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## Web-based binaural audio and sonic narratives for cultural heritage

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### ABSTRACT

This paper introduces PlugSonic Soundscape and PlugSonic Sample, two web-based applications for the creation and experience of binaural interactive audio narratives and soundscapes. The apps are being developed as part of the PLUGGY EU project (Pluggable Social Platform for Heritage Awareness and Participation). The apps audio processing is based on the Web Audio API and the 3D Tune-In toolkit. Within the paper, we report on the implementation, evaluation and future developments. We believe that the idea of a web-based application for 3D sonic narratives represents a novel contribution to the cultural heritage, digital storytelling and 3D audio technology domains.

### 1 INTRODUCTION

A heritage that is everywhere, and relevant to everyday life, is one of the preconditions for genuine sustainability. Currently, there are very few ICT tools to support citizens in their everyday activities to shape cultural heritage and be shaped by it. Existing applications and repositories for heritage dissemination do not foster the creation of heritage communities. Social platforms certainly offer potential to build networks, but they have not been exploited yet for global cultural heritage promotion and integration in people's everyday life [1].

The PLUGGY project (Pluggable Social Platform for Heritage Awareness and Participation) [2], aims to bridge this gap by providing the necessary tools to allow users to share their local knowledge and everyday experience with others, together with the contribution of cultural institutions, building extensive networks

around a common area interest, connecting the past, the present and the future.

Within PLUGGY, several tools are being developed: a Social Platform, a Curatorial Tool, and 4 separate 'pluggable' applications, to demonstrate the platform's potential and kick start applications for the after-project life. These applications focus on various aspects of digital heritage, which include Virtual (VR) and Augmented Reality (AR), Geolocation, Gamification and Sonic Narratives. The latter, called PlugSonic, is the focus of the current paper, which will look in particular at the web-based binaural audio features of the application.

Sonic narratives are generally based on music features (e.g. timbre, pitch-melody, tempo, etc.) [3], and are often not interactive (i.e. simple audio playback). The addition of spatial attributes (e.g. placement of sound sources on a full 360 sphere, and at different distances),

and most of all the addition of interactivity (e.g. to navigate soundscapes moving around in the acoustic virtual environment), are features which have not been widely explored until now - for example, [4] explored spatial sonic narratives, but exploited simple 2-dimensional audio panning techniques. The idea of developing and evaluating a web-based application for the creation and experience of 3D Sonic Narratives does indeed represent a novel contribution to both the digital heritage and audio technology domains.

### 1.1 Binaural spatialisation

The aim of binaural spatialisation is to provide the listener (through standard headphones) with the impression that sound is positioned in a specific location in the three-dimensional space. The 3D characteristics of the sound can be captured during recording with special hardware, or simulated in post-production via spatialisation techniques. The theories at the basis of the binaural spatialisation technique are not particularly recent, and the first binaural recording dates back to the end of the 19th Century [5]. However, it is only within the last twenty years that the increase in the calculation power of personal computers enabled an accurate real-time simulation of three-dimensional sound-field over headphones.

Several tools currently exist for performing binaural spatialisation; just to mention a few, Anaglyph [6], IRCAM Spat [7], the IEM binaural audio open library [8], and the 3D Tune-In Toolkit [9]. very few of these are though implemented within a web-based application, and therefore available on multiple platforms through a simple browser.

### 1.2 Web-based spatial audio

In 2011, with the specification and release of the Web Audio (WAA) [10] and the Web GL (WGL) [11] application programming interfaces (API), the World Wide Web Consortium (W3C) and the Mozilla Foundation set the basis for the development of modern web applications. As stated in the introduction to the WAA, the specification of a high-level Javascript (JS) API was necessary to satisfy the demand for audio and video processing capabilities to implement "sophisticated web-based games or interactive applications".

The WAA uses modular routing, built around the *AudioNode* class. Source, destination and processing

nodes allow for the creation of complex signal processing chains. The API also allows for the spatialisation of sound through an equal power panning and an HRTF (Head Related Transfer Function) convolution algorithms. For headphones based applications, the equal power algorithm "can only give the impression of sounds located between the ears" [12] while, as reported in [13], the HRTF algorithm implemented in Google Chrome and Mozilla Firefox embeds only one set of HRTFs from the IRCAM Listen database [14]. [13] discusses the limitations and potential drawbacks for users and developers of having only one choice of HRTFs (e.g. in-head localisation, inaccurate lateralisation, poor elevation perception and front-back confusion) and presents work to implement a *Binaural-FIRNode* class. This class extends the WAA allowing to import custom HRTFs as FIR filters.

