Using SIMPLE To Support The Teaching Of Signal Processing Through Multimedia Tools

J. Manuel Ramírez[1], David Báez[1], William M. Marcy[2], Marion O. Hagler[2], Kathleen M. Harmeyer[3]
1. Universidad delas Américas, Electrical Engineering Department, México
2. Texas Tech University 3ExperTech
mramirez@udlapvms.pue.udlap.mx

Abstract

The work presented in this paper is a result of a workshop on multimedia instructional design for Engineering faculty held in Texas Tech University during the summer 1995, supported by the NSF . In this paper, a multimedia tutorial on signal processing is presented. The goal is to take advantage of the multimedia resources in order to present the concepts traditionally hard to visualize in this topic, in such a way that the student finds himself immerse in a self-study learning environment. This resources include graphics, animations, images, video, sound, and simulation packages.

This work was developed on a software platform called SIMPLE (1,2). The first part of this paper is devoted to explain the structure of SIMPLE and the strategy for implementing a learning environment lying in the use of virtual graphical user interfaces supported by a powerful database engine. In the second part, the tutorial on signal processing and some representative examples are described. Concluding remarks about the use of this material in the classroom as an educational support in the Electrical Engineering program at Universidad de las Americas, are presented.

Introduction

With the phenomenal growth in computing resources in the last years, specially those related to multimedia environment, there has been a strong interest in the academic community to take advantage of this trend with educational purposes (3,4,5). Last year in summer, the workshop sponsored by the NSF ¨Multimedia Instructional Design for Engineering Faculty,¨ was held at Texas Tech University, with the ultimate goal to promote the develop and use of multimedia material in the different areas of Engineering. One of the most important conclusions of the workshop was that even without all the professional resources required to produce multimedia material, outstanding results can be easily obtained when the instructor is willing to spend some time in putting together his ideas on the computer. In this context, SIMPLE (1,2) is an important software tool developed at Texas Tech University, conceived with the idea to provide an easy way for the instructor to collect related software and existing teaching material, without having to learn a new programming language, or writing any code. The strategy for implementing a SIMPLE learning environment lies in the use of virtual graphical user interfaces supported by a powerful database engine. Everything that comprises the appearance and structure of the learning environment is contained in a relational database, which allow the instructor to start creating graphical learning interfaces in a short period.

Description of SIMPLE

SIMPLE (Simplified Implementations of Multimedia Peripatetic Learning Environments) is an authoring software tool developed in *Microsoft Visual Basic* at Texas Tech University, based on the use of virtual graphical user interfaces supported by a powerful database engine. Through this approach, everything that comprises the appearance and structure of the learning environment is contained in such a database. The multimedia document created consists of a series of screens with a bitmap, image or picture, interconnected by a series of interactive controls hypergraphics style. Figure 1 shows a typical screen data.

Figure 1. SIMPLE Screen data.

According to the design of the document, every screen could have invisible hot spots (hypergraphics), text, visible control buttons and images located anywhere on the bitmaps. Invisible controls placed on a bitmap provide graphical clues to the exploration possibilities. Whenever the mouse passes over any hypergraphic area on the user screen, it changes shape to indicate that a hypergraphic link exists and exploration is possible using a mouse click. Associated with every control there is an action data box, which allows the designer to specify the type of control and action required for that specific spot. Figure 2 shows a typical Action Data box.

