HaptEQ: A Collaborative Tool For Visually Impaired Audio Producers

Aaron Karp
Northwestern University
Evanston, IL
aaronkarp123@gmail.com

Bryan Pardo
Northwestern University
Evanston, IL
pardo@northwestern.edu

ABSTRACT

Audio production includes processing audio tracks to adjust sound levels with tools like compressors and modifying the sound with reverberation and equalization. In this paper, we focus on audio equalizers. We seek to make a tactile interface that lets blind or visually impaired users create an equalization curve in an intuitive manner. This interface should also promote collaboration between blind and sighted users. Our primary goals were to make something easy to install and intuitively understandable for both sighted and blind users. The result of this research is the HaptEQ system.

CCS CONCEPTS

• **Human-centered computing → Haptic devices**;

KEYWORDS

User centered design; multimodal interaction; cross modal mapping; haptic interfaces; digital audio production.

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1 INTRODUCTION

Audio production includes processing audio tracks to adjust sound levels with tools like compressors, adding effects such as reverberation and equalization and combining multiple audio recordings (tracks) together into a single recording (the mix). Production is essential to producing high quality music recordings, radio broadcasts, podcasts, and video.

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Since the output of audio production is inherently sonic, rather than visual, audio production is an area where those with visual impairments have historically been able to compete on a relatively level playing field with the sighted population. Over the last two decades, however, the prevailing trend in interfaces for audio production tools has been to move away from interfaces that are relatively friendly to eyes-free operation (e.g. traditional mixing boards with physical knobs and sliders) to ones that are extremely difficult to operate eyes-free (e.g. a mixing board on an iPad, where the sliders are visual design elements with no tactile cues).

In this work, we focus on audio equalizers. These tools affect the timbre and audibility of a sound by boosting or cutting the amplitude in restricted regions of the frequency spectrum. They are widely used for mixing and mastering audio recordings. One popular kind of equalizer is a parametric equalizer (see Figure 1), where the user manipulates a line called the equalization curve, or EQ curve. The EQ curve indicates how much to boost or cut a given frequency band (in dB). The horizontal dimension indicates frequency from low (left) to high (right). Moving up indicates boosting the volume and down indicates cutting the volume.

We seek to make a tactile interface that lets blind or visually impaired users perceive and manipulate an equalization curve in an intuitive manner. This interface should also promote collaboration between blind and sighted users. Additional goals are to make something easy to make/install, that is low cost and uses off-the-shelf parts.

2 RELATED WORK

Figure 1 is a typical software parametric equalizer interface. Without using one's eyes it is very difficult to locate and use the interface elements. Additionally, the interface provides only visual feedback on the shape of the equalization curve. This poses a large burden on people with significant vision impairments. This leads us to explore an interface that can be naturally interacted with in a non-visual way.

Non-visual interfaces, while essential for blind users, can also help sighted users complete tasks more quickly and accurately by reducing visual load. Multiple studies have shown

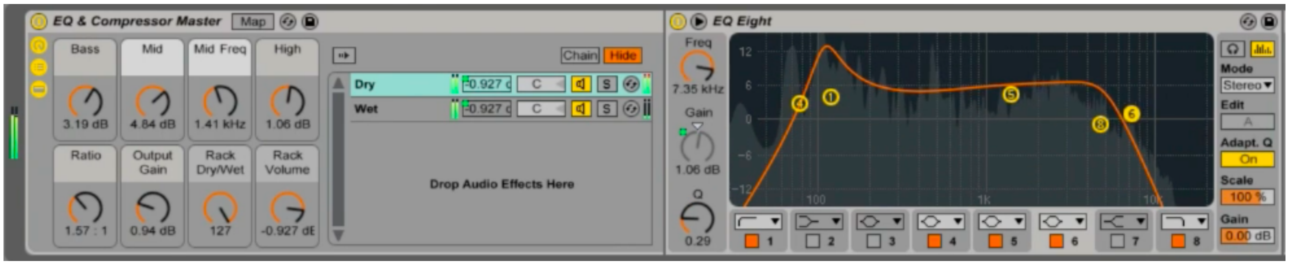

Figure 1: Above is the default equalizer used in Ableton Live. The EQ is adjusted by dragging the circles on the right and turning the labeled knobs on the left.

that an increase in visual load and complexity decreases critical listening skills [7, 12, 13] and causes inaccuracies in aural perception [5, 15].

Perhaps the most widespread non-visual interface approach is the screen reader. Screen readers [6], like the popular Jaws program, are software that speak aloud the text on a screen with a speech synthesizer. Visual displays that have text tips compatible with screen readers may allow a blind user to tab over visual elements and hear what the controls are called. Controlling an interface by tabbing over dozens of controls and menu items can, however, be very difficult. Additionally, receiving aural feedback from a screen reader while listening to the manipulated audio leads to confusion and lack of clarity on both accounts.