Another limitation of the WAA is in the method used for the simulation of distance; based on attenuation only, it does not account for frequency domain effects of waves propagation.

Even with its limitations the WAA is having a great impact on web-based applications and research on spatial audio, audio narratives, games and immersive content broadcasting. Pike et al. [12] developed an object-based and binaural rendering player with head-tracking while RadioFrance nouvOson website [15] broadcasts 5.1 surround and binaural audio.

The WAA has also been used to develop high-order Ambisonics sound processing. Google Omnitone [16] implements decoding and binaural rendering up to the third order. In [17] Politis and Porier-Quinot, present JSAmbisonics as a library that uses the WAA for interactive spatial sound processing on the web. This work is interesting for it supports Ambisonics of any order.

The INVISO project [18] focused on the development of a web-based interface for "designing and experiencing rich and dynamic sonic virtual realities" suitable for both experts and novices. Here, the WGL was used to design a 3D interface for the creation of sound objects and navigation of the environment and the WAA for the audio rendering. The project presents interesting features like the multi-cone sound object to model complex emanation patterns; the control over sources' elevation; and the possibility to define trajectories for moving sources or sound zones in which sounds are not spatialised to create ambient sounds.

### 1.3 Sonic Narratives for Cultural Heritage

Looking at the state of the art in this area, it can be noticed how research is delving into solutions to make cultural heritage immersive, adopting AR, VR and spatial audio; engaging, using personalisation and emotional storytelling; adaptive, exploiting context-awareness and location-awareness; interactive, using the paradigm of dramas; or open and inclusive, developing content for people with impairments and/or difficulties.

In [19] Ardissono et al. give an exhaustive review about digital storytelling and multi-media content delivery with a focus on cultural heritage. Here we will limit to those projects that use exclusively or mainly audio to design novel types of experiences.

The LISTEN project [20] investigated audio augmented environments and user adaptation technologies. This involved the development of ListenSpace [21] - graphical authoring tool used to represent the real space and the sound sources' position - as well as the implementation of a domain ontology [22] for an exhibition and the use of context-awareness to adapt to the user's interest. The main limitations, from the content creators' perspective, could be seen into the the system's software (server-based processing) and hardware (antennas or infrared cameras for head-tracking) requirements; and the necessity for custom development for each exhibition.

In the CHESS project [23] the focus was on personalisation, profiling first-time visitors [24] to change the narration style; and interaction, delivering the story through voice narration and adapting the visit using web browser based applications.

Interaction and context-awareness (based on geolocation) was explored in [25] with mobile urban dramas (in which the user becomes the main character of a story). The project used a multimedia style (audio, video, images, animations) and was implemented to run on mobile web browsers using XML to describe the content. Here, the advantage of multi-platform flexibility, was limited by the need for specific knowledge about the content metadata structure or the consultancy from the researchers for app implementation and web services.

The EMOTIVE project [26] is working on tools to support cultural and creative industries producing narratives that exploit emotional storytelling. The ARCHES

project [27] instead, focuses on inclusivity, searching for ways to design for people with difficulties and/or disabilities.

## 2 IMPLEMENTATION

In the next paragraphs we describe in detail the design criteria, state of development and evaluation of two web applications: PlugSonic Sample and PlugSonic Soundscape. The apps, which will be integrated into the PLUGGY social platform and as a part of the platform's curatorial tool, are developed to manage all the audio content necessary to create virtual exhibitions; enhance on-line and/or on-site visits to museums, monuments, archaeological sites; share tangible and intangible cultural heritage. The social platform and the pluggable apps will make use of standard (mono/stereo) sound files to be used in voice descriptions, audio narratives or sound accompaniment to the platform's exhibitions, as well as to create interactive and explorable 3D audio narratives and soundscapes. Therefore, we designed the Sample app to edit sound files and apply audio effects and the Soundscape app to create and experience spatialised soundscapes. In this way PLUGGY users, whether institutions or citizens, are given all the necessary instruments; without the need for specific devices, external tools (software and/or hardware), specialised knowledge or resources. "Everyone, alone or collectively, has the right to benefit from the cultural heritage and to contribute towards its enrichment" [28]. Therefore, differently from all the tools described in previous paragraphs, in our project, with its focus on inclusivity and participation, we are developing intuitive and immediate tools, so that anyone can use them to have an impact on cultural heritage.

