Sound Surfing Network (SSN): Mobile Phone-based Sound Spatialization with Audience Collaboration

Saebyul Park
C.Interaction Lab
GSCT, KAIST
Daejeon, 305-701, Korea Republic
saebyul_park@kaist.ac.kr

Seonghoon Ban
Exp Lab
GSCT, KAIST
Daejeon, 305-701, Korea Republic
bahn@kaist.ac.kr

Daeryong Hong
Audio & Interactive Media (AIM) Lab
GSCT, KAIST
Daejeon, 305-701, Korea Republic
drhong@kaist.ac.kr

Woon Seung Yeo
Audio & Interactive Media (AIM) Lab
GSCT, KAIST
Daejeon, 305-701, Korea Republic
woony@kaist.edu

ABSTRACT

SSN (Sound Surfing Network) is a system that provides a new musical experience by incorporating mobile phone-based spatial sound control to collaborative music performance. SSN enables both the performer and the audience to manipulate the spatial distribution of sound using the smartphones of the audience as distributed speaker system. Proposing a new perspective to the social aspect music appreciation, SSN will provide a new possibility to mobile music performances in the context of interactive audience collaboration as well as sound spatialization.

Keywords

Mobile music, smartphone, audience participation, spatial sound control, digital performance

1. INTRODUCTION

It has not been long since listening to music has become a private and personal experience. Throughout human history, the personal and social aspects of musical experience have been continuously changing. Before the advent and popularization of media such as phonographs and radio broadcasting, music was usually experienced as a group at public places; personal and private music appreciation was possible for only a few privileged people. Nowadays, however, various devices enable people to listen to music privately.

Mobile phones are inherently private, personal and intimate. Listening to music with a mobile phone is a personal experience, as it is usually done individually or as a small group of people. Recently, artists interested in the social aspect of musical experience transformed this personal device into a more social one by using mobile phones as a tool of audience collaboration in music performance. Examples include Dialtones (A Telesymphony), one of the first works that incorporated the audience's mobile phones in music performance [1]. Akamatsu presented Okeanos Buoys, in which the audience can affect or manipulate the synthesized sound by walking around the installation [2]. Lee also introduced a collaborative performance using the audience's iPhones [3]. While each of these shows a different paradigm of collaboration, they are all innovative attempts suggesting a new aspect of mobile phones in music.

This project aims not only to facilitate audience collaboration using mobile phones, but also further emphasize the social aspect of musical experience as a group, by implementing spatial sound control. Spatial characteristics of sound in music can be definitely considered as an important and novel aspect. Although Bates described various approaches to spatial music including architecture, real-time electroacoustic, and composition [4] along with a specially designed instrument for spatial control, the *Hexaphonic Guitar* [5], few works can be found which are based on mobile platforms.

This paper presents *Sound Surfing Network* (SSN), a new sound spatialization system in a mobile environment. The goal of this project is to provide a new musical experience by incorporating spatial sound control system to mobile music performances with audience collaboration in mind. SSN enables both the performer and audience to manipulate spatial distribution of sound by locating the sound sources, and uses the audience's smartphones to construct a distributed speaker system; the audience can hear the live sound through their own smartphone speakers. Localization of sound can be managed by either the performer, or the audience, or both. Changes in spatial distribution of the sound are displayed to the audience in real-time, on a main screen on stage as well as each smartphone screen. As the localization of sound can be moved freely throughout the audience's smartphones, this movement can be thought as "sound surfing" on a "wave of sound".

SSN emphasizes the social aspect of listening to music by enabling the audience to listen to music with a large number of people through their own mobile phones. While mobile phones are regarded as one of the most personal and intimate devices, and listening to music with them is a strictly personal activity, SSN uses this device as a part of a large multi-channel speaker array, thereby transforming the most personal device into a tool of group activity.

2. SYSTEM OVERVIEW

Using the audience's mobile phones as a distributed multi-channel speaker, the SSN system aims to enable its users to control the location of sound source in a performance. Figure 1 illustrates the conceptual model of SSN system. Figure 2

NIME'13, May 27-30, 2013, KAIST, Daejeon, Korea.

