VUSAA: AN AUGMENTED REALITY MOBILE APP FOR URBAN SOUNDWALKS

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ABSTRACT

This paper presents VUSAA, an augmented reality soundwalking application for Apple iOS Devices. The application is based on the idea of Urban Sonic Acupuncture, providing site-aware generative audio content aligned with the present sonic environment. The sound-generating algorithm was implemented in Kronos, a declarative programming language for musical signal processing. We discuss the conceptual framework and implementation of the application, along with the practical considerations of deploying it via a commercial platform. We present results from a number of soundwalks so far organized and outline an approach to develop new models for urban dwelling.

1. INTRODUCTION

City dwellers tend to be in the public space only in their transits, going from home to work to groceries to recreation and back home. The faster the transit time the better, occupying public spaces only while consuming. The use of headphones while transiting fosters new forms of urban detachment, this 'headphone city' [1] alienates any sense of place or community links. We believe that sound and the practice of soundwalking are very powerful tools to create sense of place and can lead to new forms of urban dwelling.

In this paper, we introduce the *Virtual Urban Sonic Acupuncture App* (*VUSAA*), a novel iOS application that generates site aware augmented reality urban soundwalks. The app relies on the practice and concepts behind *sonic acupuncture* and *aural weather* that Moreno is developing in his research [2]. *Urban Sonic Acupuncture* is the parallel in the sonic field of the hyper-local urban rehabilitation practices under the name of *urban acupuncture* [3] [4]. *Aural weather* echoes prior theoretical work in design and architectural atmospheres [5] [6]. The concept of "weather" also refers to alternative ways of organizing sound [7].

VUSAA is an experimental augmented reality soundwalking app for iOS mobile devices, based on *urban sonic acupuncture* strategies. It uses sensor technology to generate sonic content intended to affect the perception of the urban environment. *VUSAA* constitutes a proposal to use soundwalking and urban psychogeographic drifting as tools for finding new ways of urban attachment and conscious dwelling by using minute sonic interventions that augment the sonic reality of the urban space.

The rest of the paper is organized as follows: Background (Section 2) gives an overview of the prior work on soundwalk applications and related theory. The Conceptual Framework is discussed in Section 3. We follow up with a description of the Implementation and the achieved results in Sections 4 and 5. Conclusions are presented in Section 6.

2. BACKGROUND

In this section we discuss the concepts and practices that helped in building the conceptual and technical background of the augmented reality soundwalking app *VUSAA*.

2.1 Urban Sonic Acupuncture

To address the issue of urban decay, recent urban planning trends opt for small-scale local participatory actions that have a global impact in urban life and urban stewardship. This practice has been called *urban acupuncture* [3] [4]. *Urban sonic acupuncture* offers a sonic take on *urban acupuncture* practices, based on cultural acoustics and aural architecture [8]. Urban sound, its auditory figures [9], sound effects [10] [11] and *sonic commons* [12] have been thoroughly studied.

Using sound in this way foments urban attachment, social dialogue, different speeds and wandering [13] in public spaces. *VUSAA* offers the possibility of testing the idea of *urban sonic acupuncture* in the form of augmented reality, generating minute subtle sonic content according to the present sonic situation and other environmental data gathered by the sensors on a mobile device. These sonic interventions affect the perception and relationships of the sounds and events that the listener participates in.

In developing the practice of *sonic acupuncture*, the concept of *aural weather* was coined by Moreno [2] and formulated inspired by the theory of atmospheres [5]. This concept can also refer to alternative ways of organizing music [14] [7], as shown in Section 3.1.

2.2 Prior Soundwalking Apps

Some augmented reality and soundwalking apps exist in the iOS App Store. *GeoComposer/GeoPlayer* from *sonicPlanet* links field recordings and pre-composed sonic content to the Google Street View. This creates site-specific 3D soundscapes. The soundscapes can be experienced on-site as audiovisual augmented reality or remotely.

Collectif MU has developed *SOUNDWAYS*. This app plays back pre-composed music which gets triggered when the user enters a specific area linked to a GPS position. The app displays the area of playback for each sonic event as bubbles of different size and loudness–balance behaviour. The walks can be done on-site or remotely, by moving a cursor around a map on which the bubbles are displayed. Based on this platform, *MSWalks* app was developed for the Sibelius Academy Music Technology Department. The *MSWalks* app contains soundwalks specific to the Helsinki Töölönlahti area. There are plans to include more soundwalks for different areas in Helsinki.

