A Web Audio Node for the Fast Creation of Natural Language Interfaces for Audio Production

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ABSTRACT

Audio production involves the use of tools such as reverberators, compressors, and equalizers to transform raw audio into a state ready for public consumption. These tools are in wide use by both musicians and expert audio engineers for this purpose. The typical interfaces for these tools use low-level signal parameters as controls for the audio effect. These signal parameters often have unintuitive names such as "feedback" or "low-high" that have little meaning to many people. This makes them difficult to use and learn for many people. Such low-level interfaces are also common throughout audio production interfaces using the Web Audio API. Recent work in bridging the semantic gap between verbal descriptions of audio effects (e.g. "underwater", "warm", "bright") and low-level signal parameters has resulted in provably better interfaces for a population of laypeople. In that work, a vocabulary of hundreds of descriptive terms was crowdsourced, along with their mappings to audio effects settings for reverberation and equalization. In this paper, we present a Web Audio node that lets web developers leverage this vocabulary to easily create web-based audio effects tools that use natural language interfaces. Our Web Audio node and additional documentation can be accessed at `https://interactiveaudiolab.github.io/audealize_api`.

1. INTRODUCTION

We wish to help builders of audio production tools, such as reverberators, compressors, and equalizers, make easy-to-use interfaces so that a broader range of people will be empowered to use these tools. In this work we describe the Audealize API, which provides a natural language interface for controlling two audio effects: equalization and reverberation. The API provides an `AudioNode` for Web Audio that uses crowdsourced mappings between descriptions and low-level signal parameters to allow a user to control the settings of each effect by specifying a word (e.g. "bright", "warm") that describes their desired sound.

Audio production tools are used by musicians, engineers, producers, v-loggers, podcasters and others to transform raw audio into a state ready for public consumption. Two of the most popular production tools are reverberation and equalization. Reverberation is used to add echoes to a recording to make it sound as if it is in some space (e.g. a cathedral), to make the sound better (e.g. "warmer") or make it more interesting (e.g. "chaotic"). Equalization is used to cut or boost frequencies in the sound to make it sound, for example, "muffled" or "bright." End-user interfaces for typical reverberators, compressors and equalizers have steep learning curves, due to their reliance on using knobs and dials with labels relating to low-level signal parameters to control the audio effect, such as the equalizer shown in Figure 1. This forces the user to navigate a space of low-level signal parameters to find the desired effect.

Experienced engineers can use this signal-parameter space effectively and tool developers are typically experienced engineers. Therefore, interfaces to these tools typically reflect this mindset. There is, however, a conceptual gap between these tool builders and many potential users of these tools. Example users who often do not know the technical language of audio production include acoustic musicians, podcasters, v-loggers, and music hobbyists. Such people typically formulate their thoughts about acoustic concepts using colloquial terms and communicate audio concepts with those terms. A well known engineer described this phenomenon as follows: "It's a situation all engineers have been in, where a musician is frustratedly trying to explain to you the sound he or she is after, but lacking your ability to describe it in terms that relate to technology, can only abstract. I have been asked to make things more 'pinky blue', 'Castrol GTXy' and...'buttery"' [2].

This interface paradigm (low-level controls) for traditional audio production tools has been transferred to Web Audio [9] implementations of audio production tools. However, many users of audio applications on the web are likely to be laypeople, due to the low barrier of entry (no installation beyond your browser required) and ease of sharing (just linking others to a page would have them using the tool). Because of this, it is important to facilitate the creation of audio production tools on the web that are accessible to laypeople.

Designers of traditional interfaces have tried to address this accessibility problem by introducing "presets", which are predefined settings for the audio production tool with a natural language label, defined by the tool designer. However, the vocabulary used by tool builders to name presets does not have a large overlap with the vocabulary laypeople use to describe audio effects. One prior study found

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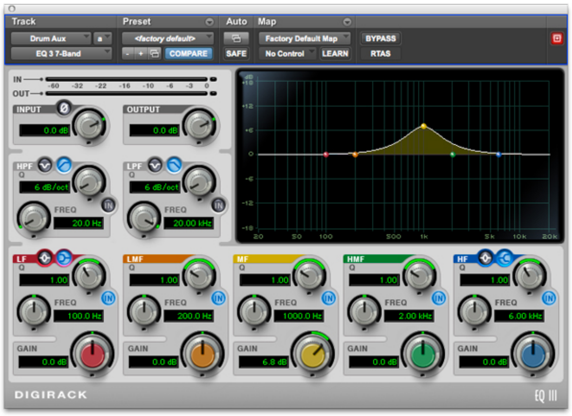


Figure 1: A standard equalizer interface, full of knobs and sliders with labels that do not correlate well to human perception of the resultant effect.

