

# Sense of Space: The Audience Participation Music Performance with High-Frequency Sound ID

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## ABSTRACT

We performed the musical work "Sense of Space" which uses the sound ID with high frequency sound DTMF. The IDs are embedded into the music, audiences' smartphones and tablets at the venue reacted to the IDs and then they play music pieces. We considered the possibility for novel music experiences brought about through the participation of audiences and spreading sound at the music venue.

## Keywords

Sound ID, audience participation, music performance

## 1. INTRODUCTION

According to the popularization of media technologies, systems that enhance music experiences with real-time and interactive technologies have been attracting attention. We make practical research for novel experiences and novel ways of enjoying music at music venues by introducing methodologies of expression in media-arts.

In NxPC.Lab [6], our activity, we have made club-music events and developed systems and art-works to enhance music experiences. In particular we developed the system Cryptone [5] which enables interaction between performers and audiences by utilizing high-frequency sound – the so called "mosquito sound" – as a sound ID. The sound ID, which we refer to as Ultra Sound Communication (USC), has features that are easy to use for musicians, and easy to set up for music venues.

We made a system that utilizes USC, and made the music performance "Sense of Space" in which audiences can participate, and produce the space/venue surrounded by music.

In this paper, we describe the system and two live performances with different setups.

## 2. RELATED WORKS

For interactive stage effects in music venues, the iPhone application SYNK [8] is a famous work. That was made for the world tour of Plastikman, where sounds and LED-lighting in the venue can be controlled by the audience with the application. Recently, wireless controlled light-pens [12] or Wrist-bands [13] are starting to be utilized at major pop concerts.

For music artworks, the Sine Wave Orchestra [9] is similar to our concept. In that work, the audience has balls of sound that have particular frequency sinewaves, and generate music harmony of sinewaves when the audience gathers. It enables the participation of the audience for the music performance. SWARMED [1] is also a musical work where the audience can participate. In this work, the audience can control music through mobile devices connected with WiFi.

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In the area of sound IDs utilizing high-frequency sound, there is InfoSound [3], which was developed by YAMAHA, Sonic Notify [11], which is being used on YouTube, and so on. Automatic Contents Recognition technologies such as Evixar [2] or Intrasonics [4] can also be thought of as utilizing high-frequency sound.

## 3. SENSE OF SPACE

The objective of the work "Sense of Space" is to achieve live music performances in which audiences can participate. We are conducting research that focuses on the interaction between performers and their audiences. It is generally difficult to join music performances with sounds made by the audience. In this work, music played by the performer sounds from the main PA system, with audience members being able to participate in the music with sounds played from their smartphones. The sounds from the PA and the smartphones make the music work as a whole and it spreads to the venue. This saturation brings a sense of unity for the performer, the audience and its venue, and also allows them to feel the atmosphere of other audiences and venue spaces with sounds played by smartphones at various locations. All participants can sense the other audiences and expanse of the venue, and because of this we have named this work "Sense of Space".

The quality of the music is the most important element for sufficient music experiences. Therefore we made music in cooperation with Kafuka (the artist name for Kazuomi Eshima), who created the composition while considering the synchronization of music pieces and the special property of venues. The music consist of the main melody and rhythm part sounds from the main PA and 16 music piece sounds from iPads placed in the venue and iPhones held by audience members. These music pieces start to play when triggered by the number of sound ID, which are associated to the music piece and are embedded in the music from the main PA. All of the music from the main PA and music pieces from iPad/iPhone are merged into the venue to compose the entire music work. The performer can flexibly play the music because the sound IDs can be embedded into the music in advance or generate/play real-time during the performance.

The usage of sound IDs has the following merits compared to other methods (WiFi, Bluetooth etc.):

- Easy to manipulate for musicians; embedded into the music, generate in real-time, etc.
- Easy to compose synchronization of music; sound and sound IDs are transmitted at the same speed.

These features can bring improvement to the quality of music when the artist composes music.