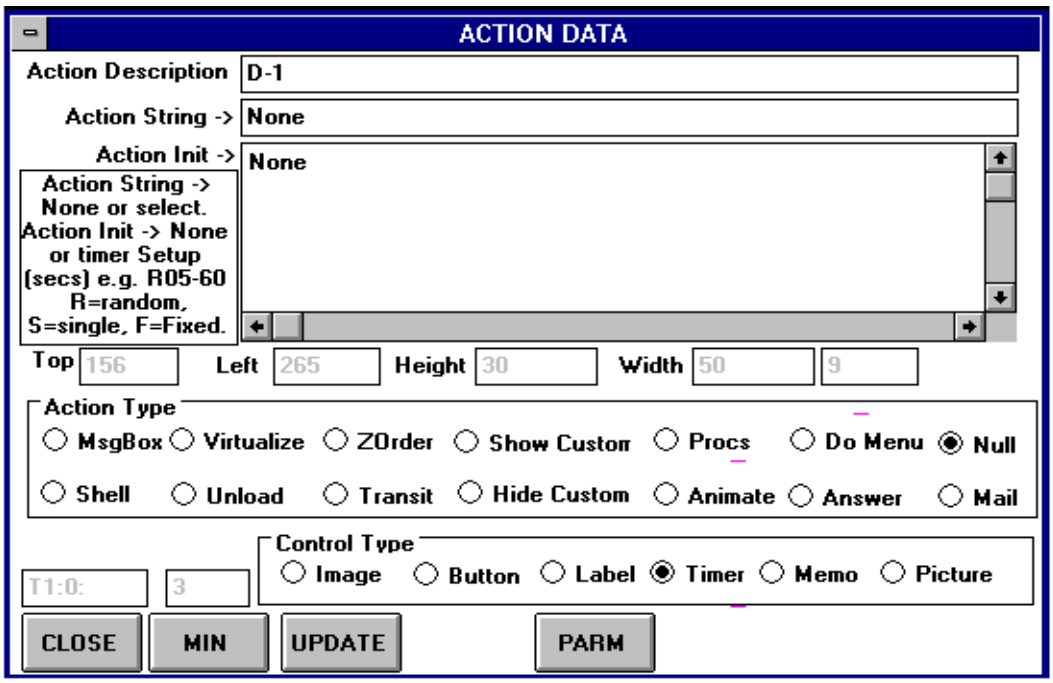

Figure 2. SIMPLE action data box.

Additional Multimedia Tools

Visual Basic 3.0 HelpWriter. An important tool to add context sensitive help for each screen, is the Visual Basic 3.0 HelpWriter from Microsoft. The HelpWriter can provide full hypergraphic support including pop-up menus, keyword searches, tables of contents, hypertext, etc. In the tutorial presented in this paper, the notes corresponding to the course Digital Signal Processing were used to provide a theoretical support to some concepts related to the topic. Once the required hypertext is compiled, a file with the extension .HLP is created. This file can be easily accessed from the SIMPLE environment by creating a control with the Action Type selected as a Shell, specifying the path in the corresponding place.

MathCAD Animations. The last version of the commercial software MathCAD Plus 6.0, from MathSoft Co., includes a feature to create animations on-the-fly from any worksheet. During the development of this tutorial, MathCAD 6.0 was found a valuable tool to support graphical visualization of several signal processing operations. The only required step is to define a variable named FRAME, which MathCAD recognizes as the changing variable required to create the animation. Figure 3 shows the box included in MathCAD 6.0 to create an animation.

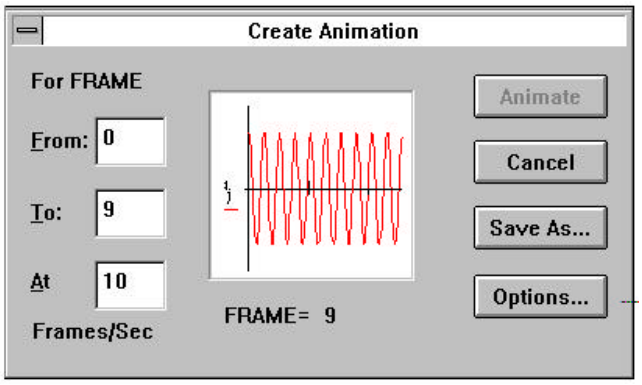

Figure 3. MathCAD 6.0 animation box.

Digital Signal Processing Tutorial Content

The multimedia tutorial presented in this paper is intended to be a complement of the theory revised in the undergraduate course on DSP taught at the Electrical Engineering Department of Universidad de las Americas, Mexico. The syllabus of the course is as follows:

- Discrete Time Signals and Systems
- Z Transform
- Discrete Time Fourier Analysis
- Fast Fourier Transform
- Digital Filters; Structures and Design

In every topic, the student is encouraged to try some videos, animations, or MathCAD worksheets, included with the goal of promoting his understanding of the subject. The content is not necessarily material that spans an entire course. Rather, it is thought of as a collection of relevant modules that can be drawn upon when needed. Multimedia courseware is, above all, interactive in nature. The concepts are supposed to be organized in a logical order by the designer, however, the students are free to explore other paths according to their own interest and progress. Some representative examples of these features are commented as follows.