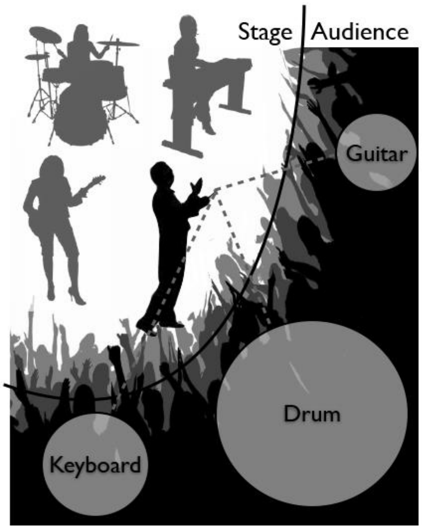


Figure 1. Conceptual model of SSN system. Spatial sound control is implemented through speakers of each audience's mobile phone. Performer decides the sound source location and influence

shows the system diagram of SSN. While locating the position of a virtual sound source, the performer (or multiple performers) on stage plays a MIDI instrument (i.e., any device which can translate performance information as MIDI messages). Both the performance MIDI data and position information are transmitted to a server computer, which calculates the output level of (and broadcasts MIDI data to) each phone. It is noteworthy that performance information is sent as MIDI messages – not PCM sound sample data – in order to minimize delay as much as possible.

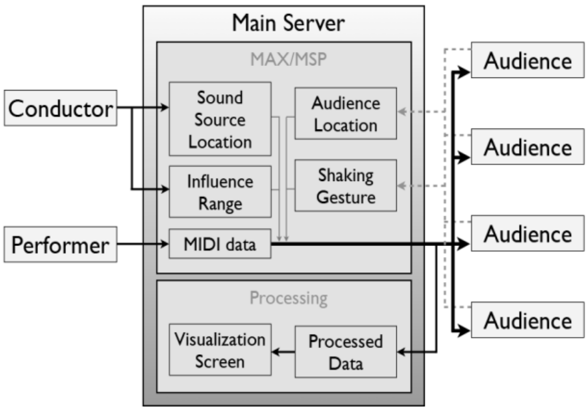


Figure 2. System diagram of SSN. MAX/MSP was used in order to communicate with performer and audience's devices. Processing language was also used for visualization.

The output level of each phone is determined by the distance from the location of the virtual sound source (1/r^2);

2.1 Applications

SSN uses two different versions of applications: one for the performer and another for the audience. The performer's mobile application, designed to run on the iPad, allows the user to place a virtual sound source and adjust its influence range on the screen; these parameter values are then transmitted to the server. The user interface of this app is shown in figure 3. All mobile phone applications were developed on the iOS platform.

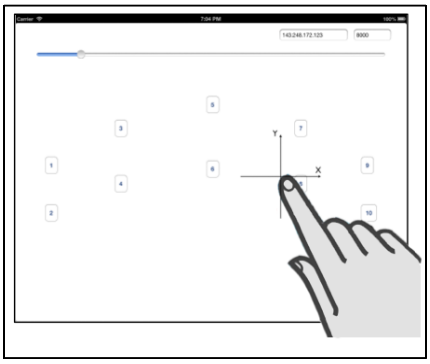


Figure 3. Performer's app. The performer changes the location of sound source using dragging, and controls the influence range by slider control or pinch gestures

The audience app turns each mobile phone of the audience into a speaker array element; it takes MIDI messages as well as output level from the server and plays them accordingly. We used MoMu [6] and STK [7, 8] toolkits to implement MIDI data communication (`MoNet` class from MoMu) and sound synthesis (STK).

Similar to the performer's app, the audience's app features a text field to enter the IP address and port number of the server as well as another text field to enter the seat number of the audience; based on this information, the server can identify the position of the phone and send proper information for sound localization.

In addition, the audience app provides a simple and intuitive visualization of the currently played sound and its spatial distribution (figure 4), making the experience more immersive and participatory. The range of influence is represented by the saturation level of background color, and the output amplitude determines the center circle's radius.

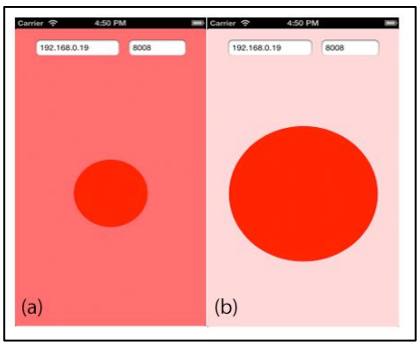


Figure 4. Audience's app. Circle size represented the amplitude of each audience. High background saturation means the influence range is wide.

2.2 Public Visualization

SSN also provides a large-screen display that visualizes the location of the virtual sound source and its influence range; sound source is shown as a white circle, and its size is determined by the influence range. Selected seats are shown as dots, and gradually become red when approached and influenced by the sound source (figure 5). This type of visualization, illustrating the current state of sound distribution, offers additional understandability to the audience. The public visualization is implemented using Processing, and the program is run on the main server.