## 4. ULTRA SOUND COMMUNICATION (USC)

We developed a method of communication by using DTMF (Dual Tone Multiple Frequency) with high frequency sound, which we call Ultra Sound Communication (USC). USC is the method of defining sound IDs by using the DTMF method with sounds from 18000Hz to 20000Hz.

In general, humans can hear sounds from 20Hz to 20000Hz, but it is said that people over 20 years old cannot hear sounds over 16000Hz.

In addition, these sound wave lengths are not actively used in music. Therefore we think that there are not many people aware of sound IDs with USC in music venues, and malfunctions do not occur frequently in music.

We examined the frequency range of the sound used in USC, and the available range can be recognized and played back with built-in loudspeakers for all iPhone and iPad models after the iPhone3GS. We investigated the upper limit frequency of the sound that can be recognized by a built-in microphone with FFT analysis of sine wave sound that was gradually increased from 20Hz.

As a result, we confirmed that they can recognize up to 22050Hz, and also confirmed that they can playback up to 20000Hz, which is the exact specification on Apple's catalogue. We decided from these results that the frequency of DTMF for USC uses from 18000Hz to 20000Hz, the range needed to ensure sufficient bandwidth.

DTMF is a traditional method defining sound IDs by playing two frequencies simultaneously, which is a commonly used method for telephone tones (ITU Q.24). We applied this method to high frequency sounds. We divide the frequency from 18000Hz to 20000Hz by 250Hz steps, with table 1 showing DTMF frequency for USC.

Table 1 Configuration of Tones and IDs

|         | 19000Hz | 19250Hz | 19500Hz | 19750Hz |
|---------|---------|---------|---------|---------|
| 18000Hz | 1       | 2       | 3       | 4       |
| 18250Hz | 5       | 6       | 7       | 8       |
| 18500Hz | 9       | 10      | 11      | 12      |
| 18750Hz | 13      | 14      | 15      | 16      |

USC originally developed for near field communication method for data exchange between iPhones. We created several artworks as examples of near field communication between iPhones. USC also can be used for a broadcast when sound is amplified and played back with large loudspeakers. The USC can easily broadcast IDs with popular PA systems (amplifiers and loudspeakers) in venues without any special equipment. In addition, IDs can be recognized with microphones, such as the ones built-in on iPhones or those inside PA systems. Also, musicians can easily generate USC sound with music software, and can incorporate it into their music. The response time after receiving sound IDs to play music pieces is within 66msec (2 frames at 30fps), which is compatible enough and adjustable for music.

### 5. SYSTEM OF THE WORK

We have performed this work "Sense of Space" two times with different setups. For each performance we developed an iPhone application, with said applications being distributed on the Apple AppStore, so audiences can participate in performances instantly by downloading the application.

The outline process of the smartphone (iPhone) application is shown in figure 1. Audio input from the microphone on the iPhone is analyzed with FFT (Fast Fourier Transform) into the frequency spectrum. The USC ID is recognized from the spectrum, and then we judged the number of the ID by its two loudest frequencies. We do not judge the ID if there are three or more loud frequency sounds so as to avoid wrong ID recognition from unexpected noise. When the ID is recognized, the music piece corresponding to the ID is played, and particular motion graphics are displayed, indicating the ID is recognized and playing sound on the iPhone.

#### 5.1 System for the Gifu Ogaki Biennale

The first performance was carried out on September 7th, 2013 at Ogaki Japan in the opening music event of Gifu-Ogaki Biennale, "NxPC.Lives" [7]. In this performance the sound system consisted of