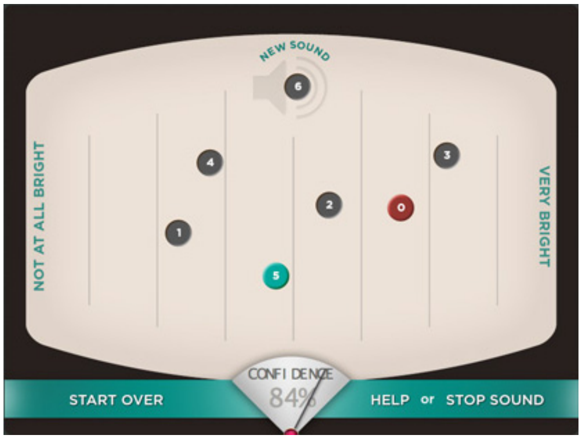


Figure 2: An interface and data collection mechanism for equalization. Users rate equalization curves in terms of how closely it matches their desired audio effect.

only 6% (for equalization) to 10% (for reverberation) overlap between the vocabulary used to describe presets and the vocabulary used by laypeople to describe audio effects [13]. Given this, naming presets to effectively communicate with end users may be difficult for a tool builder.

Zheng et al. [15] recently released the SocialFX crowdsourced data set. SocialFX encodes the strength of association between the vocabulary of laypeople and specific audio effects settings. This data set contains 4297 words learned from 1233 unique users. The effect settings related to each word were derived from crowdsourced studies [12] [3]. These words were used to describe specific settings for three kinds of audio effects: equalization, reverberation, and compression. This data is a step towards implementing an end-to-end language-based audio production system, where a user could control an audio effect tool by describing a creative goal in natural language directly to the tool.

In this work, we take the next step by creating a Web Audio node that gives developers access to the SocialFX vocabulary, facilitating the development of audio production tools using natural language. By developing this node and making it open-source and widely available, we seek to encourage web developers to build new natural language interfaces for audio manipulation and production.

2. RELATED WORK

The most closely related work to our own is by Stables et al. [14], in which they also gather data relating user effect descriptions and low-level signal parameter from interactions a user has with a VST (Virtual Studio Technology) or AudioUnit audio effect plugin, such as the one in Figure 1. Our work differs from theirs in two ways. First, it is meant for audio effects via the Web Audio API rather than VSTs. Second, our vocabulary is derived from crowdsourcing tasks on the web (via Amazon Mechanical Turk [8]), resulting in a vocabulary drawn from laypeople with little to no experience with audio production.

Mycroft et al. [6] [7] looks at the effect that traditional audio production interfaces have on creativity and cognition. They find that complex signal-parameter interfaces for audio effects, such as the one in Figure 1, can affect working memory and cognitive load, having an adverse effect on critical listening. Further, the visual paradigm adapted by equalizers can create perverse incentives (e.g. making a good-looking equalization curve, rather than making an equalization curve that sounds good). An interface that uses natural language is one way to circumvent these issues.

Schmidt [11] presented an early natural language interface for audio production. In the interface, rather than control audio effects, users could give commands like 'Play/pause the bass" and perform other basic audio production tasks. This had a limited vocabulary, determined by the system developer. Sabin et al. [10], made an interface for equalization where users alter the effect by navigating a two dimensional space, where the axes of the space are equalization settings along different perceptual parameters. It was parameterized with a vocabulary of four words. Mecklenburg et al. [4] built an equalizer interface where users can communicate to the system in subjective terms, enabling interactions such as making sounds "warmer" or "brighter".