Walk With Me by Strijbos & Van Rijswijk is another app with similar GPS-linked sonic bubbles, with the addition of text information as means of extending the experience of visiting places. Significantly, this app uses the microphone input and site-specific sound effects to modify ambient sounds. [1]

2.3 The Kronos Programming Language

Kronos is a declarative programming language designed for musical signal processing. It features declarative, generic programming and a semi-functional reactive model. [15] There is also prior work on deploying Kronos programs on mobile devices [16].

Kronos applications are modeled as reactive signal graphs. Implementing an augmented reality application consists of connecting the various sensors and inputs on the physical device to the signal graph, which in turn produces the result audio stream.

3. CONCEPTUAL FRAMEWORK

In all the apps mentioned in Section 2.2, soundwalks are bound to specific geographical areas and the sonic content is preordained. None of them uses real-time generated music; they rely on pre-composed or pre-recorded material. Among them, only *Walk With Me* utilizes real-time audio input in any way.

A motivator for the present study was our belief that using the microphone input and listening to it, is what makes the actual environment and its inherent sound relevant to the provided sonic content. *VUSAA* proposes a generative way of engaging sonically with the environment. This is achieve by making the app aware of the present sonic and other site-related conditions. Therefore, we decided to exclusively support on-site, augmented reality soundwalking.

The work of the duo A+O (Sam Auinger and Bruce Odland) *"Harmonic Bridge"* (MASS MoCA, North Adams, MA, 1997–present), Max Neuhaus "Times square", and Alvin Lucier's slow sweeping waves pieces and *"I am sitting in a room"* have played an important role in the development of sonic acupuncture strategies used in VUSAA. What all these works have in common is that they take a non-exclusionary, transformative attitude towards diegetic sound. This resonates strongly with our goal of urban sound augmentation. In addition, ***VUSAA*** takes direct inspiration from the practice of *soundwalking* [17] and *psychogeography*'s [18] inclination to drifting.

3.1 Composing Aural Weather

When composing for an unknown range of possibilities, spaces and local conditions, it is important to find the balance between the variety of generated sonic reactions and the identity of the work itself. In order to compose *aural weather*, one has to learn how to create music with a primary dimension other than *time*, learning *"to move from structure to process, from music as an object having parts, to music without beginning, middle, or end, music as weather"* [14]. The challenge consists of creating the conditions in which the sonic atmosphere (*aural weather*) provided by VUSAA, installs itself in whatever pre-existing sonic atmosphere the user might find.

The theory of atmospheres has gained momentum recently in the fields of architecture and design [5] [6] [19]. These practices foment peripheral perception and light Gestalt as means of approaching architecture and design. To install an atmosphere, Thibaud suggests learning how to master *"the art of transpiring, the art of coloring, and the art of accompanying"* [19]. The connotations of weather, that atmospheres already have, are suggested in sonic context by Ingold [20]. Along the same lines, the concept of acoustemology – knowing a place through sound [21] – is highly relevant.

From all this, we envisioned a reactive multi-layered "weather" in the form of an algorithm with no pre-recorded material. The algorithm is designed to allow for driving the user's attention towards surprising elements in the urban soundscape. In this way, the *aural weather* behaves dynamically and musically under complex sonic situations such as heavy traffic. On the other hand, it gets very subtle under more a tranquil atmosphere.

Finally, a musical structure that is not based on time requires a great deal of user agency in articulating the temporal dimension, choosing the walking path, the walking pace, choosing where to point the device's microphone at, etc. We tried to avoid the need to interact with the screen. However, we added a slider to the main screen to let the user adjust their preferred listening balance between the microphone and generated sound.

4. IMPLEMENTATION

This section discusses the implementation of the iOS application supporting the soundwalk concept that is the topic of the present study. We will describe the user interface and sound processors in *VUSAA* as well as some details specific to deploying the application on iOS.

4.1 Presentation

The user interface in *VUSAA* is meant to divert the user from the screen, prioritizing other means of agency, such as speed of walking, choice of path, or where to point the device's microphone.

[1] All the apps mentioned in this section can be downloaded from the iOS App Store or directly from the embedded link in the text.

