GUEST EDITORS' NOTE
Special Issue on Web Audio

The capability of playing background sounds in web pages was added to web browsers as early as in the 1990s. It has been, however, a long journey from this limited capability, through different browser-specific features, third-party solutions such as Flash or Java, and the basic cross-browser functionality in the HTML5 standard, to arrive at the rich cross-browser solution specified by the Web Audio API [1]. Initiated in 2011 by the W3C Audio Working Group,[1] this API has now reached the status of Candidate Recommendation[2] and is implemented in most web browsers. The API includes high-level functionality, inspired by common tools used in gaming and music production, as well as direct audio processing functionality. Both facilitate the development of sophisticated audio applications in JavaScript. The power of using web audio not only remains in the possibility of creating content that is freely accessible from anywhere in the world, as originally envisioned for the Web by Tim Berners-Lee, but in that it also aligns with the W3C's vision of creating a more universal web that is "*available to all people, whatever their hardware, software, network infrastructure, native language, culture, geographical location, or physical or mental ability.*"[3]

The first international Web Audio Conference (WAC) was hosted by IRCAM and Mozilla in Paris in 2015, under the guidance of Norbert Schnell and Samuel Goldszmidt. Dedicated to web audio technologies and applications, this conference has gathered developers, academics, and artists from all over the world during five editions so far:[4] at Georgia Tech in Atlanta (2016), at the Centre for Digital Music, Queen Mary University of London (2017), at the Technical University of Berlin (2018), and at the Norwegian University of Science and Technology (NTNU) in Trondheim (2019). The conference is committed to bringing more diversity to the audio engineering community, as reflected in the theme of the WAC 2019 conference "Diversity in Web Audio." The forthcoming sixth edition is programmed to be held at Universitat Pompeu Fabra in Barcelona (2021).

Web audio is not new for the AES members. Dating back in 2013, the Web Audio API was demonstrated in a lecture to the UK AES Section by Chris Lowis in the representation of the W3C Audio Working Group [2], as well as in one of the Game Audio Sessions of the 135th International AES Convention by Jan Linden and Jory K. Prum [3]. The potential of web audio for teaching music technology, and in particular for technical ear training, was introduced at the 2015 AES Conference on Audio Education [4]. The need for standard frameworks was tackled early on, as exemplified with the work by Jillings et al., who proposed a framework to develop plug-ins including intelligent music production features [5]. There was also interest in improving real-time FFT analysis [6]. Spatial audio applications have been discussed in more recent AES events [7, 8].

This special issue is the result of the first-time WAC 2019 Best Papers Awards, whose awardees were invited to submit an extended version of their papers to the *Journal of the Audio Engineering Society* (*JAES*). In all, the six selected articles present an overview of what is possible today with web audio, including the popular audio engineering themes such as plug-ins and music production frameworks, applications to education, and spatial audio, while pointing to future directions.

The first article, "Using Faust DSL to Develop Custom, Sample Accurate DSP Code and Audio Plugins for the Web Browser," by Ren et al. [9], proposes a solution based on an online editor and a GUI to generate and deploy open-format Web Audio Plug-ins (e.g., virtual instruments or audio effects) on the web using Faust, a domain-specific language (DSL). The article describes the process of building audio plug-ins exemplified with a tube guitar amplifier model. It then reports a successful user evaluation on using the online documentation to build a phaser effect.

The second article is "A Web-Based Framework for Distributed Music System Research and Creation," by Matuszewski [10]. This article presents the open-source Soundworks framework. The framework supports prototyping and developing distributed interactive audiovisual applications based on web technologies for different artistic and research scenarios (e.g., concerts, installations, workshops). The author details the framework architecture, including the features of the distributed state management system and the plug-in system, which are essential to support effective distributed music systems.