### 2.1 General Implementation

Both the Sample and the Soundscape app use established web development technologies and libraries. HTML and CSS languages have been used to create the web page and define its aspect; while JavaScript (JS) to make the apps dynamic and interactive. To build the user interface (UI) we used ReactJS [29]. The main reason behind the use of React is its efficiency in managing the UI's rendering. To manage the app's state, and therefore the apps' UI, we used the Redux library [30]. The Redux API allows to define the whole app state as a single JS Object; update the state as the user interacts with the app; trigger the re-rendering process

when a state change occurs. Both apps use a responsive design to scale the UI to different devices and screen sizes, even if, at the moment of writing, the UI is being redesigned and is not fully adaptive to tablet and smartphone use.

## 2.2 PlugSonic Sample

PlugSonic Sample [31] has been developed with two main goals: allow people with no audio editing experience to become quickly productive; be immediately usable.

To address the first challenge, we designed Sample and its interface around a subset of the features usually available in professional audio editing software. We implemented playback control, sample editing (Copy/Cut/Paste, Mute, Fade In, Fade Out), filters (Equaliser, Compressor, Reverb) and audio export. Audio playback and display is handled by the *wavesurfer.js* library [32] which, internally, uses the WAA. The WAA (*BiquadFilter*, *DynamicsCompressor* and *Convolver*) has also been used to implement the filters. Audio export was implemented by rendering the signal chain in a memory buffer, ready to be downloaded as an audio file or uploaded to the social platform.

The user interface is composed of three main sections: visualisation (1), commands (2), and dismissible filters panel (3). In the visualisation section we render the waveform and allow the user to skim and select subsections of the audio file. The commands section is composed of playback controls, sample editing operations and the undo command. In the filters panel, users can see and enable the available filters and set their parameters. Filters are rendered in real-time and so are changes to filter parameters. The side menu includes a file upload section, which lets the user load an audio file from their device, and the social platform section.

To tackle the second challenge, and make Sample available on different platforms without requiring the installation of additional software, we implemented it as a responsive web application. In this way, the app can be used on different platforms, using most modern browsers, and it will always be kept up-to-date without user intervention. Moreover, Sample can take advantage of the WAA to provide hardware-accelerated real-time audio playback and filtering, consistent across different platforms. Also, since all the processing is

performed locally, the playback is not affected by lag, network communication delays or altered by audio compression.