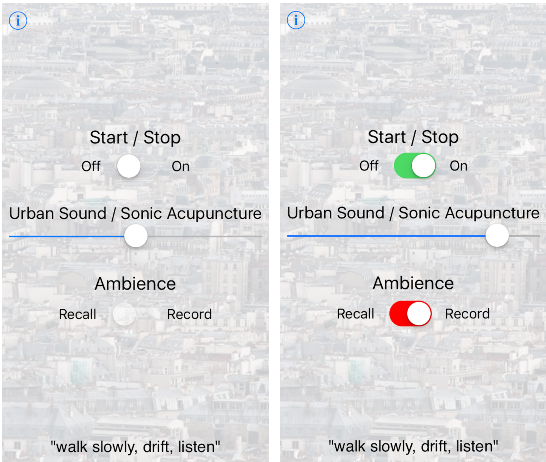

Figure 1. On/Off *VUSAA* main screen.

The on-screen user interface consists of a slider and two buttons; please see Figure 1. The application features an ambience loop of 5 seconds. The user may toggle between recording and reproduction of the loop by toggling the *Ambience* switch; when record is engaged, the audio loop is overdubbed. The recorded urban sound will be subsequently played back at different times and loudness levels.

The rest of the interface consists of the info screen and the statement *walk slowly, drift, listen*. In the info screen, there is information about how to use the app and a small introduction to the concepts behind *urban sonic acupuncture* and *VUSAA*. We understood that such an explanation would be needed to make the app and its sparse user interface easy to navigate.

4.2 Sound Generation

The signal flow diagram of the VUSAA application is shown in Figure 2. The actual signal processor responsible for sound generation is implemented in the Kronos programming language.

The application derives control data from transient analysis, as well as non-audio inputs including luminance (via camera), GPS position and the time of day relative to local sunrise and sunset.

The control data is used to drive several synthesis algorithms in parallel. The recorded ambient loop is processed with a luminance-dependent high frequency rolloff and mixed with a thresholded noise generator ("dust") and fed into a resonator bank. The bank is tuned to a chord that changes with the time of day.

Another preset chord controls a pseudorandomly arpeggiated Karplus-Strong string model with a luminance-dependant damping parameter. The excitation for the model is derived from the microphone input, gated by the transient detector; percussive sounds in the ambience gain a windchime-like echo in the augmented soundscape.

A progressively transposing echo is implemented with a tape loop -style delay effect with a real-time write head and a slower read head. The transient detector causes the heads to realign, giving the effect of resetting the transposition when an audible echo begins.

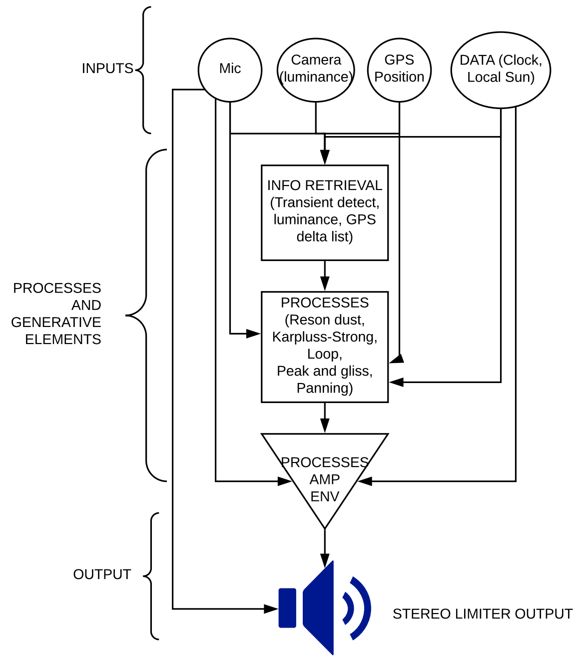

Figure 2. Overview of the *VUSAA* algorithm.

All the processes described so far are modulated by slow, gradually phasing amplitude envelopes. The overall speed of the envelope is determined by time of day, while the least significant portion of GPS latitude and longitude change the phase offsets between the envelopes. This causes new aspects of the mix to appear as the soundwalker moves around.

Finally, the synthesized sound is mixed with raw microphone input according to the slider position on the user interface.

4.2.1 *iOS Deployment*

Kronos is originally a just-in-time compiler. A mobile application should, however, be statically compiled. Apple guidelines prohibit code generation on the device, and in any case it is best to take that burden away from the end user.

Kronos does also feature a static compiler called *kc*, incorporating the LLVM [22] code generator. As such, it can generate C-compatible object files, LLVM bitcode, or symbolic assembly. LLVM is also inherently a *cross-compiler*, which means that it can, by default, generate code for architectures other than the host machine it is running on. For iOS development, we configured and built LLVM and Kronos on macOS with support for x86 and ARM.

