2DEQ: An Intuitive Audio Equalizer

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ABSTRACT

The complexity of music production tools can be a significant bottleneck in the creative process. Here we describe the development of a simple, intuitive audio equalizer with the idea that our approach could also be applied to other types of music production tools. First, users generate a large set of equalization curves representative of the most common types of modifications. Next, we represent the entire set of curves in 2-dimensional space and determine the spatial location of common auditory adjectives. Finally we create an interface, called 2DEQ, where the user can drag a single dot to control equalization in this adjective-labeled space.

Author Keywords

adaptive filters, music, user interfaces

ACM Classification Keywords

H.5.2 [User Interfaces]: Auditory (non-speech) feedback

General Terms

Algorithms, Experimentation, Human Factors.

INTRODUCTION

Software tools are widely used in audio recording and production. While these tools are powerful, they are also complex. The result of this complexity is that musicians without technical expertise can spend a great deal of time stumbling through a large range of parameter settings, thereby disrupting the creative process by directing attention away from the music itself.

We wish to rethink interface design for audio production tools. Musical creators should not need to have technical expertise and should not reconceptualize their ideas in terms of a fixed interface with esoteric parameters. Instead, we propose to build a software tool based on user data with a simple interface designed to provide easy access to common audio modifications. In this paper, we apply this approach to the audio equalizer, but we anticipate that it can be applied to a wider range of audio processing techniques.

Audio equalizers are perhaps the most common signal processing tools used in audio production. Equalizers selectively boost or cut restricted portions of the frequency spectrum, and in doing so dramatically alter the timbre of a sound. The effect of an equalizer can be described by the *equalization curve,* which describes the extent of energy boost or cut at each frequency. In general, frequency is on the x-axis and *gain* (the amount of boost or cut) is on the y-axis.

The most similar previous work is that of Mecklenburg and Loviscach [1] who also designed a simple equalizer (subjEQt) where a user drags a single dot in 2 dimensional space labeled with natural language. However, in this work the spatial layout of the equalization curves on the control structure was determined using a self organizing map [2] governed by rules that the researchers felt were intuitive, but were not based on any explicit perceptual data. Similarly the researchers' intuition was used to create the equalization curves themselves. The present work distinguishes itself from this approach because the potential equalization curves, the spatial layout, and the mapping to descriptors are all derived through an analysis of user-generated behavioral data.

EQUALIZER CONSTRUCTION

First we collected a large set of user-generated equalization curves that were intended to represent that user's mapping to a particular descriptor. For a more detailed description of this process see [3]. Briefly, a series of 25 equalization curves are applied to a single recording. After each curve is presented, the user rates how well that curve captured their concept of a particular descriptor (e.g., how "tinny" was that piano sound?). After rating a line is fit to gain vs. rating data for each frequency band. We call the array of slopes across frequency the *weighting function,* which represents the direction and extent to which each frequency band influences the perception of the descriptor. In total we gathered a total 279 weighting functions from nineteen normal hearing listeners using 5 different recordings (piano, drums, saxophone, vocals, guitar) and 4 different descriptors (tinny, warm, bright, dark).

Next, we represented the entire set of curves in low dimensional space. Each weighting function was comprised of 40 separate frequency bands. Assigning a parameter to each band would create a complex interface. To address this problem, we performed a dimension reducing procedure called Principal Component Analysis (PCA) to determine how well the learned set of equalization weighting functions could be described as a linear combination of a small number of component weighting functions. Interestingly, two components (depicted in Fig 1 A and B) can account for 87% of the variance in weighting functions, and therefore could be used to create a useful interface.