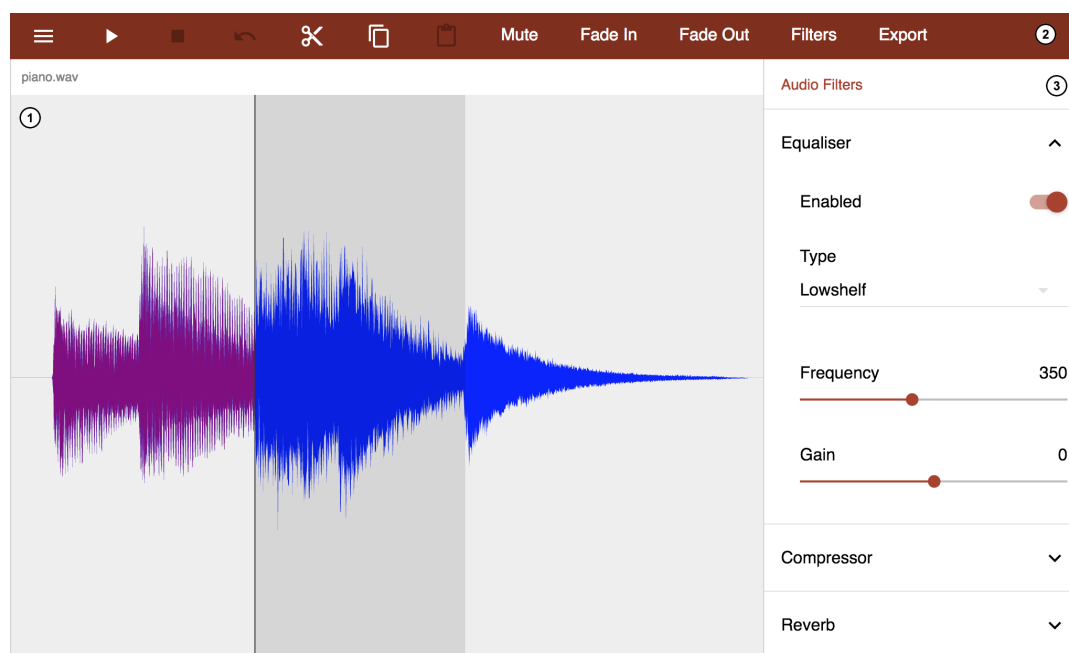
## 2.3 PlugSonic Soundscape

Before describing the current prototype of PlugSonic Soundscape [33] we introduce the technologies and libraries used.

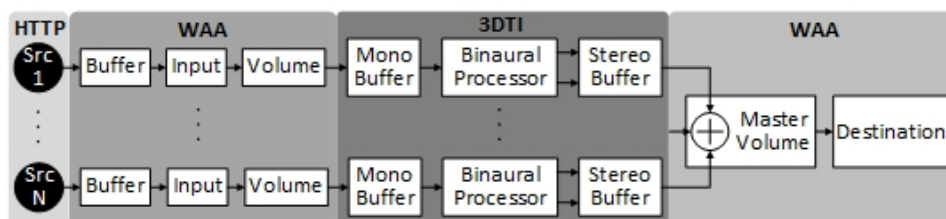
To asynchronously manage the side-effects of user's interaction on the sound rendering we used the Redux-Saga JS library [34]; which allows to define event listeners on the Redux state. When events occur, separate threads execute the code that affects the sound rendering chain without interfering with the UI rendering. In our case, examples of actions that generate side effects are: change listener/sources positions, change listener/sources settings, set volume, add/delete or activate/deactivate sound sources, start/stop playback.

For the binaural processing we used the 3D Tune-In Toolkit [35], an open-source spatialisation library developed during the 3D Tune-In EU project. The library is presented in [9] and gives control over full 3D listener's and sources' position and movement. With respect to the WAA the 3D Tune-In Toolkit allows for full customisation in terms of HRIRs selection, HRIRs length and sampling rate. Also, the interaural time difference (ITD) is computed from the listener's head circumference and the head shadowing effect on the interaural level difference (ILD) is simulated for near-field sound sources. The library also implements a high-performance mode which adopts an IIR filter approximation of the HRIRs for a less demanding, but also less realistic, spatial processing. A further advantage is obtained in the distance simulation. The library gives the option to choose the amount of attenuation with distance in dB per metre and simulates far-field sources using a low pass filter to emulate air absorption. Being natively written in C++, we used a JS compiled version generated using the *emscripten toolchain* [36].

The interconnections of sound processing blocks (Fig. 2) are implemented using the WAA *AudioNode* objects. For each sound source two objects are created: an input node, connected to an input buffer to read the sound samples; and a gain node, to control the volume. Each gain node is then connected to the mono input buffer of a binaural rendering processor. The spatialised stereo output is then connected to the master volume summing