When compiling for iOS, Xcode behaves differently depending on the target. If a physical device is connected, the code generators target its native hardware architecture. For the iOS simulator, x86 is used. When deploying to the app store, Xcode builds code for all the three variants of ARM processor currently supported. As of this writing, the Apple App store can also record binaries in the LLVM bitcode. These attain a degree of hardware independence, and in theory allow support for as-of-yet unknown future architectures.

4.2.2 Xcode Integration

We integrated *kc* into Xcode with a custom build rule. This way, the Kronos-language DSP implementation can be added to the Xcode project as a normal source file. Xcode automatically sets a *TARGET_TRIPLE* variable describing the platform and architecture for each build. The build rule relays that to the *kc* driver, and thus to LLVM, resulting in transparent cross compilation support; Xcode invokes *kc* to build the DSP code for any required hardware targets.

Because we used a non-standard, cross-compilation capable build of *kc* for the present project, the specific compiler binaries were embedded and archived within the *VUSAA* repository.

5. RESULTS AND DISCUSSION

5.1 Public Presentations

We presented *VUSAA* in two events, involving a short theoretical presentation and a soundwalk utilizing the app. Given that not all the attendants had an iOS device or headphones, devices were provided along with headphones. Headphone splitters were used to stretch the number of available iOS devices, allowing for a social soundwalking experience in pairs, as shown in Figure 3. Having two users per device meant that two people would have the same sonic experience, having to negotiate the path to follow and the app settings.

The first event happened in Venice in June 2017 in the Research Pavilion – Camino Events of the University of the Arts Helsinki. The *VUSAA*-enhanced soundwalk was hosted in the Giudecca island in the surroundings of the pavilion. This was a very interesting place for soundwalking given the absence of car traffic and the interesting noises produced by the vaporetto platforms. A group of international researchers contributed to the discussion after the soundwalk.

The second event happened in the Tampere Biennale in Finland for several days. On the first day, we used the app to transit between art galleries in the opening day. That day, some sound artists started spontaneously using the app to listen to other sound art works and musical compositions. For the second soundwalking event, the walk happened around the centre of the city, designed by the production team to experience the app in different urban settings that ranged from a waterfall area to the transit under a heavily-used car bridge.

We toured intensively during the Summer of 2017, testing the app in multiple countries. As a result, we produced a set of recordings documenting the app evolution and reactions to different urban environments. We presented these recordings and the concepts behind *VUSAA* at the Sibelius Academy Music Technology Department's *Generative Art Café* in Helsinki.

We gathered feedback from the users in the form of notes taken during discussions following each presentation and during personal interviews. It seems that *VUSAA* is particularly successful in creating relationships among pre-existing

Figure 3. *VUSAA*-enhanced second soundwalking event during Tampere Biennale 2018.

sound objects. For instance, the always moving "dust" element is a subtle and yet powerful way of affecting the perceived fundamental of pitched sound objects. Simultaneously, the resonant algorithms are efficient in generating harmonic content and creating harmonic relations between disparate sound objects.

5.2 Problems with the App Store review process

We faced an interesting problem during the app review and publishing process. *VUSAA* was originally meant to work in background mode to discourage users from staring at the screen only. The iOS App Store review team initially rejected our app because they did not find a compelling reason for the application to be accessing the microphone while in the background. After some back and forth submission-rejection cycles we asked them for a phone conversation in which it became clear that their and our notion of *audio content* were not aligned. They clearly stated that resonant dust or softly playing background chords do not count as audio content.

At that point, it became obvious that our digital platforms are products subject to corporate ownership and control, and not public services. A privately owned platform has no space for flexibility in their interpretations and they have all the right to reject our submissions or even ban us from App Store. We learned that proposing an audio application that consists mainly of a complex passive sonic object was a difficult proposition for the App Store review team. We solved this by giving up the background mode altogether. This decision turned out to have no significant impact on the app usability during the soundwalking events.

VUSAA app can be downloaded from the App Store from this *link* [2] or from *Moreno's website*.

5.3 Future Work

Taking into account the received feedback and our findings through daily use, we have plans for further developing *VUSAA*'s variety of processing modules extending the posible *aural weather* situations provided by the app. We will work on keeping the app updated and extend the hardware compatibility with different headsets. At the same time,

[2] VUSAA can be downloaded from this link: https://itunes.apple.com/es/app/vusaa/id1244860977?mt=8 ; or from the project's website: http://josuemoreno.eu/project/vusaa/

more *VUSAA*-enhanced soundwalking events are currently under production in several European cities. Finally, further development will be done in refining and implementing the interaction between control parameters and the audio algorithm.

