Integrated System for Cross-Platform/Cross-Application Education on Sound Synthesis and Signal Processing

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Abstract

This is a presentation of a Cross-Platform/Cross-Application Computer Music Education project in Italian and in English, at present based on Max-MSP and Csound 5, but expandable to other systems of Sound Synthesis and Signal Processing. The integrated system includes 1) a text of practice and theory (closely interconnected) in three volumes with a DVD-Rom. 2) An on-line course with tests, forum etc. The aim is to create a deeper awareness and a more widespread practical acquaintance with the field of electro-acoustic composition, sound synthesis and signal processing with a continuous interchange between practice and theory which is not based on a specific software application, but updatable and expandable to software and present or future systems.

1 Some History and Future Plans

The concept of an integrated system for computer music education called "Virtual Sound" dates back to 1998, when Riccardo Bianchini and Alessandro Cipriani planned the first version of the text Virtual Sound - Sound Synthesis and Signal Processing - Theory and Practice with Csound published by ConTempoNet (Rome), with the intention of creating a base for an integrated multimedia system. Since then the text has been published in 3 editions in Italian as well as one in English and it is currently used in several Universities and Conservatories all over the world. After the sad and unexpected passing away of Riccardo Bianchini, Alessandro Cipriani asked Maurizio Giri to continue to work with him on the construction of an integrated system that would involve the expansion to other cross-platform programs, such as Max-MSP, and the realization of an advanced site for teaching. The version of the project in the Italian language, to be called Virtual Sound with Max-MSP and Csound, will be published in 2007 (with a text published in three volumes with an interactive DVD and an on-line e-learning section). As regards the English version, the text and the DVD will be published in 2008 and the activation of the site is scheduled for the end of 2008.

2 Integration of Theory and Practice

This text with a DVD has a special feature, which is that of including theory and practice together, by means of Csound and Max-MSP. The book is divided into three volumes which are used in conjunction. In the first one the basic concepts are presented, including sound synthesis and signal processing theory for most common techniques. The second and third ones are dedicated to the practical uses of Csound and Max-MSP. The reader can choose which software application to work with and each paragraph of the theoretical volume corresponds to a paragraph in the second (or third) volume dedicated to practice with the chosen software. In the DVD all the resources and files necessary in order to work with a computer are to be found.

Some of the characteristics of this system are as follows:

Holistic Approach. The theoretical text is planned for an immediate practical application and has been tested with two of the most widespread applications. In this way the theory is never abstract, since the first volume is closely connected to the practice volumes, the DVD and to the practical use of the software. This volume is therefore not intended as just another manual of theory and it is not possible to compare it to other theory textbooks on sound synthesis and processing, such as Roads (1996) or Dodge and Jerse (1997). The aim of our system is to explain theoretical issues always in connection with production and perception of sound, in a holistic approach. The planning and presentation of the course takes account of the learning process and the progressive experience that the student will acquire in both areas (theoretical and practical). The student therefore always learns within a creative and motivating context, always in contact with the production and perception of sound and without ever entering into lengthy theoretical discourses or endless explanations of the mechanisms of the software.
knowledge and perception, and the interchange between deductive, inductive and creative processes is continuous. There are advantages and disadvantages, of course. Our theory manual cannot in any way substitute more complete and straightforward theory textbooks like the ones we just mentioned. On the other hand it introduces the main issues with a "hands on" approach.

**Cross-Application Approach.** The theory is connected to practice but it is not limited to a specific type of software. The theoretical part has been tested with two very different applications (one of them based on text programming, the other based on a graphical programming environment). The theory is conceived and presented in such a way that the user can alternate its study with practical exercises as s/he progresses. This makes it possible to expand the practice volumes to cover other software applications which conform to the presentation of the theory, while leaving the first volume unchanged. In fact we expect that it will be possible to apply the system to other applications such as PD, Kyma, Super Collider, Reaktor etc.

**Net-Like Configuration.** In every chapter there is a glossary and a specific discography regarding the type of synthesis, tests, technical and creative exercises, reverse engineering activities, analysis of algorithms etc. The teaching process therefore has a non-linear net-like configuration. In addition the support supplied by the exchanges that the user can establish with other users in the forums and by the integration of the course with on-line teaching allows for further verification of the terrain that has been covered. At the beginning of every chapter there is a "teaching contract" that indicates which are the requirements and demands for understanding the following chapter (generally an acquaintance with some of the previous chapters) and specifies the notions which will be acquired by studying it.

## 3 The content of the three texts

The list of the chapters contained within the three volumes is as follows. The titles of the chapters of the volume of theory and each of the practical volumes correspond to each other. One practical volume is for Csound5, the other for Max-MSP.

**Chapter 1 – Sound Synthesis with Csound and Max/MSP**

In this first chapter the fundamental concepts of sound synthesis and signal processing are introduced and the syntax of Csound and Max/MSP is presented, putting the reader in a position to be able to work with these two programs.

**Chapter 2 - Additive Synthesis and Vectorial Synthesis**

The various types of additive synthesis are explained: with fixed and variable, harmonic and inharmonic spectra. The concepts of periodic and aperiodic waveforms and the phenomena of beatings and wave interference are introduced. Also wavelable synthesis and vectorial synthesis are illustrated as techniques that are conceptually analogous to harmonic additive synthesis.