**Fig. 1:** PlugSonic Sample user interface. In this example the user selected part of a partially reproduced file.



**Fig. 2:** PlugSonic Soundscape signal chain

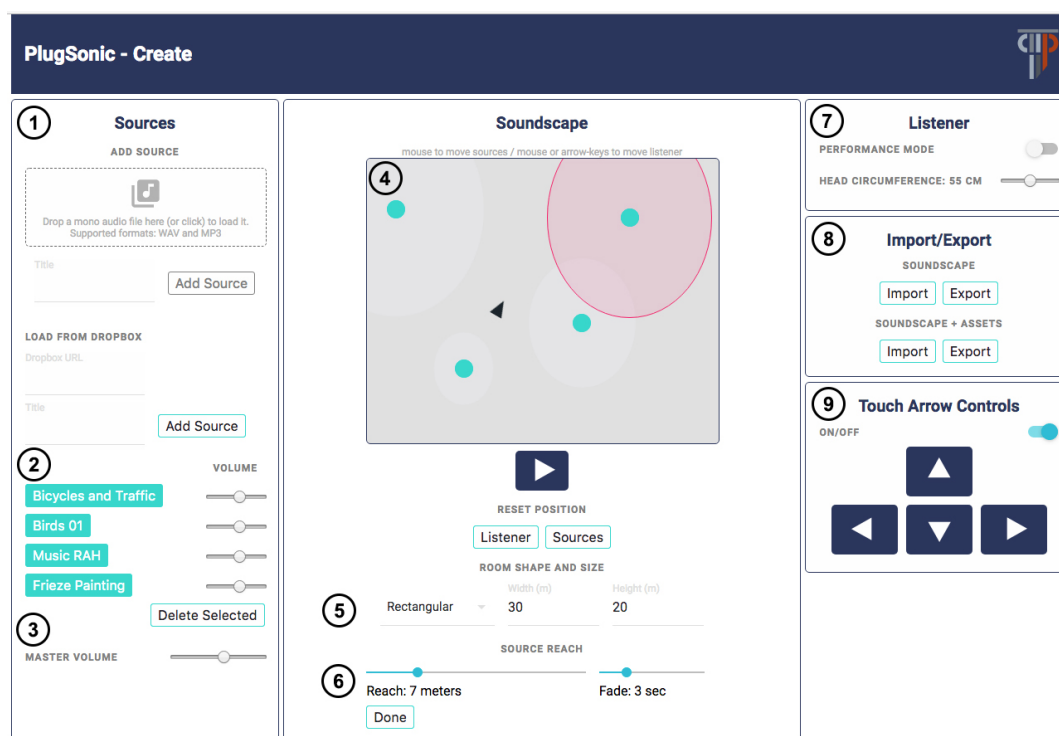
and gain node. The master volume gain node is finally connected to the *AudioContext* destination node which represents the actual audio-rendering device (speakers or headphones).

In terms of user-experience, Soundscape is designed to be divided into two versions we called Create and Experience. The Create version is used for authoring and gives full control over the soundscape settings. The Experience version is used for navigation and gives limited control. At the moment of writing, the prototype includes only the Create app, but a mobile (iOS) version of the experience app is currently being developed. With reference to Figure 3 we describe the app UI and controls:

1. Sound files in WAV or MP3 format can be added

either from local, using a drag and drop area; or from Dropbox, using the file URL.

2. List of loaded sources with volume control. Each source can be activated/deactivated. Sources are deleted using the Delete Selected button.
3. Master volume control.
4. Soundscape environment which shows the listener and sources position. The listener can be moved using mouse, arrow keys or, for touch screens, the Touch Arrow Controls shown in section 9. Sources can be moved using mouse or touch. This section includes the button to play/stop the soundscape and two buttons to reset the listener/sources positions.
5. Controls for the soundscape's shape (rectangular



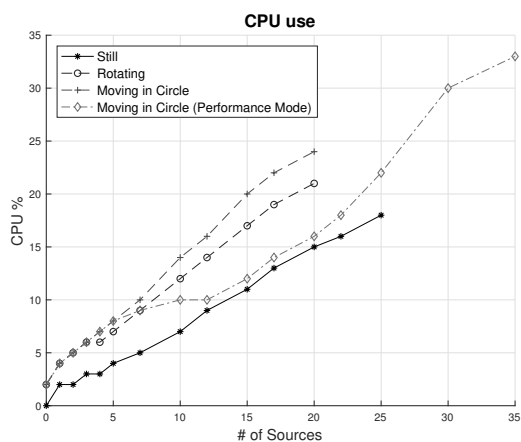
**Fig. 3:** PlugSonic Soundscape user interface

- or round) and size (width and height).
6. When a sound source is selected this section appears and allows to set the sound source Reach and Fade-In/Fade-Out times. The Reach controls the size of a circular area around the source. The source starts and stops playing as the listener steps in or out of the area.
  7. Listener settings: high-performance mode on/off and head circumference.
  8. Buttons to Import and Export soundscapes. The buttons allow to save/load a soundscape in two formats as a JS Object Notation (JSON) file: metadata only or metadata and sound data, with the second version allowing for offline use.
  9. Toggle to show/hide the touch enabled arrow controls

