Team SilentRave Proposal

Introduction

As headphone use has become more prevalent with the advent of mobile music players, a culture of isolation has emerged. We propose a solution to reincorporate the environment back into the listening experience. The group members are Tom Blanford, Eric Nolan, Michael Sizemore, Sara Taylor, and Mark Wurzelbacher.

Problem Description

When you wear headphones to listen to music you are often times still trying to do something besides listening to music. This may be walking to class, going for a run, or even holding a conversation. Current high-end ear bud headphones can create a comfortable sense of isolation to best allow you to hear your music, but they do not adjust for changes in the environment. When you're running with your iPod, you still need to turn the volume up when the environment gets louder (for example, a train passes or you run past the power plant on campus). In other cases you must take your ear buds out when someone is trying to talk to you (for example, when the flight attendant asks for your meal preference on an airplane, or someone says hello when you walk past them). If you are walking to class, you might want to be able listen to your music but still have a conversation with the person walking next to you, forcing you to leave one ear bud out to be able to hear them.

In all these cases you are either forced to constantly adjust the volume on your iPod (which is cumbersome, especially if you are running), or compromise your listening experience by removing your ear buds (which is an annoying task if you have good quality, isolating ear buds). If you remove one ear bud, you only hear half of your stereo music. Some headphones incorporate a single microphone to facilitate phone calls or pass through audio from the environment, but you must turn the microphone on yourself. Furthermore, with these headphones you still do not hear the sound of the outside world in a way that mimics what you normally hear, and you cannot tell where a sound is coming from based on sound alone.

Proposed Solution

In order to automatically adjust the sound you hear through your ear buds, we propose creating a small device to interface between your sound source that would sense the external environment and adjust the sound accordingly. You could specify your preferred aural environment (music only, occasional conversation, music and environment), and let the device take care of the rest. If you only wanted to hear your music when running, the device would sense the increase in environmental noise and boost the volume of your music to compensate. If you wanted to walk down the street and hear both the sounds of your music and the sounds of the city, the device would pick up the sounds of the environment as you would hear them yourself (in stereo, without the rumble of wind and microphone noise) and mix this with your music. If you wanted to only hear the outside world when someone was talking to you (say, the flight attendant), the device would sense these occasions and lower the volume of your music and mix in your environment.

Demonstrated Features

The functional system will demonstrate three modes, each with different features:

- Conversation mode: the device will play music normally until a voice is detected. The device will then lower the volume of the music and mix in the sound picked up by the microphones to allow you to hear someone talking to you.
- Running mode: the device will play music normally until it senses that the environmental noise has increased passed a given threshold. At this point the device will increase the volume of your music (with dynamic compression to prevent distortion and clipping) to compensate for the increased ambient noise.
- Ambient mode (Safe Running mode): the device will continuously mix in environmental sound with your music.

In all cases where the device is mixing in sound picked up by the microphones, the device will:

- Process the external sound through a stereo enhancement algorithm to simulate natural stereo imaging.
- Compress and limit the external sound to prevent overloading and protect your ears (e.g. if someone yelled into one of the microphones).
- Equalize the external sound to seem natural and comfortable through your headphones.

The device will also demonstrate a number of other features:

- Alert the user when battery power is low.
- Allow the music to be played through headphones when the device is off (or in the case of device failure).
- Display the current operating mode to the user.

Available Technologies

To solve this problem, we will need to use one pair of isolating ear bud headphones, two small diaphragm microphones, a digital signal processor, a microcontroller to control states and load software, and an input switch to select the operating mode.

There are numerous small diaphragm microphones currently available, separated into two types: Electret Condenser Microphones (ECMs) and Micro Electromechanical Systems microphones (MEMS). We would apply MEMS microphones for this product because of the required means of voltage biasing the microphone capsule. ECM microphones operate by superimposing the AC sound signal on top of the DC supply voltage. While they only need two lines (Supply and Ground) to operate, they require a capacitor (and possibly a resistor network to provide the required supply voltage) next to the microphone to separate the AC and DC voltages. MEMS microphones require three wires for operation: Vdd, Vout, and Ground. As a result, they do not require a DC blocking capacitor. MEMS microphones also work on a lower supply voltage than most ECMs as well. We will apply MEMS microphones for this project because we will be using low DC voltages and working with small spaces. Currently the Analog Devices 405 microphone is the proposed solution.

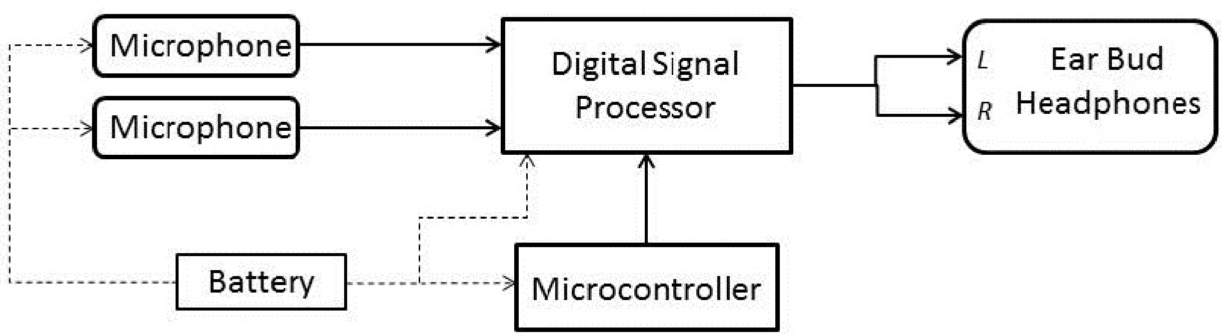
We will use a low-power digital signal processor with analog input and output capabilities to implement the equalization, compression, limiting, and stereo enhancement functions. The DSP must be able to accept four discrete channels of input (two microphones, iPod sound in stereo) and output in stereo. The DSP should have ADC and DAC built in, but alternative solutions with external ADC and DAC processing may be feasible (though they would consume more space). Currently the Analog Devices SigmaDSP processors are the proposed processor as it is low power, can handle all the I/O requirements, and has ADC and DAC built into the chip.

A microcontroller will handle switching between operating modes and loading the programs onto the DSP chip. The microcontroller will be a low power device and will also output the current operating signal to display to the user.

The system will be powered off of a replaceable battery or from the music device (iPod, etc.) itself.

Engineering Content

The following block diagram outlines each of the functional components of this system:



There are a number of critical tasks that our team must complete to implement this system. They are:

- Programming the microcontroller to handle switching modes, startup and shutdown of the DSP, and loading programs onto the DSP.
- Programming the DSP with algorithms for stereo enhancement, mixing of signals, dynamic control (volume adjustment, compression, and limiting), and equalization.
- Mounting and connecting all the subsystems and developing a convenient and clear interface for the user to connect their iPod and headphones to the device.
- Powering the device with a battery solution or from the music device (iPod, etc.)

Conclusions

The proposed solution should result in a device of a reasonable size which can be integrated into a case, arm band or separate module. Thus with our solution as a small add-on, users will be able to listen to their audio of choice and have the option to remain a part of the external world or completely tune it out without constantly adjusting settings. The device gives its user significantly more control over their personal listening experience.