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Adjusting Equalizer Settings Based on Learned User Preferences

ABSTRACT

Currently, the equalizer settings for media playback via a headset are selected based on a limited number of user studies. Equalizer preferences depend on various factors, including earbud fit (which impacts audio leakage levels) and the genre of audio being listened to. This disclosure describes techniques to automatically set or recommend equalizer settings using machine learning models that are trained on a crowdsourced dataset of user preferences, obtained with user permission. Equalizer settings, audio genre, and magnitude of acoustic leakage are obtained from deployed media playback devices and are used to train the machine learning model. During operation, the trained machine learning model adjusts the equalizer to a setting optimized over observed consumer preferences.

KEYWORDS

- Earbud
- Headphone
- Equalizer setting
- Acoustic seal
- Seal test
- Ear-tip
- Audio leakage
- Bass boost
- True wireless stereo (TWS)
- Active noise cancelation (ANC)
- Occlusion effect (audiology)
- Adaptive equalization
- Error microphone
- Frequency response
- Machine learning
- Federated learning

BACKGROUND

The media playback frequency response for a digital audio headset is adjusted by an equalizer (usually provided via an app accompanying the headset) in the digital signal processing (DSP) stages of the audio chain. The adjustment translates the natural frequency response of the electroacoustic system (speaker transducer, acoustic cavities, ports, mesh, etc.) to a desired frequency response target. At present, the desired frequency response target is set based on user studies, research papers, and competitive analysis on what consumers want [1, 2]. Such studies, research, and analyses are, however, based on a limited number of subjects and are presumed to be applicable to the general population. In truth, the equalizer preferences for a broad swathe of consumers remain largely unknown. Additionally, equalizer preferences depend on the genre of music or other audio being listened to.

Further, in true wireless stereo (TWS) headsets, the acoustic seal that the user achieves between their ear canals and the ear-tips is paramount to a good frequency response and to effective active noise cancelation (ANC). If the ear-tip is not sealed well into the ear canal, low-frequency (bass) sounds are deficient. A user that increases bass (e.g., by using equalizer settings) may be responding to genuinely insufficient bass content in the audio track or to a perceived lack of bass that originates from an inadequate acoustic seal rather than the audio track. While some users are unaware of the importance of selecting the right ear-tip to fit the earbud to their ear, others intentionally prefer the comfort of a leaky seal because they feel a tight seal is uncomfortable or they don't like the way they sound when they talk with a sealed earbud due to the occlusion effect.

An ear-tip seal test is a routine that guides the user into achieving a comfortable and effective acoustic seal. A test song plays into the earbud speaker and is simultaneously recorded with an error microphone mounted inside the snout of the ANC headset. A pass/fail signal is generated based on the bass-content loss between the error-microphone and the earbud-speaker signals. If determined to be necessary, the user is advised to try a different set of ear-tips for a better seal.

DESCRIPTION

This disclosure describes techniques to set equalizer sliders (that tune audio playback via a headset) using machine learning models trained on a crowdsource dataset of consumer behavior, obtained with user permission. With user permission, one or more pieces of information are obtained from deployed media playback devices, such as:

- equalizer settings being used by the user, in particular, settings for the bass-boost slider;
- genre of content being listened to, e.g., obtained from the metadata of the content;
- the magnitude of acoustic leak (or the efficacy of acoustic seal) that the user is experiencing; etc.

The third of the above pieces of information (magnitude of acoustic leak) is obtained as follows. The equalizer is adjusted for a slight leak (intentional or unintentional) by determining the bass-content loss between the sound inside the ear canal (captured by an internal microphone) and the playback signal and by automatically adjusting (increasing) bass to the extent of the bass-content loss. This is similar to a continuously running an ear-tip test that also automatically adapts the equalizer (adaptive equalization). The magnitude of the adjustment added to compensate for bass content loss is an indicator of the magnitude of the acoustic leak.

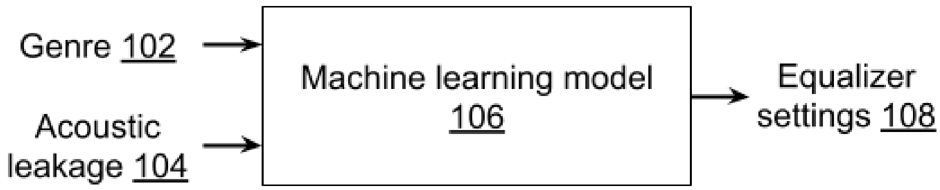

Fig. 1: Equalizer settings using a machine learning model

Fig. 1 illustrates setting an equalizer using a machine learning model (106). The machine learning model accepts as input the audio genre (102) and the magnitude of the acoustic leak (104) and produces as output the equalizer settings (108). In particular, the machine learning model outputs the bass-boost slider setting. The machine learning model is trained by feeding training data that includes labeled inputs and outputs, e.g., the audio genre, the magnitude of acoustic leakage, and the equalizer settings, obtained with user permission from deployed media playback devices.

The described techniques can automatically adjust the equalizer to a setting most preferred by the population given the genre of the song and the magnitude of the acoustic leak. Additionally, the techniques can provide data on how media playback tuning is perceived and point to ways to improve it. For example, if a large proportion of users always adjust the equalizer a certain way, then the default can be moved in that direction. If most users are found to use the headset with a certain leak level, then the default tuning for the equalizer can be optimized for that leak level. It can be determined if users who require more bass achieve it by sealing the earbud into their ear better or by adjusting the equalizer (bass-boost control). In this manner, with user permission, the described techniques leverage user-permitted information from a deployed population of media playback devices to learn consumer preferences that are then utilized to automatically optimize default equalizer settings.

Further to the descriptions above, a user may be provided with controls allowing the user to make an election as to both if and when systems, programs, or features described herein may enable the collection of user information (e.g., information about a user's headset, audio playback activity, a user's preferences,), and if the user is sent content or communications from a server. In addition, certain data may be treated in one or more ways before it is stored or used so that personally identifiable information is removed. For example, a user's identity may be treated so that no personally identifiable information can be determined for the user. Thus, the user may have control over what information is collected about the user, how that information is used, and what information is provided to the user.

CONCLUSION

This disclosure describes techniques to automatically set or recommend equalizer settings using machine learning models that are trained on a crowdsourced dataset of user preferences, obtained with user permission. Equalizer settings, audio genre, and magnitude of acoustic leakage are obtained from deployed media playback devices and are used to train the machine learning model. During operation, the trained machine learning model adjusts the equalizer to a setting optimized over observed consumer preferences.

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