In Seetharaman et al. [13], users control an audio effect using a two dimensional word-map, as seen in Figure 4. Words that are nearby on the map are similar in terms of human perception of the audio effect.

In Seetharaman et al. [12] and Zheng et al. [15], users are presented with a lightweight survey in which users describe the effect an audio effect has on a sound using natural language. The datasets collected by Seetharaman et al. [12], Cartwright et al. [3], and Zheng et al. [15] form the basis for our proposed Web Audio node. For an overview of the crowdsourcing mechanisms and the mapping between words and low-level signal parameters, the reader is referred to [13].

The API we present here makes these mappings between crowdsourced vocabulary and actionable settings of audio effects available as an API so that anyone can build interfaces for audio effects based on natural language vocabulary. To our knowledge, this is the only such API available.

3. PROPOSED WEB AUDIO NODE

Our work builds on the Web Audio API, a JavaScript API that enables real-time audio synthesis and processing for web applications [9]. Our proposed Web Audio node provides a natural language interface for controlling two audio effects:

equalization and reverberation. The node allows a user to control the settings of each effect by specifying a word (e.g. “bright”, “warm”) that describes their desired sound. The node then processes any incoming audio first through the equalizer and then through the reverberator.

The underlying equalizer is the same one used in Audealize [13]. It is a graphic equalizer composed of forty peaking filters with center frequencies logarithmically spaced between 20Hz and 20kHz. Since the center frequencies are fixed, each filter is controlled only by a gain parameter. An equalization curve may then be described by forty gain values, given in dB, where positive values correspond to a boost and negative values correspond to a cut around a given center frequency.

For the underlying reverberator, we use the reverberator used in SocialReverb [12]. The reverberator is built around a network of six parallel comb filters and is controlled by five main parameters: the gain and delay of the first comb filter in the network (which dictate the gain and delay values of the rest of the filters), the delay between the two stereo channels (which controls the perceived width of the stereo effect), the center frequency of a low-pass filter applied to the output of the reverberator, and the ratio between the wet and dry signals.

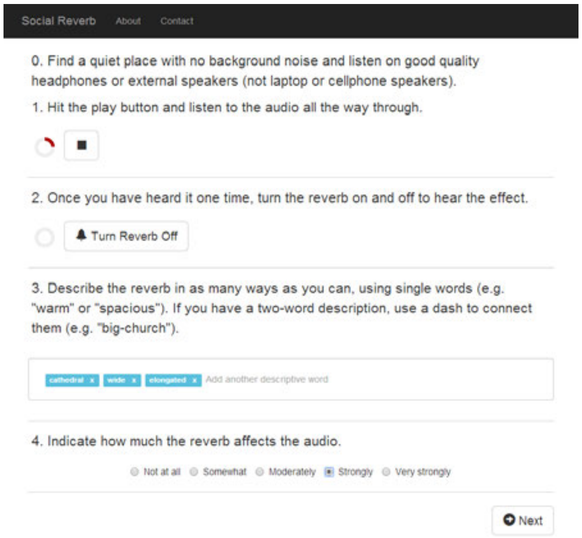
3.1 API Reference

Our node implements the Web Audio `AudioNode` interface and contains two main child nodes,one for each effect. Our node takes in an incoming audio signal and processes it first through the equalizer node and then through the reverberation node. Each effect is controlled by three high-level parameters: the natural language descriptor, a parameter specifying the strength of the effect, and an on/off parameter. These parameters are exposed to the developer as member variables of our Web Audio node.

The “amount” parameter controls the intensity of the effect. Member variable `eq_amount` is a single scalar that multiplies the gain values of all 40 filters in the equalizer. The default value for `eq_amount` is `1.0`, with higher values corresponding to a more intense application of the descriptor. A value of 0 yields a flat EQ curve, and negative values can be used to achieve the inverse effect. For example, setting `eq_descriptor` to “bright” and setting `eq_amount` to a negative value will apply an equalization effect that makes the sound less “bright.”

The intensity of the reverberation effect is controlled via `reverb_amount`. This value can be in the range [0,1] represents to the ratio between wet and dry signals, with a value of `1.0` meaning that the node will output only the reverberation and none of the dry signal. The final two parameters, `eq_on` and `reverb_on`, are simply Boolean values indicating whether or not each effect is engaged. Setting either variable will cause the corresponding effect to immediately turn on or off. Both effects are bypassed by default and are enabled automatically when a descriptor is set.