Currently, there are new projects under development that are based on the technology and conceptual framework developed for *VUSAA*. These elements will allow us to implement site-specific *urban sonic acupuncture* projects quickly, by taking advantage of the rapid development enabled by Kronos.

6. CONCLUSION

VUSAA constitutes a first attempt at augmented reallity soundwalking based on *urban sonic acupuncture* strategies for iOS mobile devices. It takes advantages of the many sensing and listening abilities the iOS mobile devices provide to generate sonic content meant to affect the perception of the urban environment.

We believe that VUSAA breaks new ground in several ways; it is the first Kronos-based application that was successfully shipped via the iOS App Store. It is arguably the first site-aware soundwalk app, and definitely the first Urban Sonic Acupuncture app available. The initial group *VUSAA*-enhanced soundwalks and the received feedback from the users positions this app as a very interesting proposal for turning soundwalking and urban psychogeographic drifting into tools for finding new urban dwelling models in which to develop a more conscious attitude towards sound. We consider it very promising to use the very same tools that contribute to urban aural detachment – mobile devices and headphones – to revert the situation.

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7. REFERENCES

[1] C. Ripley, "Instrumental operations in the urban assemblage," in *Journal of Sonic Studies, 11*, 2016.

[2] O. Lähdeoja, J. Moreno, and D. Malpica, "In situ: Sonic greenhouse. composing for the intersections between the sonic and the built," *Journal for Artistic Research*, 2019.

[3] J. Lerner, *Urban Acupuncture: Celebrating Pinpricks of Change that Enrich City Life*. Washington: Island Press, 2014.

[4] H. Casanova and J. Hernandez, *Public Space Acupuncture: Strategies and Interventions for Activating City Life*. Actar, 2015.

[5] T. Griffero, *Atmospheres: Aesthetics of Emotional Spaces*. Routledge, 2014.

[6] G. Böhme, "Urban atmospheres; charting new directions for architecture and urban planning," in *Architectural Atmospheres: On the Experience and Politics of Architecture, ed. Christian Borch, Birkhuser Basel*, 2014.

[7] D. Toop, *Haunted Weather: Music, Silence and Memory*. Five Star Fiction S., 2006.

[8] B. Blesser and L.-R. Salter, *Spaces speak, are you listening?: Experiencing aural architecture*. Cambridge, Mass: MIT Press., 2007.

[9] B. LaBelle, *Acoustic Territories: Sound Culture and Everyday Life*. New York: Continuum, 2010.

[10] J.-F. Augoyard and e. H. Torgue, *Sonic Experience: A Guide to Everyday Sounds*. McGill-Queens University Press, 2005.

[11] P. Amphoux, *Aux coutes de la ville : la qualit sonore des espaces publics europens. Mthode danalyse comparative. Enqułte sur trois villes suisses.* CRESSON, 1991.

[12] B. Odland and S. Auinger, "Reflections on the sonic commons," in *Leonardo Music Journal, 19*, 2009, p. 64.

[13] Y.-F. Tuan, *Space and Place: The Perspective of Experience*. Minneapolis, London: University of Minnesota Press, 2001.

[14] J. Cage, *An Autobiographical Statement*. Southwest Review, 1991.

[15] Vesa. Norilo, "Kronos: A declarative metaprogramming language for digital signal processing," *Computer Music Journal*, vol. 39, no. 4, pp. 30–48, 2015.

[16] ——, "Kronos as a Visual Development Tool for Mobile Applications," in *Proceedings of the International Computer Music Conference*, Ljubljana, 2012, pp. 144–147.

[17] H. Westerkamp, "Soundwalking," in *Sound Heritage, Volume III Number 4, Victoria B.C.*, 1974 Revised 2001.

[18] G. Debord, *Introduction to a Critique of Urban Geography*. Les Lvres Nues, 1955.

[19] J.-P. Thibaud, "Installing an atmosphere," in *Architecture and Atmosphere, ed. Philip Tidwell Tapio Wirkkala-Rut Bryk Foundation, 2014*, 2014.

[20] T. Ingold, "Against soundscape," in *Autumn leaves, A. Carlyle ed., Double Entendre*, 2007, pp. 10–13.

[21] S. Feld, "Acoustemology," in *David Novak & Matt Sakakeeny, eds, Keywords in Sound. Duke University Press*, 2015.

[22] C. Lattner and V. Adve, "LLVM: A compilation framework for lifelong program analysis & transformation," *International Symposium on Code Generation and Optimization 2004 CGO 2004*, vol. 57, no. c, pp. 75–86, 2004.