Studies have shown that direct translations from graphical interfaces to audio or haptic interfaces are often unintuitive or entirely non-existent, especially with regard to DAWs (digital audio workstations) [8]. This causes particular problems because of the tendency of graphical user interfaces (GUIs) to present a large amount of information simultaneously [9, 10], something difficult to accomplish in a non-visual medium.

Within the world of music production, haptics are often used as methods of control [11]. Haptic modes of interaction are most frequently seen in conjunction with novel instrument design or manipulation [1, 4]. There also exist some tools for audio production that employ visualization [3] and/or hands-free controls [14] as means of altering lower level sonic properties. There are no haptic tools for audio production that we are aware of that combine control, visualization and non-visual feedback into a single interaction, creating an eyes-free mode of interaction that still allows visual inspection.

The closest such tool that has been created is *Haptic Wave* [16], which is a device targeted towards blind musicians and sound engineers. It lets one scan the amplitude curve of an audio file by pulling a slider horizontally. Horizontal position indicates time. As the user pulls, the slider is pushed up or down by the machine, and the height is determined by the amplitude of the audio at that point in time. Haptic Wave, while beneficial as a tactile display for blind audio producers, has no method for accepting input to alter the audio. Thus its use is limited to various applications of displays, rather than manipulation. Further, there is no way for a sighted user to visually grasp a curve as a whole with Haptic Wave, as one has to pull the lever and feel it being pushed up and down. We seek something that is both haptic and easily perceptible with vision. to allow natural collaboration between sighted and blind users. Finally, Haptic Wave is a complex and specially engineered device. At present, only three Haptic Waves have been produced and more cannot be easily made by anyone other than its designers.

3 DESIGN GOALS

The work presented here, while informed by projects such as Haptic Wave, takes a different approach to the design of non-visual interaction. In designing HaptEQ, we had three primary goals in mind. First, we wanted it to be low-cost to prevent price from being a barrier to creativity. Second, we sought to make it easy to put together. Instead of creating a device that could be mass-produced and sold, we felt it would be more realistic to create a tool that people could easily build or modify themselves.

Finally, we wanted to make a system that could be used by people with visual impairments in collaboration with sighted users. Creating a device that has both haptic and visual representations was essential to creating a collaborative tool, thus allowing one user to interact with the haptics while other users can view an equivalent visual representation.

4 DESIGN PROCESS/DESIGN SPACE

The display paradigm we settled on was the standard equalization curve. Figure 1. shows such a display on the right side of the interface. If one could both feel and directly manipulate such a line, it could make an ideal haptic display and control.

We considered using a variety of sensors and servomotors to provide electro-mechanical haptic feedback. The cost and

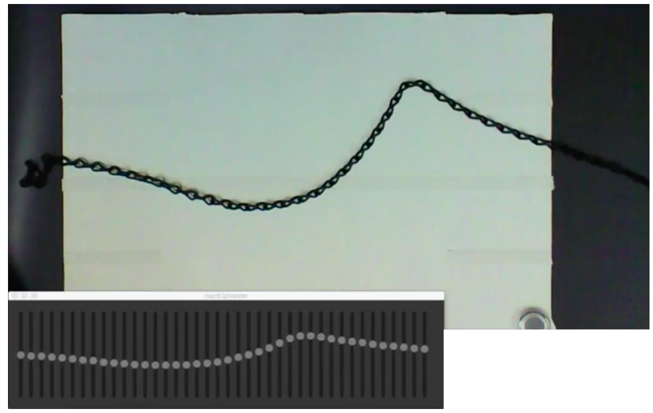

Figure 2: This is a screenshot of the HaptEQ plug-in in Ableton Live with the camera live feed enabled. The small circle in the bottom-right corner is the on/off magnet.

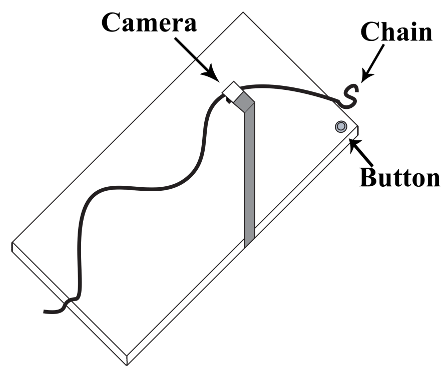

Figure 3: This is a diagram of the physical HaptEQ setup.

complexity of such a system proved prohibitive. We considered simply using a standard slider-based board (like existing mixing boards) and assigning different frequency channels to different sliders. Such boards, however, cost hundreds or thousands of dollars and lack the ability to flexibly represent a curve like that in Figure 1. Finally, we chose to focus on using, low-cost, passive tactile elements that could be easily felt and manipulated by hand, while simultaneously being easy to understand visually.

We settled on using a flexible chain on a plain background to represent the EQ curve. This can be easily felt and easily seen and maps directly onto standard EQ curves used in existing tools.