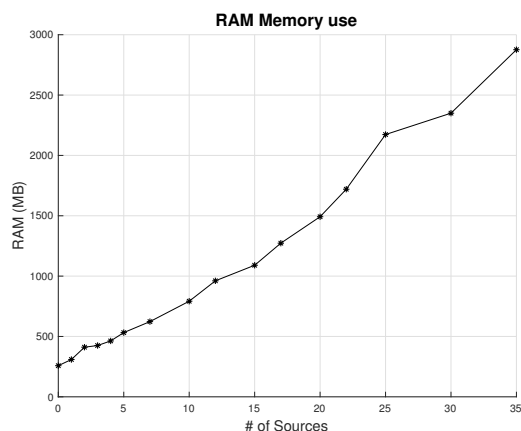
### 3 PERFORMANCE

To check the compatibility we tested the apps both on MacOS and Windows using the following browsers: Google Chrome, Mozilla Firefox, Microsoft Edge and

macOS Safari. The Soundscape app has also been tested for loading time and CPU/memory requirements. For the test we used a Lenovo ThinkPad Intel i7-7700HQ @ 2.80GHz – 16GB RAM running Windows 10. Table 1 shows the average and standard deviation of the loading times (in ms) when using Imperial College’s wi-fi network. The quantities were calculated over five runs using Google Chrome. It can be noticed how a good portion of the loading time (more than two seconds) is spent on scripting. This is due to the initialisation of the binaural processor which includes the retrieval of the many HRIRs wav files. To test CPU and memory requirements with the number of sources we used a 30 seconds white noise excerpt. Figure 4 shows the percentage of CPU when rendering the soundscape in several listener’s conditions: stationary, rotating, moving in circle (with and without the performance mode option). For each condition the lines end at the maximum number of sources the browser was able to render without sound and graphical performance degradation. We can notice how there is a linear relation between number of sources and CPU percentage with a considerable difference between stationary



**Fig. 4:** PlugSonic Soundscape CPU use as a function of the number of sound sources



**Fig. 5:** PlugSonic Soundscape memory use as a function of the number of sound sources

and moving conditions. The graph also shows how the performance mode allows for the rendering of up to 35 sources. Figure 5 shows how the memory can be a major limiting factor to the rendering process being directly proportional to the number of sources.

**Table 1:** PlugSonic Soundscape loading time in ms

	Load	Script	Render	Paint	Other	Idle	Total
Avg.	1.6	2382.2	13.8	2.6	246.4	782.4	3429.2
SD	0.6	179.7	0.84	1.3	12.1	136.9	270.9

## 4 EVALUATION

We invited sound experts to test PlugSonic and answer questions about their experience using the prototype. Questions were a mix of open ended and multiple choice, aiming at understanding which features they were missing and if, and how, usability principles were violated, respectively.

### 4.1 Method

We created an online survey with Google Forms and sent it out to sound experts by email. The first section of the survey aimed at collecting demographic information and an example scenario in which participants would create an audio experience and the tools they currently use. The second section consisted of links

to the Sample and the Soundscape apps with short instruction videos and example sound files. Participants were given the task to use the apps for the scenario they have described in the first section or use provided example sound files to create a soundscape and then export it and share it with the authors. In the third section, we asked open questions about their likes and dislikes with regard to both apps, to what extent they were able to create the soundscape, and if there were any features they were missing. The fourth section consisted of statements of usability principles to assess to what extent they were violated. These statements considered visibility of system status, match between system and the real world, user control and freedom, consistency and standards, recognition, diagnosis and recovering from errors, error prevention, recognition rather than recall, flexibility and efficiency of use, aesthetics and minimalist design, help and documentation, skills support, pleasurable and respectful interaction, and privacy. Participants rated the degree to which they agree or disagree with the statements using a 5 point Likert scale.