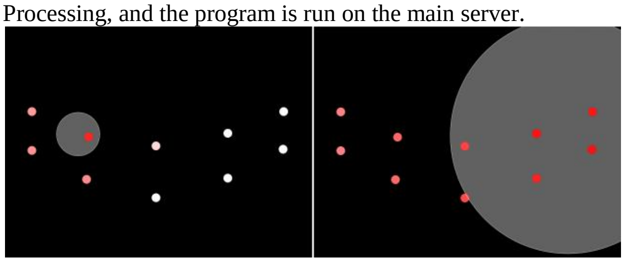


Figure 5. Screenshots of sound source visualization.

Furthermore, performer's hand motions to move sound source on touchscreen can be captured by a webcam and shown on screen in real-time. Another video camera can take the audience, as shown in figure 6.

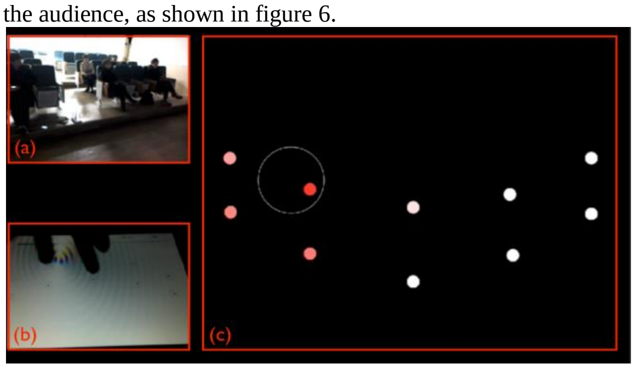


Figure 6. Example of SSN public display configuration: view of the audience (a), performer's control gesture (b), and sound source location (c).

3. PERFORMANCE

Performance based on SSN can be configured in different ways depending on how (and by whom) the virtual sound source is located and controlled. By default, the performer uses the performer app to move the sound source on stage. Alternatively, for more active audience participation, each of the audience can contribute to the motion of the sound source by "pulling" it to him/her through shaking gesture; stronger shaking gesture results in harder pulling gesture.

3.1 Performance Demonstration

An experimental SSN performance was premiered on January 24, 2013. The venue was a multi-purpose conference room at Korea Advanced Institute of Science and Technology. The dimension of the room is 6m x 10m, a rectangle shape, and the height is 2.5m.

There were 3 performers proceeded the experiment. Firstly, the piano player played an instrumental song with a MIDI keyboard. Secondly, the app operator conducted the application control for the audience. Finally, the programming engineer designed the audio and visual output during the play.

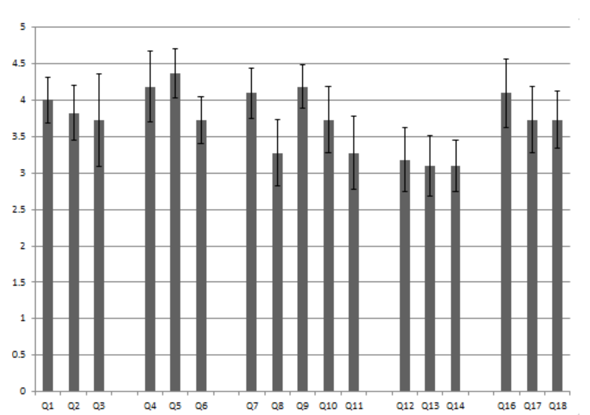
Table 1.Specification of the device and software used for SSN

Computer	Macbook Pro Retina 15" 2.6 GHz Intel Core i7 8GB 1600MHz DDR3 MAC OSX 10.8.2
Network device	ipTIME N8004
Midi instrument	M-AUDIO PROKEYS88
Mobile device	iPhone & iPod
Audio programming	Max 6
Visual programming	Processing 2.0 b4

Table 1 shows the specification of the used devices. The MIDI signal was transmitted to the laptop computer and processed for the audio signaling and visualization. The app operator used his iPad to change the sound field during the performance. The whole data signal was communicated via a portable WiFi device.

As for the audience, 20 participants were divided into 2 groups; the first group was given the smartphone with the SSN app installed, and the second group was participated without any device. In order to apply differences between tempo, the song was played with 80 and 120 bpm. The first step was demonstrated without the audience participation, and the second step was followed with shaking their phones to check the movement of the audio field.