The settings of each effect are controlled primarily by descriptors, one-word strings that describe the desired sound (e.g “tinny”, “underwater”). Each effect is controlled by a separate descriptor, represented as member variables `eq_descriptor` and `reverb_descriptor`. When set with a string, our node will search for a matching entry in the SocialFX dataset of 4297 words for the relevant effect and setting. If a match is found, the low-level signal parameters of the effect will be immediately set to the values corresponding to the descriptor. If the descriptor is not found, the node can optionally attempt to find synonyms using WordNet [5] and return the closest synonym in SocialFX. When accessed, the descriptor member variables will return an object with the following properties:



0. Find a quiet place with no background noise and listen on good quality headphones or external speakers (not laptop or cellphone speakers).

1. Hit the play button and listen to the audio all the way through.

■

2. Once you have heard it one time, turn the reverb on and off to hear the effect.

Turn Reverb Off

3. Describe the reverb in as many ways as you can, using single words (e.g. "warm" or "spacious"). If you have a two-word description, use a dash to connect them (e.g. "big-church").

cathedral x wide x elongated x Add another descriptive word

4. Indicate how much the reverb affects the audio.

○ Not at all ○ Somewhat ○ Moderately ● Strongly ○ Very strongly

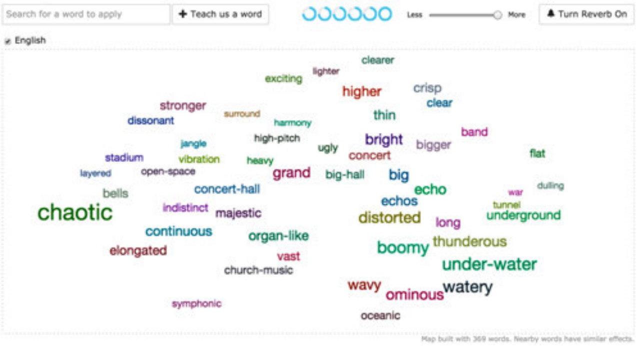
Next

Figure 3: A data collection mechanism for audio effects. Users freely describe the audio effect using their own words.

- `word`: The natural language descriptor
- `effect`: The effect being described (`"eq"` or `"reverb"`)
- `settings`: An array containing the settings of the low-level signal parameters as they are defined for the descriptor. For equalization descriptors, this contains gain values for each of the 40 filters.
- `num`: The number of unique user interaction sessions upon which the definition of the descriptor is based.
- `agreement`: A measure of the agreement between the definitions provided for the descriptor by the `num` user sessions. This indicates how confident we are in the assumption that the natural language descriptor and its corresponding audio effect settings match perceptually. Higher agreement values indicate higher confidence.
- `x, y`: The coordinates of the descriptor when a corresponding feature vector relating to its audio effect setting are mapped onto a 2-dimensional space using multidimensional scaling [1]. Descriptors that are near each other in this 2D space have similar perceptual characteristics when their corresponding audio effects are applied. This can be used to build interfaces such as the one in Figure 4.

4. EXAMPLE USES

Audealize, described in [13], offers one example of a natural language interface enabled by our Web Audio node. In this interface, equalization and reverberation descriptors are presented in separate 2-dimensional word-maps, one of which is shown in Figure 4. This lets the user select an effect



Map built with 369 words. Nearby words have similar effects.

Figure 4: One interface for reverberation, using the semantic web audio node, from [13]. Instead of using low-level signal parameter controls, this interface uses a word-map to control the reverberation. Users navigate the 2D map to apply effects to the audio. Effects that are close in perceptual quality are placed near each other on the map.

setting by simply clicking on a word. Word positions in the map are calculated using using multidimensional scaling [1] to map the effects setting associated with each word onto a 2-dimensional space. As a result, words that are close to each other in the word-map indicates that they represent similar effects.