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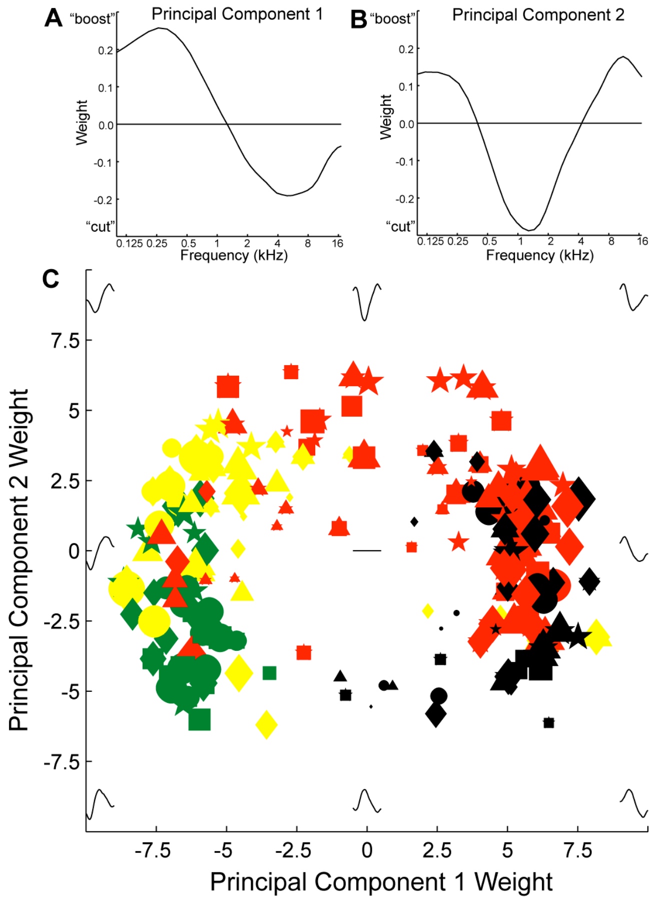

Figure 1. (A-B) The two principal components shown as weighting functions. (C) All weighting functions in the space of principal components.

We then computed the location of each weighting function in this two-dimensional principal component space. Each weighting function can be represented by a pair of multipliers where each multiplier is applied to one of the components before the two are summed together. In Figure 1C the multipliers summarizing each weighting function are represented in the horizontal and vertical position of each point. The color of the symbol indicates the descriptor corresponding to the weighting function (red = warm, yellow = bright, black = dark, green = tinny), and the shape indicates which recording was used (diamond = saxophone, vocals = square, drums = star, piano = triangle, acoustic guitar = circle). The size of each symbol indicates the reliability of the learned equalization weighting function (larger = more reliable, see [3] for details). Despite a fair amount of variability, there appears to be some consensus in the mapping of the descriptors to location in this 2-dimensional space.

Finally, we used this space and the corresponding mapping to descriptors to construct a novel equalizer interface, which we call 2DEQ (Figure 2). The user can simultaneously manipulate all 40 frequency bands of the equalization curve by moving a single point around in the two dimensional principal component space. Each point in the space has a particular color (same as above) that reflects the probability given our dataset that the current equalization curve (the bottom of the interface) will be perceived as a particular descriptor.

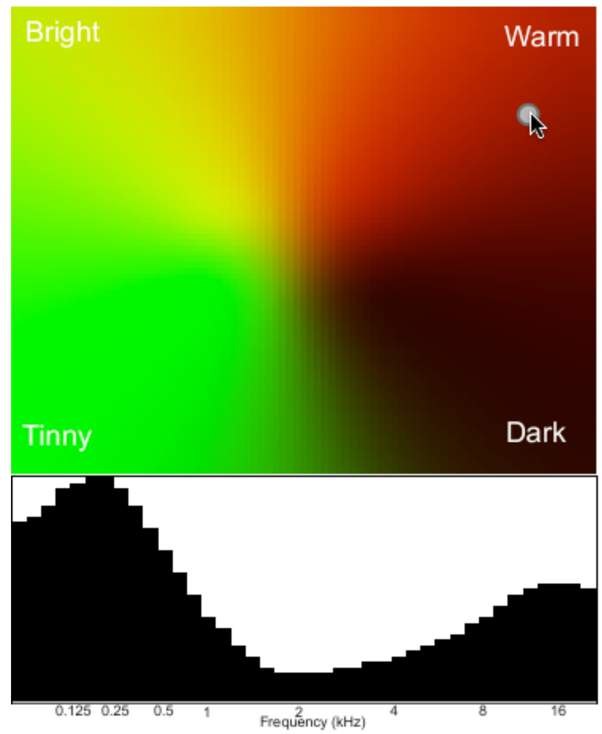

Figure 2. A screenshot of 2DEQ

CONCLUSIONS

We feel that the current approach could be applied to a wide array of creative signal processing applications with some limitations. A representative set of the most common parameter settings must be gathered and then analyzed by a dimension reduction technique. Those dimensions are then presented to the user with a simplified interface, labeled with descriptors where applicable.

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