### 4.2 Results

#### 4.2.1 Participants

We evaluated PlugSonic with 8 sound experts, of which 5 were males, 2 females, and one not revealed. Their job descriptions included director for musical instruments company, computer science researcher with audio editing experience in storytelling, museum special

effects engineer, student and musician, researcher in acoustics and psycho acoustics, and a student in audiology with music processing experience. A total of 4 participants had 4 to 8 years of experience in working with audio, and 3 participants had 20 to 30 years of experience.

Participants were accustomed to use audio for product demos, exhibitions and installations. Examples of tools and technologies they currently use are Audacity, Adobe Premier, digital audio workstations (including Adobe Audition, Garageband, Logic, Cubase, Reaper), Ambisonics, Max MSP.

Complete results for each application and question are listed at the end of the paper in Table 2 and 3.

#### 4.2.2 Evaluation of PlugSonic Sample

Almost all participants found the Sample app easy to use; one participant preferred to use his own editing tool, but did not justify the choice. Specifically, participants liked the ease of applying commands such as fade-in and fade-out and cutting and pasting. They further liked the graphical interface with the sound file changing colour as it is played, the simple audio effects, and the fades represented on the waveform. Overall, the Sample app was considered useful as a quick editing tool.

However, a number of limitations were reported which requires further improvements in the user interface and functionalities. For the user interface, P6 found it hard to differentiate between the selected area and the area that has already played. P1 and P5 could not easily drag a selection encompassing the start or end of the audio making it hard to create a fade in/out.

In terms of features, P2 would like to have undo and redo commands. Participants also requested to have a time reference on the horizontal axis to be able to move the pointer around easily. P4 would like to work on multiple sound files at once. Moreover, P4 and P6 requested more effects and filters such as warping or reversing audio, an editable frequency domain graph to apply equalisation, and reverb settings such as dry and wet mix. Other requested features were by P1, who would like to use keyboard shortcuts and loop audio while P8 and P2 highlighted how, when loading a new sound, filters are not applied automatically to it. Finally, other issues were found on performance. When effects were disabled it stopped sound processing momentarily. And there were glitches when adjusting the parameters.

#### 4.2.3 Evaluation of PlugSonic Soundscape

When asked to what extent they were able to create a soundscape: 62.5% of participants answered 3 out of 5, and 37.5% answered 4 out of 5. They judged Soundscape easy to use and generally performing well. P3 and P7 liked the spatial rendering when moving around the sounds and the listener. P4 valued the Dropbox integration.

However, limitations were reported, which were merely on the user interface and minor glitches. For example, P2 and P4, had difficulties differentiating the sources since they all had the same colour. There were also issues when moving the sources. When P3 selected a source to move, it would automatically go to the outer edge of the bounding box. Also P6 could not drag the sources inside the box unless the mouse was moved to the bottom of the screen first. P6 and P8 couldn't move the listener with the arrows. Finally, when exporting the soundscape, it was unclear if it was done successfully.

In terms of functionality, P1 wanted to import stereo files and have level meters to judge the overall volume. P2 would like to see a timeline to create timed sounds, for example to create a dialogue. Moreover, P8 would like to see how far in the loop the playback was. P2 would also want to record the sound while moving around the listener. P4 was missing a control for source elevation. And for P5 the navigation method forces you to reduce an immersive frontal experience to a top view.

## 5 CONCLUSIONS and FUTURE WORK

In this paper we presented the design criteria and the state of development of two web applications, PlugSonic Sample and PlugSonic Soundscape, implemented as part of the PLUGGY project. The project aims at developing a social platform and several web apps (AR, 3D Audio, Geolocation, Gamification) to provide the users with the necessary tools to shape cultural heritage; both as a curator and as visitor of virtual or augmented exhibitions. The two apps presented here were developed in order to be integrated in the social platform and allow to edit sound files and to create and experience binaural soundscapes. The main objective was to design simple and effective tools that could be quickly understood and used even by inexperienced users. Being web-based, the two apps help to deliver a smooth experience due to the familiarity most people



have with web browsers and the fact that there is no need to install any additional software.

After describing the technology used and the features implemented so far we presented the results of some performance tests. The tests focused on browser compatibility, loading time and CPU/RAM requirements, highlighting how, even if the performance is already good, there is margin for improvement with regards to the initialisation time and memory requirements.