Nyquist Criterium. A basic concept on Digital Signal Processing is the fact that in order to reconstruct a band limited signal, the sampling frequency has to be at least twice the bandwidth of the continuous signal, otherwise, aliasing will appear. This is the well known Nyquist Criterium. In this MathCAD animation the student can experience the result obtained when the criterium is exceeded. Figure 4 shows a snap shot of this animation. In this example, the sampling period is fixed, while the frequency of the continuous signal increases, allowing the student to visualize even the specific point corresponding to Fs/2, i.e., two samples per period.

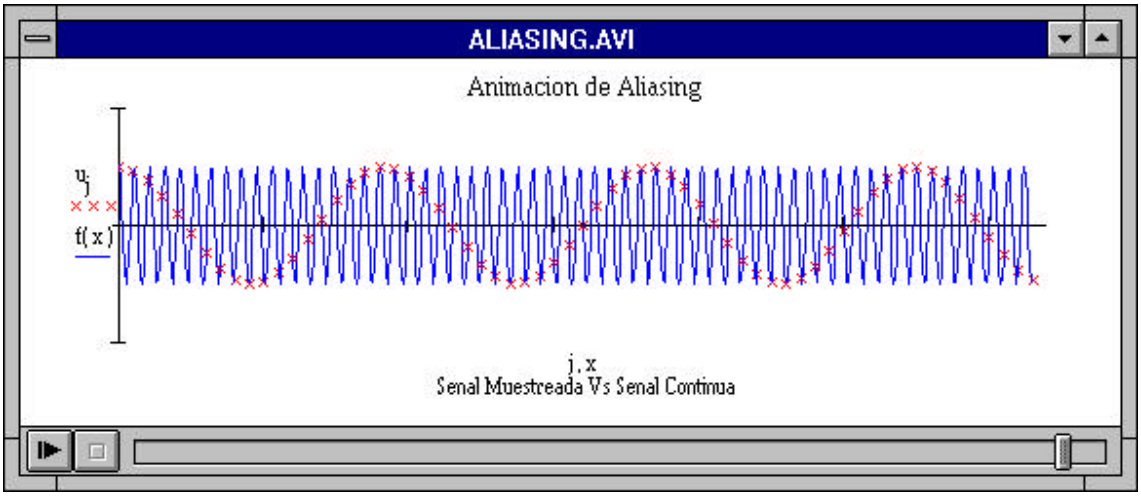

Figure 4. Aliasing

Discrete convolution. The convolution between the discrete sequences f1(k) and f2(k) is defined as: $f1(k) * f2(k) = \sum_{m=-\infty}^{\infty} f1(m) f2(k-m)$. The correct understanding of this operation is very important in the analysis and design of digital filters because the output of

a linear system is given by the convolution of the input sequence with the impulse response of the system. The coefficients of FIR digital filters, for instance, define the impulse response of the system. In most DSP textbooks the student will find several attempts to describe graphically

the mathematical operation of convolution. It is evident the advantage of multimedia facilities to illustrate the basic concept of this operation. In figure 5 a still image corresponding to the animation is presented. The student is able to see the animation at once, or any selected frame.

