Digital Filtering for Musicians

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Abstract

The CD-ROM *Digital Filtering for Musicians* was made to build a bridge between two very diverse, yet interrelated topics; digital audio techniques and music, with the main focus on one of the central techniques: filtering. To make optimal use of digital filtering in a musical context requires insight in mathematics and computational theory as well as music. By presenting these three fields side-by-side on an interactive basis, readers can familiarize themselves with the relevant topics and their relations, without being overwhelmed by the complexity of the subject.

1 Introduction

Music, digital theory and filtering theory are three diverse and very broad subjects, yet knowledge of all three is needed for the optimal use of digital audio filtering.

While many books exist on both the individual fields and their combinations, with excellent ones among them, *Digital Filtering for Musicians* takes a different approach. For various reasons, the CD-ROM was chosen instead of a book, and the content is laid out much like a website, with information structured in pages, and links containing their relations. The digital format allows the inclusion of sound fragments, as well as the freedom to choose a path of reading, rather than just turning the pages. Because of this approach, the complex, difficult material may be understandable for a broad range of readers.

This article introduces the CD-ROM, and motivates the approach.

2 Digital filtering

Digital filtering is a central technique in digital signal processing (DSP). A filter can modify the spectral content of a signal, or to put it in musical terms, change its timbre. This, plus the fact that viewed from a mathematical and computational point of view filters are very simple, makes filters ideal building blocks for signal processing.

Digital filtering forms the basis for most digital audio processing. Digital filters are used in effects processors like flangers, reverbs, phasers and wah-wahs. They are also common building blocks in analytical devices such as spectral analyzers, and digital synthesizers.

2.1 The relevance of understanding filters

Filters are usually described in terms of their frequency response; the way in which the filter affects the spectral content of its input signal.

To design a filter with a specific frequency response is not a simple task. While various modeling methods exist, they often require a good knowledge of complex mathematics. As a result, many musicians shy away from filter theory and only use those applications that are readily available. On the other hand, designing a filter without sufficient musical skills can result in filters that do not meet musicians' demands.

Having both a musical ear as well as insight into the issues involved with digital filtering opens the way to the development of new instruments and techniques.

3 The CD-ROM

The structure of the *Digital Filtering for Musicians* is very much like a website. Viewed in the browser, the window consists of three parts, a navigation frame, a content frame and a topic frame. In the topic frame the actual information is presented, consisting of text, images, audio examples and programming source code.
To switch topics, the reader can either select a topic from the content list, click a link in the topic text, or use the navigation services, which lead to related subjects.

3.1 Topics

The CD contains over 100 topics, ranging from synthesis and effects processing to Fourier analysis, circular buffers and convolution. In the content list all topics are grouped into chapters, such as digital system implementation, musical applications and mathematical analysis. Browsing from the links in the text bypasses this ordering, and thereby circumvents the conventional layout of textbooks.

3.2 Audio examples

Over 75 audio examples complement the written text. The audio files are provided in the high-quality 16-bit 44.1 kHz format, and can be played immediately from the browser. While some are pieces of music captured from recordings of the actual use of filtering, others are made solely to further explain a discussed technique.

3.3 Code examples

Programming source code examples are also included. Written in the C or the Csound language, they are intended as an introduction to the implementation of digital filtering techniques. Seeing the actual implementation of an algorithm can sometimes be far clearer than a complex mathematical formula.

As the examples are working programs, the interested reader can use them as a basis for further exploration.

4 An electronic book

Digital Filtering for Musicians is an electronic book, which allows for some possibilities not found in conventional books. Rather than being 'a book on the screen', the CD-ROM has interactive features to facilitate the reader in studying the various aspects of digital filtering. In addition, many readers will probably just 'click away', and have fun playing the audio examples.

4.1 Customizing the content

Without a scientific background, most books on digital signal processing (DSP) are hard to read. The abundance of complex formulas can be distracting if one is only interested in the underlying global mechanisms. Therefore the CD-ROM has a switching mechanism, allowing the reader to switch extra information on mathematics, music or computational science on and off. When all switches are on, every topic is presented in full, thereby clarifying the relation between formulas, programming code and audio. Setting only one switch facilitates the concentration on one aspect, without distraction by other details.

4.2 Implementation

To be able to create a book with auditory examples, a customizable content, and without a pre-fixed order, the HTML language was chosen, enriched with JavaScript. These languages are ways of coding text, image and auditory content so that when interpreted by a browser (such as Netscape's Navigator) an equal result is produced on most computers and monitors. When the reader calls up a topic, a new page is rendered to suit the current settings and configuration

5 Intended audience

The theory and application of musical digital filtering requires knowledge of three disciplines; mathematics, computer science and music. *Digital Filtering for Musicians* is intended for anyone who has a background in one of these fields, and an interest in the others.

Rather than presenting new approaches or algorithms, the aim is to give an extensive overview, in an unconventional format.

Because of the absence of a pre-fixed order of reading, one can at any point decide to delve deeper into a subject, or skip distracting information. In this way it is tried to make a 'multi-level book', a book that can be read by novices as well as experienced scholars.

6 A practical example

To clarify the way, in which the CD-ROM can be used, take the case of a musician who wants to know how a flanger works. A likely starting point would be the flanger page, which can be selected from the list of contents. The topic frame contains text, explaining the internals and the use of a flanger, a block diagram and an audio example. Additionally, there are links in the text that point to further explanation of delay lines, spectrum, feedback etc. At any given time a reference list can be called up, containing books, websites and other sources where information on the current subject can be found. Also, there is a list of related topics, which in the case of the flanger contains links to subjects like dynamic filters, csound and comb filters.

Likewise, an experienced mathematician may also end up at the flanger page, via topics like the Fourier Transform and the delay line.

7 Conclusion

The goal of *Digital Filtering for Musicians* is to open the world of musical digital filters and their applications to anyone who is interested, regardless of his background and ambitions. Through multimedia and Internet technology it is possible to create a customizable textbook, which presents its content through text, image, audio and interrelation.

The reader can choose his own path, from any starting point, and investigate along the lines of his interest at that point in time. It is this functionality, combined with the consequent integration of music and technology, which can give the CD a place in the already large body of literature on the subject.

8 Availability

The CD is currently available only from the author. It runs on Windows as well as MacOS, using Netscape's Navigator browser. Microsoft Internet Explorer can not be used.

As Netscape does not provide the LiveAudio plug-in with its UNIX versions, audio examples can not be played directly from the browser in a UNIX environment.

9 Acknowledgements

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