We also conducted an evaluation of the two prototypes with experts in the fields of cultural heritage and/or audio. The initial results were positive both in terms of usability (the apps were perceived as quick and responsive) and functionality (editing options and immersiveness). However, the evaluation suggested that further improvements are necessary in terms of user interface (UI), flexibility and compatibility; and showed how there is interest and potential to extend the apps with desirable features.

The results of the early evaluation are being used to revise further development of the apps and extend the set of features. The PLUGGY project will end in December 2019 and the PlugSonic apps development until then will include the redesign of the UI and complete integration with the social platform and curatorial tool. Building on the experience with the PlugSonic apps we also aim at making a more extensive use of the 3D Tune-In toolkit (e.g. HRTF selection, Binaural Room Impulse Response reverberation), which will be integrated in a web-based open research tool.

## 6 ACKNOWLEDGMENT

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**Table 2:** PlugSonic Sample evaluation results

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The Tool always kept me informed about what is going on through appropriate feedback within reasonable time	0%	0%	42.9%	42.9%	14.3%
The Tool speaks my language, with words, phrases and concepts familiar to me. The information appear in a natural and logical order	0%	0%	14.3%	57.1%	28.6%
I feel the Tool supports undo and redo	14.3%	14.3%	42.9%	14.3%	14.3%
I never have to wonder whether different words, situations, or actions mean the same thing	0%	0%	0%	28.6%	71.4%
The Tool helps me to recognise, diagnose and recover from errors	0%	42.9%	42.9%	14.3%	0%
The Tool prevents a problem from occurring in the first place	0%	0%	71.4%	28.6%	0%
I feel I had to remember information from one part of the dialogue to another	14.3%	42.9%	28.6%	14.3%	0%
The Tool supports flexibility and efficiency of use. It allow me to tailor frequent actions	28.6%	14.3%	14.3%	42.9%	0%
The Tool contains information which is irrelevant or rarely needed	28.6%	71.4%	0%	0%	0%
Help is easy to search, focused on the user's task, list concrete steps to be carried out, and not too large	0%	14.3%	71.4%	14.3%	0%
The Tool support, extend, supplement, or enhance my skills, background knowledge, and expertise - not replace them	0%	0%	42.9%	57.1%	0%
The Tool would enhance the quality of my work-life. The design is aesthetically pleasing with artistic as well as functional value	14.3%	42.9%	14.3%	14.3%	14.3%
I feel the Tool would help me in protecting personal or private information belonging to me or my clients	14.3%	28.6%	57.1%	0%	0%

**Table 3:** PlugSonic Soundscape evaluation results

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
You were able to create to a great extent the soundscape	0%	0%	62.5%	37.5%	0%
The Tool always keep me informed about what is going on through appropriate feedback within reasonable time	0%	12.5%	37.5%	50%	0%
The Tool speaks my language, with words, phrases and concepts familiar to me. The information appear in a natural and logical order	0%	0%	12.5%	62.5%	25%
I feel the Tool supports undo and redo	25.0%	37.5%	37.5%	0%	0%
I never have to wonder whether different words, situations, or actions mean the same thing	12.5%	0%	25%	62.5%	0%
The Tool helps me to recognise, diagnose and recover from errors	0.0%	37.5%	50%	12.5%	0%
The Tool prevents a problem from occurring in the first place	0%	50%	37.5%	12.5%	0%
I feel I had to remember information from one part of the dialogue to another	25%	62.5%	12.5%	0%	0%
The Tool supports flexibility and efficiency of use. It allow me to tailor frequent actions	12.5%	12.5%	37.5%	25%	12.5%
The Tool contains information which is irrelevant or rarely needed	37.5%	50%	12.5%	0%	0%
Help is easy to search, focused on the user's task, list concrete steps to be carried out, and not too large	14.3%	0%	42.9%	28.6%	14.3%
The Tool support, extend, supplement, or enhance my skills, background knowledge, and expertise - not replace them	0%	0%	50%	37.5%	12.5%
The Tool would enhance the quality of my work-life. The design is aesthetically pleasing with artistic as well as functional value	0%	37.5%	25%	25%	12.5%
I feel the Tool would help me in protecting personal or private information belonging to me or my clients	42.9%	14.3%	42.9%	0%	0%