3.2 Audience Survey Result



Q1) Was the sound interesting?
Q2) Was the sound immersive?
Q3) Was the sound novel?

Q4) Was the movement of sound noticeable?
Q5) Was the movement of sound a novel experience?
Q6) Did the movement of sound enhance the overall experience?

Q7) Did you enjoy your mobile phone generating sound?
Q8) Did you feel the performance as a personal experience?
Q9) Did you feel the performance as a social experience?
Q10) Did you feel indirect participation to the performance?
Q11) Did you feel direct participation to the performance?

Q12) Was the volume of the sound loud enough?
Q13) Was the quality of the sound good enough?
Q14) Was the latency of sound tolerable?

Q15) Did the visualization enhance the feeling of sound movement?
Q16) Did the visualization enhance the listening experience?
Q17) Did the visualization enhance the participation to the performance?

Figure 7. Audience survey result.

Figure 7 shows the questionnaire questions and the result of audience survey after the SSN performance. Each question has been answered in a five-point scale (one to five points).

The audience gave high rates to interestingness (Q1) and immersion (Q2). The movement of sound was fairly noticed by the audience (Q4), and the novelty of sound movement received the highest score (Q5; average = 4.36). The audience enjoyed the sound generated from their mobile phones (Q7), and regarded the listening experience through SSN as a social activity, rather than personal (Q8 and Q9). Visualization of sound helped the audience to feel the movement of sound (Q15).

The relatively low scores in Figure 7 suggest certain limitations of SSN. The participants felt to be indirect in the performance (Q10) rather than participating directly (Q11) and the quality and volume of sound was not comparatively satisfying (Q12 and Q13). Latency has become a notable issue to the audience (Q14), as the accumulated latency has grown along with the increase in number of mobile phones used.

Although certain technical issues remain, survey results suggest that SSN can enhance the music listening experience.

4. Conclusion

Sound Surfing Network (SSN) is a new interactive spatial sound control system that facilitates audience collaboration. Using smartphones and two different applications, SSN enables the performer and audience to control spatial sound distribution. While the performer's application can control the overall sound distribution, the audience's smartphones are used to form a multichannel speaker system. The audience can sense the sound's spatial movement, not only aurally but also visually through their smartphone screens and the on-stage visualization.

The audience survey results on the demonstration of SSN showed that SSN has a great potential to enhance musical experiences in many aspects in overall, despite of certain technical issues which are expected to be resolved in further development.

We believe that SSN has great significance in terms of spatial sound control in mobile music performances, and that SSN can provide a new musical experience through changing spatial sound distribution by gestures of the performer and/or the audience. Mapping audience gesture to sound distribution proposes a new model of audience's participation in music making process. We also expect that listening to the music with other audience using their own mobile-phones as a multi-channel speaker can provide the audience a new social musical experience.

One of the remaining challenges is how to draw more active participation from the audience. Interaction methods for sound control, such as featuring more gestures, can enhance the sense of controllability. We will also continue to work on spatial musical experience on a mobile platform. Sound field presented by distributed mobile devices (and controlled by mobile devices, too) has a huge potential not only in mobile music but also many other areas.

5. REFERENCES

[1] Dialtones. http://www.flong.com/storage/experience/telesymphony/index.html, recent visit: January 31, 2013.

[2] OKeanos Buoys. http://akamatsu.org/aka/works/okeanos-buoys/, recent visit: January 31, 2013.

[3] S. W. Lee. Audience Participation using Mobile Phones as Musical Instruments. M.S. Thesis, Georgia Institute of Technology, Atlanta, GA, USA, 2012.

[4] E. Bates. The Composition and Performance of Spatial Music. Ph.D. Thesis, Trinity College, Dublin, 2009.

[5] E. Bates, D. Furlong, and D. Dennehy. "Adapting Polyphonic Pickup Technology for Spatial Music Performance." In Proceedings of the International Computer Music Conference, Belfast, UK, 2008.

[6] N. J. Bryan, J. Herrera, J. Oh, and G. Wang. "MoMu: A Mobile Music Toolkit." In Proceedings of the International Conference on New Interfaces for Musical Expression (NIME), Sydney, Australia, 2010.

[7] P. R. Cook and G. P. Scavone. "The Synthesis ToolKit (STK)." In Proceedings of the International Computer Music Conference, Beijing, China, 1999.

[8] G. P. Scavone and P. R. Cook. "RTMidi, RTAudio, and a Synthesis ToolKit (STK) Update." In Proceedings of the International Computer Music Conference, Barcelona, Spain, 2005.