The third article, "Learning to Code Through Web Audio: A Team-Based Learning Approach," by Xambó et al. [11], discusses the challenges and opportunities of using web audio to teach audio programming adopting a team-based learning (TBL) approach in a cross-campus scenario at a postgraduate's level. The authors share their teaching materials and report the results and findings from students' feedback, software complexity metrics, students' blog posts, and teacher's reflections. It was found that the use of web audio technologies combined with a TBL approach is suitable for learning computer programming.

The fourth article is "iMuSciCA Workbench: Web-based Music Activities for Science Education," by Kritsis et al. [12]. It describes the online, freely accessible iMuSciCA Workbench. The platform promotes Science, Technology, Engineering, Arts, and Mathematics (STEAM) education and is addressed to secondary school students. The article introduces an overview of the technical architecture of the web platform, a set of musical activity environments, and two user studies: a pilot test in three European countries and a teachers' usability assessment. The former has been useful to improve the educational scenarios and the online platform, whilst the latter has been useful to confirm the ease of use of the iMuSciCA Workbench.

The fifth article, "*od*: Composing Spatial Multimedia for the Web," by Çakmak and Hamilton [13], details the technical design and artistic concept of *od*, a spatial multimedia production for binaural listening on the web. The authors present a tool-agnostic theoretical workflow, which aims to be useful for documenting similar spatial compositions.

The sixth article is "A Signal Engine for a Live Coding Language Ecosystem," by Bernardo et al. [14]. The authors propose a brows-

[1] https://www.w3.org/2011/audio

[2] https://www.w3.org/standards/history/webaudio

[3] https://www.w3.org/Consortium/mission

[4] https://webaudioconf.com

er-based ecosystem for creating new live coding languages in an environment that supports audio synthesis, machine learning, and machine listening. The article describes a high-performance sound synthesis engine based on an adaptation of the Maximilian signal processing library for AudioWorklet. It also reports the online open-source environment Sema, dedicated to the design of customized live coding languages and machine learning. The results of a performance and reliability evaluation of the system indicate that the system is efficient, reliable, and has low latency.

It is an honor to introduce the latest research in web audio to the AES community, as well as for the web audio community to have been given the opportunity to share their work at *JAES* in this curated issue. This, we hope, can lead to future fruitful cross-pollination. In a time of so many uncertainties driven by the COVID-19 crisis, using web audio and web technologies can be seen as an opportunity to improve the world we live in. It is more timely than ever to explore fully the options brought by web-based technologies to create novel, networked audio services, experiences, and ecosystems for a better future.

We are very thankful to the reviewers for their expert insights, without whose this special issue would not exist. We are truly thankful to the *JAES* editorial team, with special thanks to Bozena Kostek (Editor-in-Chief), Francis Rumsey (Consultant Technical Writer and Editor), and Christopher Cifani (Managing Editor) for their expertise, constant help and professional advice, and for the opportunity in the first place to publish this special issue in one of the most prestigious journals in the field. We hope that this can be the first of a prolific collaboration. We are especially grateful to the three jury members of the WAC 2019 Best Papers Awards, Jan Monschke (SoundCloud), Garth Paine (Arizona State University), and Ariane Stolfi (Federal University of South Bahia) for sharing their proficiency in selecting the papers to be included in this special issue. We would like to thank Norbert Schnell and the WAC Steering Committee for the opportunity of organizing the WAC 2019 conference in Trondheim, Norway, as well as NTNU for hosting the conference, where the initiative of this special issue emerged. We are also thankful to the WAC 2019 Conference Committee and the WAC 2019 Program Committee for their generous commitment to producing a high-quality conference that has contributed to the existence of this special issue.

Last but not least, we wish to express our gratitude to the sponsors of the WAC 2019 conference: Department of Electronic Systems at NTNU, SonoSuite, ROLI, Mozilla, Ableton, Native Instruments, and Spotify.

Hopefully, see you at the next Web Audio Conference in Barcelona! Stay well and safe.

Anna Xambó,
Sara R. Martín,
Gerard Roma,
Guest Editors

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