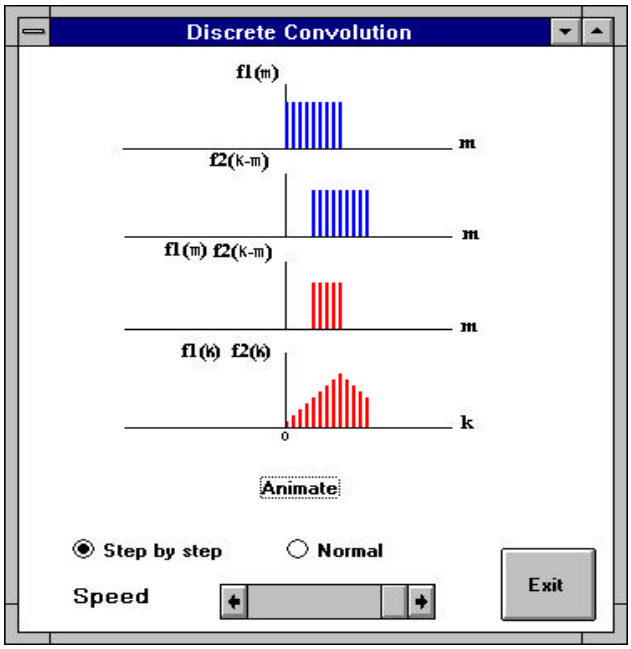

Figure 5. Animation of a discrete convolution.

Frequency response from pole-zero location in the Z plane. The last example is an executable file created in Visual Basic, which illustrates the relationship between the frequency response of a second order transfer function, and the corresponding pole-zero location in the Z plane. As can be seen in Figure 6, the student is able to enter poles and zeroes as needed, and the construction of the frequency response in magnitude can be visualized according to the position of the normalized frequency in the unit circle.

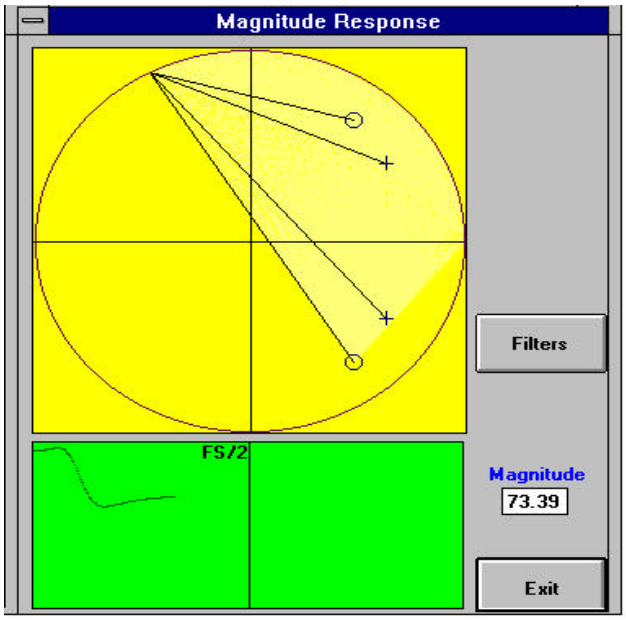

Figure 6. Animation of frequency response.

Conclusions

Preliminary results indicate that the multimedia tutorial described in this paper, can provide visualization tools through animations, videos, and still images, that are valuable additions to theoretical description in the classroom. Students have been invited to test the lessons, and their comments have been used to modify and improve the tutorial. With the aid of SIMPLE this process has been carried out in a very efficient way with good results so far. In a multimedia document, it is usual that the size of de data involved is very large, and this tutorial is not the exception. The most convenient solution is a writable CD-ROM, and a multimedia-ready computer, however, the result obtained with the students is worthwhile.

References

1. William M. Marcy, and Marion O. Hagler, ¨A new software environment for efficient production and use of interactive courseware.¨ Annual Conference Proceedings, American Society for Engineering Education, Edmonton, Alberta, Canada, pp. 2617-2622, June 26-29, 1994
2. Marion O. Hagler, and William M. Marcy, ¨SIMPLE in practice.¨ Frontiers in Education FIE 95, Atlanta Georgia, November 1995
3. M. Iskander and T. Reed, ¨Multimedia lessons for electromagnetic education,¨ IEEE AP-S International Symposium Digest, Vol. 3, 1993, pp. 1110-1113.

4. M. El-Sharkawy, ¨A multimedia laboratory,¨ Computer Applications in Engineering Education, Vol. 1, No. 2, 1993, pp. 129-140.
5. A. Elsherbeni, M. Tew, and A. Mokaddem, ¨Applying multimedia technology to undergraduate engineering laboratories,¨ Computer Applications in Engineering Education, Vol. 3, No. 3, 1995, pp. 157-164.