In a user study conducted on 432 non-experts, users were asked to use both the Audealize interface and a traditional interface of sliders corresponding to signal parameters to apply an effect to an unmodified recording so that it matches a recording that has been processed with an audio effect. The study found that the word-map interfaces that use natural language were more effective for a population of laypeople than traditional audio production interfaces with low-level signal parameter controls [13]. Audealize is available for use at `http://audealize.appspot.com`.

As an initial release, we made our API available to students in a course on music audio programming taught at Northwestern University. Their feedback guided the fleshing out of our documentation. These students also created Songbird, a web application that aims to provide a fun and simple way for untrained vocalists to create musical-sounding recordings of their voice. The interface allows the user to input semantic descriptors to select equalization and reverberation effects before recording their voice. The application then applies pitch correction, equalization, reverberation, and dynamic range compression effects to the recordings in order to make the voice sound more like what one might be accustomed to hearing on professional recordings. The ease with which the students were able to create Songbird indicates the API can be used to facilitate creation of novel audio effects interfaces.

5. CONCLUSION

It is important for Web Audio applications to have more intuitive interfaces for audio production because the audience for these applications is far broader than those of traditional VST applications. This is due to the ease of access to web-based applications as well as the ease of sharing. However, the paradigm for audio production interfaces on the web is still dominated by traditional interfaces involving low-level signal parameters. We have created a Web Audio node that facilitates the creation of natural language interfaces for audio production on the web. This project is open source and we welcome pull requests. Our hope is that developers who use our Web Audio node will create more intuitive audio production interfaces for the web. Our Web Audio node and additional documentation can be accessed at `https://interactiveaudiolab.github.io/audealize_api`.

6. REFERENCES

[1] I. Borg and P. J. Groenen. *Modern multidimensional scaling: Theory and applications*. Springer Science & Business Media, 2005.

[2] J. Burton. Ear machine iq: Intelligent equaliser plug-in. http://www.soundonsound.com/sos/jun11/articles/em-iq.htm. Accessed: 2015-04-12.

[3] M. Cartwright and B. Pardo. Social-EQ: Crowdsourcing an equalization descriptor map. In *14th International Society for Music Information Retrieval*, 2013.

[4] S. Mecklenburg and J. Loviscach. subjEQt: Controlling an equalizer through subjective terms. *CHI'06 Extended Abstracts on Human Factors in Computing Systems*, 2006.

[5] G. A. Miller. Wordnet: a lexical database for english. *Communications of the ACM*, 38(11):39–41, 1995.

[6] J. Mycroft and J. Paterson. Activity flow in music equalization: The cognitive and creative implications of interface design. In *Audio Engineering Society Convention 130*. Audio Engineering Society, 2011.

[7] J. Mycroft, T. Stockman, and J. D. Reiss. Audio mixing displays: The influence of overviews on information search and critical listening. In *International Symposium on Computer Music Modelling and Retrieval (CMMR)*, 2015.

[8] G. Paolacci, J. Chandler, and P. G. Ipeirotis. Running experiments on amazon mechanical turk. *Judgment and Decision making*, 5(5):411–419, 2010.

[9] C. Rogers. Web audio api. *Draft [online specification], Version*, 1, 2012.

[10] A. Sabin and B. Pardo. 2DEQ: an intuitive audio equalizer. *Proceedings of the 7th ACM conference on Creativity and Cognition*, 2009.

[11] B. L. Schmidt. A natural language system for music. *Computer music journal*, pages 25–34, 1987.

[12] P. Seetharaman and B. Pardo. Crowdsourcing a reverberation descriptor map. In *Proceedings of the ACM International Conference on Multimedia*, pages 587–596. ACM, 2014.

[13] P. Seetharaman and B. Pardo. Audealize: Crowdsourced audio production tools. *Journal of the Audio Engineering Society*, 64(9):683–695, 2016.

[14] R. Stables, S. Enderby, B. De Man, G. Fazekas, and J. Reiss. Safe: A system for the extraction and retrieval of semantic audio descriptors. 2014.

[15] T. Zheng, P. Seetharaman, and B. Pardo. Socialfx: Studying a crowdsourced folksonomy of audio effects terms. In *Proceedings of the 2016 ACM on Multimedia Conference*, pages 182–186. ACM, 2016.