The shape of the curve specified by a chain on a plain background can be easily determined using a simple USB camera and standard computer vision software. We use *OpenCV* [2] to handle low-level vision processing. Once the line is captured, we translate it to an equalization curve used to control a custom equalization plugin for audio workstations.

Some of our design choices were made to facilitate detection of the EQ contour. Our initial interface background was a standard whiteboard, but we found the reflectance of the board made object detection unreliable. Therefore, we switched to a matte surface, and found white cardstock works well. User tests revealed that we needed to make our line detection software (based on *OpenCV*) more robust to rejecting the hand of the user from being considered part of the EQ curve. By combining multiple properties of the image contour, such as its arc length and the size of its bounding rectangle, we were able to ignore the hand when it does not directly lie over the chain.

Other design choices were to make the interface more stable in the face of manipulation. A significant issue is that of unintentionally moving the chain: Specifically, when a user set a boost or a cut to one frequency (say...a low frequency boost) they would move the chain to some position. Then, if they wished to manipulate another frequency, (say...a high frequency cut), the second manipulation would cause the entire chain to move, undoing the low frequency manipulation.

To correct this issue, we explored different options, such as putting a pin through the chain to fix a point, or using a very heavy chain. We finally settled on using a magnetic surface for the board, which let us use a thinner chain, for finer control, while giving it an induced sense of greater weight. We found flexible magnetic sheets work well and settled on using four sheets of size 11.75"x 17.75"x 0.060" (85 lbs. pull per sq. foot each), stacked on top of one another achieve a board of the appropriate magnetic strength (roughly 150 lbs. pull per sq. foot on the surface of the top sheet). The use of a weak magnetic surface makes it much easier for a user to manipulate one portion of the EQ curve without disturbing other portions of the curve. It also lets one trace a finger along the chain to feel the EQ curve without disturbing it, thereby letting visually impaired users feel the shape of the EQ.

Feedback from sample users indicated it was necessary to have some haptic indication of ones' relative position on the board. By placing white matte tape marking regular intervals along the vertical axis of the surface, we maintained visual simplicity while allowing the user to feel different set positions (e.g. 0 dB boost/cut) by encountering the slight ridge caused by the tape. One visually impaired musician was included early on in the design process, and her feedback informed the final texture and spacing of the physical markings.

User feedback also showed it was necessary to have a simply physical control to turn the equalizer on and off. To achieve this, we simply have the user place a circular magnet on the board (to indicate "on"). The user takes the magnet off the board to turn it off. The interface is shown in Figure 2

5 THE HAPTEQ SYSTEM

The parts list for our configuration and the the source code for HaptEQ can be found on our Github repository: https://github.com/aaronkarp123/HaptEQ. This compiled and ready-to-use version of the software includes the equalization plug-in, which can be linked to your DAW of choice by adding the plug-in's folder path to the DAW's plug-in settings.

The physical portion of HaptEQ satisfies our goal of making an affordable haptic interface. The total cost of the parts list for HaptEQ is $58.34. A physical 40-band interface costs upwards of $2,000 and the median price for an Ableton Launchchpad, which is a standard touch-based controller for Ableton Live, is around $300. Viewed next to any comparable equipment, HaptEQ is very inexpensive.

The physical materials and setup described on our website are one example configuration of HaptEQ. These can be varied to suit the user. For example, we used a Creative Live! Cam Sync HD 720p Webcam, although any USB-interfacing camera can be used for HaptEQ.

6 USING HAPTEQ

In use, the HaptEQ system functions as follows. First, the user would open up a project in a standard DAW of their choice, such as Ableton Live, Logic Pro, or Garageband, and select what track they wish to apply the equalization to. Next, they select HaptEQ from the *Plug-in* menu and it is added to the selected audio track. When the audio is being played, the user can put the chain onto the board and manipulate it freely; the equalizer will live-update with the shape of the chain. It can be difficult to remember what the audio sounds like without the applied EQ once it's been manipulated. The user can move the magnetic button off of the board to hear the original, un-affected audio, and then place the button back on the board to hear the EQ again.

7 CONCLUSION AND FUTURE WORK

We have presented the design for HaptEQ, a haptic interface for drawing out equalization curves.

While HaptEQ has been tried informally by a number of users with experience in audio production, we haven't yet tried it with a significant population of people with visual impairments. In the immediate future we hope to conduct a comprehensive user study with visually impaired audio producers and musicians, sighted audio producers, and visually impaired audio production novices.

The HaptEQ software can, with minimal alteration, be used to map any graphical curve to an audio control (e.g. ASDR curves for synthesizers). We plan to explore controlling other applications (compressors, synthesizers) using this paradigm. Since the software is open source, it also leaves open the possibility of others adopting our approach to develop a variety of interfaces for blind/sighted collaboration.

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