winning clan are added to the "hall of fame". Customization includes selection of different *skins* (figure 2).

Figure 1. Web-like starting screen

- *Prior-knowledge inclusion:* newborns do not come with a *tabula rasa* by brain, the same is true for any person starting to study any discipline. Every concept should be built in connection with those already present. Personalization let the users choose among several fields which they feel comfortable with, so the tool can build a profile, which can guide the selection of examples and help to maximize meaning.

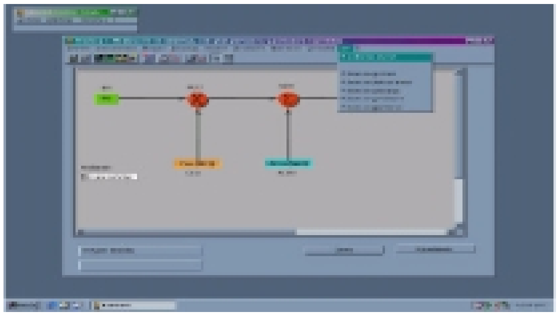
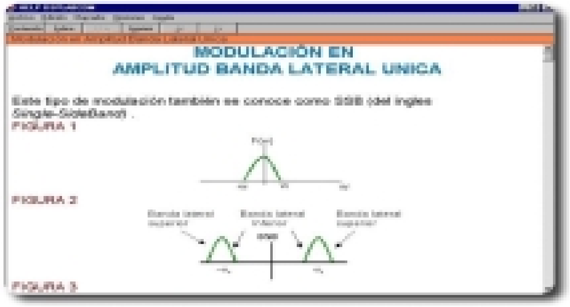


Figure 2. Menu-driven interface

- *Rehearsal:* students are encouraged to teach selected practices to lower-level classmates. This process promotes consolidation of knowledge through personalization and necessity of *verbalization*.
- *Elaboration:* students who have spent some time with the tool are presented with practices having mistakes, in order to promote elaboration of new concepts and relationships. Final steps include creation of entire new practices to solve *real* problems to ease meaning assignment.
- *Immediate support:* extensive help is provided, in several contextual, hyperlinked, and general forms. Insofar as possible, user-dependent strategies are provided. If a student solicits a specific subject several times, other forms of presenting the idea are given to his/her claim (figure 3)


MODULACIÓN EN
AMPLITUD BANDA LATERAL UNICA

Este tipo de modulación también se conoce como SSB (del inglés Single-SideBand) .

FIGURA 1

FIGURA 2

FIGURA 3

Figure 3. Help screen example

4. TECHNICAL DETAILS

In order to support the several strategies and requirements of the brain learning model, the learning environment must allow for different approaches to the object of study, likewise high customization must be provided.

The system is comprised of an application running on a computer acting as Server, a DSP network which emulates the practices [1], and communication possibilities to interact with real instruments and with other computers acting as Clients via Internet (figure 4).

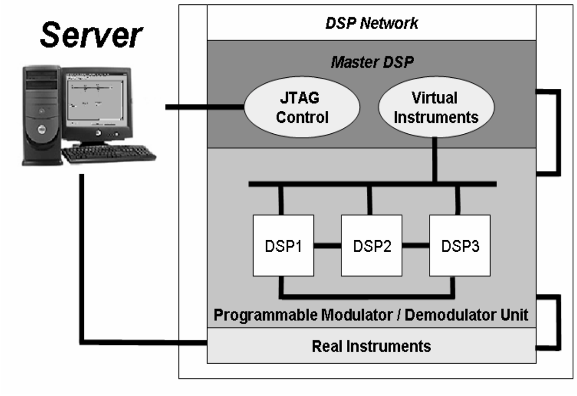


Figure 4. Components of the Lab

The Server is the place where the user selects or creates, customizes, simulates, and sends the practice. Practices have been chosen to grasp the main techniques for frequency, amplitude, phase, and spread spectrum modulation and demodulation [8]. Each practice has a set of predefined parameters, which allows for standard functionality. As the students evolve in their learning process, different parameters are required to be set by them. At the end, practices which must be fully customizable are presented. Simulations permit the students to get a feel of what the circuit must do, and of what possibilities the real instruments have (figure 5).

Once simulation has been analyzed, the practice is sent to the emulator. The external model comprised of blocks and connections is supported by an internal model based on a set of linked tables, which carries all the information necessary for the DSPs to execute the algorithms corresponding to a given practice (table 1). These tables, along with the object code for the constituent blocks, are downloaded either by serial of parallel ports. Through a JTAG port, it is possible to change parameters and control the behavior of the emulation, all on line.