**Chapter 3 - Filters and Subtractive Synthesis**

Various types of spectrally rich signal generators and noise generators are illustrated, followed by an in-depth explanation of the uses of various types of filters. This is then followed by various different applications of subtractive synthesis and the use of filter banks as equalizers.

**Chapter 4 – Control signals for Vibrato and Tremolo, Filters and Spatialization.**

This chapter presents and explains the various techniques for the use of envelopes and LFO for parameter control of spatialization and the techniques of synthesis illustrated up to this point.

**Chapter 5 - Amplitude, Frequency, Phase and Ring Modulation, Phase Distortion and Non-linear Distortion (Waveshaping)**

This chapter is dedicated to the most frequently used techniques of modulation and distortion, and the characteristics and specific applications of each technique are indicated.

**Chapter 6 - Digital Audio and Sampled Sounds**

In this chapter digital sound is discussed, as well as Analog to Digital and Digital to Analog conversion, the sampling theorem, Nyquist frequency and foldover, and the recording and use of sampled sounds.

**Chapter 7 - Granular Synthesis and Formant Synthesis**

The various techniques of synchronous and asynchronous granular synthesis are illustrated. The granulation of sampled sounds is discussed, as well as the use of formant wave synthesis (FOF) for the simulation of voice and resonant bodies.

**Chapter 8 - Delay, Echo, Chorus, Flanger, Phaser, Comb**

The chapter is dedicated to some of the most widespread techniques of sound processing.

**Chapter 9 - Dynamic Processors**

This chapter deals with the techniques for dynamic range processing: compressors, expanders and limiters, and multi-band dynamics processors.
Chapter 10 – Reverberation
Various techniques for the simulation of reverberation are illustrated, ranging from the reverberators of Schroeder and Moorer to those of Gardner.

Chapter 11 - Convolution
This chapter deals with the various uses of convolution technique: from cross-synthesis to the creation of reverberations and resonant bodies.

Chapter 12 - Analysis and Resynthesis
In this chapter Fast Fourier Transform, Phase Vocoder, Heterodine Analysis and Linear Prediction are discussed.

Chapter 13 - Physical Modeling
The principles of synthesis for physical modeling are explained. Those principles are applied to the simulation of plucked string, struck plate and the tube with single reed.

Chapter 14 - MIDI and Real-time
The topic of real-time control of the parameters for synthesis and sound processing is examined with particular reference to the various MIDI devices available today.

4 Content of the DVD
The DVD contains:
- All the orchestras and scores of Csound and the patches of Max/MSP which are mentioned in the text.
- An archive of externals for Max/MSP that simplifies the programming and supplies new functions. This archive is widely used in the text and the On-Line Courses.
- A series of applications for Windows and Macintosh that interactively illustrate the topics explained in the theoretical part.
- Appendixes containing in-depth analysis and support, dealing with Acoustics, Trigonometry, Conversion Tables, etc.
- A series of passages and reading matter by various authors dealing with particular techniques of synthesis and other topics regarding computer music.
- A large database of musical examples.

5 Online Courses

5.1 The structure of the course
The on-line courses (www.virtual-sound.com) consist of a series of units arranged in groups of teaching modules.

A teaching module can contain between 5 and 20 units, and a course can consist of from 5 to 10 teaching modules:

Figure 1. Structure of the Course

At the same time as the study of the educational units, the student will take a series of tests that will allow him or her to verify the level of learning reached, as well as having various exercises to do. In order to resolve any doubts and problems, but also to stimulate the exchange of ideas and suggest themes for discussion the student will have a forum at his or her disposition where s/he will be able to communicate publicly with the teachers and the other students of the course.

As well as this s/he will be able to communicate privately with teachers and colleagues through an internal system of e-mail dedicated to the course. Also interactive communication will be possible thanks to the chat-room that will be available.

5.2 Development of the courses
- The student studies the chapters of the text Virtual Sound and the educational units that are assigned to him or her. At the end of every series of units there is a self-evaluation test.
- The student carries out the self-evaluation test that consists of a series of multiple choice questions and a series of interactive exercises. At the end of the test the percentage of exact answers is calculated.

Figure 2. Interactive exercise: the student must drag the elements of a Csound command to the correct position
The test can be repeated a number of times, until the percentage of correct answers exceeds 80%. A score of over 80% indicates a sufficiently good knowledge of the arguments dealt with.

- When the student has passed the test, the tutor sends him or her a series of exercises to carry out, through the system of internal e-mail. The student carries out the exercise and sends it back to the tutor who corrects it and comments on it.

- During all the phases of the course the student can ask the tutor to provide clarifying explanations, to go into certain issues in more depth, and to exchange ideas with the other students through the forum associated with the course.

- The most interesting solutions that the students come up with while performing the exercises assigned to them will also be discussed in the forum.

- Within the chat-room a communication in real-time between the students and their tutor will be possible. The chat-room will also be used for the verification of the knowledge acquired.

- At the end of the course an attendance certificate will be issued with the indication of the final mark obtained, signed by the teacher of the course.

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References