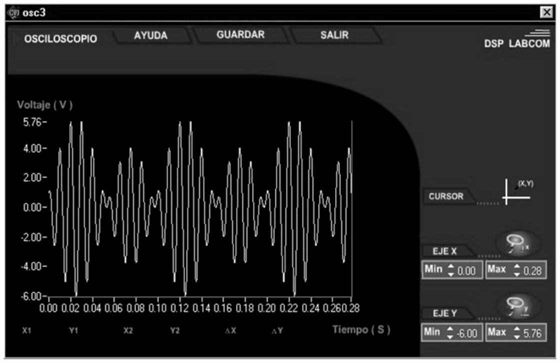
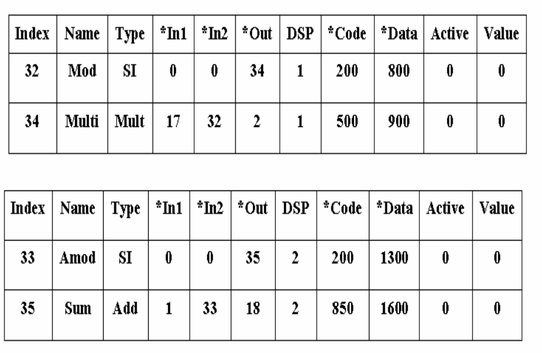


Figure 5. Scope output simulation

Besides the DSPs, which emulate the practice in a distributed fashion, there is another DSP that acts as a set of virtual instruments, which agree in place and functionality with those used in simulation. These instruments measure analog signals taken at the outputs of each emulator. At the same points, real instruments are connected, which are controlled via IEEE488 protocol. Both measurements are sent back to the Server in order for the students to observe and explain possible differences, so they realize intrinsic limitations of simulators and/or unavoidable presence of noise in physical signals.



Index	Name	Type	*In1	*In2	*Out	DSP	*Code	*Data	Active	Value
32	Mod	SI	0	0	34	1	200	800	0	0
34	Multi	Mult	17	32	2	1	500	900	0	0

Index	Name	Type	*In1	*In2	*Out	DSP	*Code	*Data	Active	Value
33	Amod	SI	0	0	35	2	200	1300	0	0
35	Sum	Add	1	33	18	2	850	1600	0	0

Table 1. Internal model of practices

5. TESTS AND RESULTS

The tool has been tested with several groups of students, having simultaneously control groups which do not use the tool and receive the traditional course. The scores obtained by the tested groups were consistently superior to those obtained by the control ones. Moreover, conceptual and practical examinations performed several months after finishing the courses, showed permanent and logical elaboration of key concepts by tested groups, and lack of continuity and poor elaboration by control groups.

Surveys were run to measure both groups' opinions (figure 6). As should be expected, given the type of users, the features that obtained the lowest punctuations are operability and controllability. They want to have absolute control of the tool, and want it to be quick and direct in all their procedures. It is necessary further evaluation to see if these changes are adequate or if it is important to set a limit to the freedom of action allowed to the users.

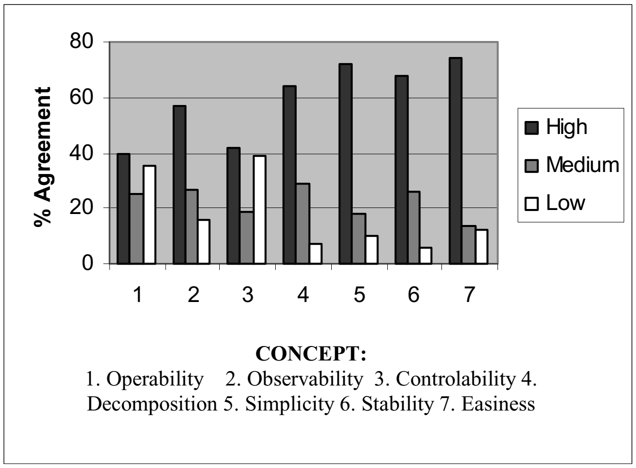


Figure 6. Concepts of the students about the tool

6. CONCLUSIONS

- Designing a laboratory tool based on cognitive models opens new perspectives for teaching
- A system like the presented here is an effective help for the learning process, since it combines the flexibility and comfort of simulation with the necessary contact with real elements
- Digital signal processing is a powerful and valid tool for emulation of communication systems and analysis and processing of modulated signals
- It is possible to design the simulation and execution engines the same way, obtaining more accurate results in simulation, and equivalent models to ease debugging and updating
- Using a standard interface such as JTAG for programming and debugging allows a robust and reliable system
- The set of practices selected permits the students to adapt to new technologies, maintaining conceptual formalism
- The way data is manipulated is coherent with the scheme followed by VHDL, allowing future integration with digital systems using the same tool

7. ACKNOWLEDGMENTS

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