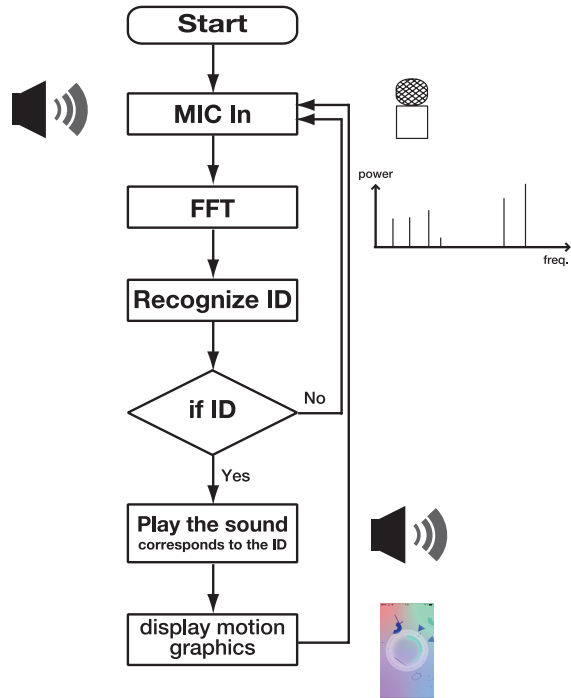


Figure 1 Outline Process of the Application

6 iPads, each connected to a powered speaker, and iPhones in the hands of the audience, in addition to the normal PA system. Figure 2 shows the overview of the system.

Each iPhone carried by audience members is assigned 8 IDs, from ID1 to ID8. 6 iPads are placed at the venue surrounding the audience, and each of them is assigned 8 IDs, from ID9 to ID16. The sound IDs are controlled by Kafuka, the performer, and played through the PA system embedded within the music. When iPads/iPhones receive the sound ID, the music corresponding to the ID plays. The music pieces assigned to the iPhones are some kinds of music harmonized with the main music that are suited for audience members to listen to. The music pieces assigned to the iPads are some kinds of natural ambient music. The iPhone application, shown in figure 3, was created as an application for the event and includes general information for the event. Audiences can start "Sense of Space" as one of the contents in the application.

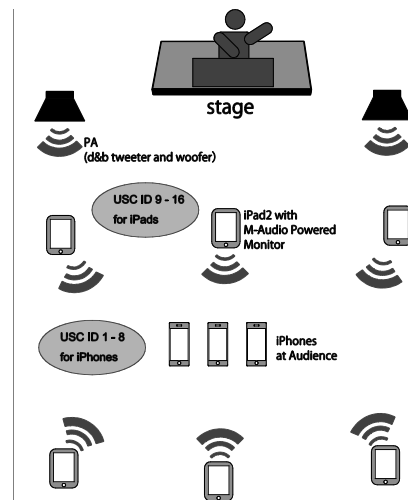


Figure 2 System for the biennale

### 5.2 1.1 System for NxPC.Live Vol.17

The second performance was carried out on August 23rd, 2014 at NxPC.Live Vol.17 in Ogaki Japan, as an associated event for the Ogaki Mini Maker Faire. The underground parking was used as the venue. In this performance, all 16 sound IDs are assigned to iPhones so as to increase the flexibility of composing music. The scene of the performance is shown in figure 4.



Figure 3 iPhone Application screenshots

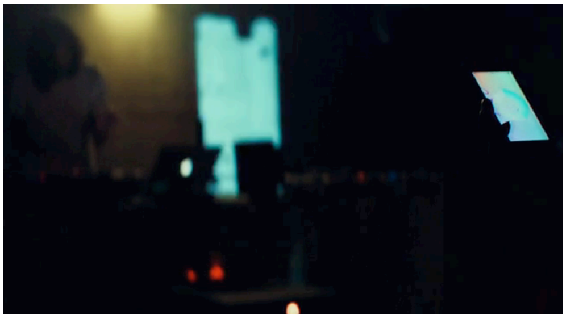
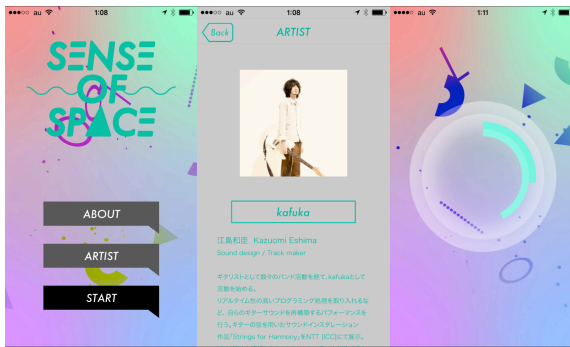


Figure 4 Scene of the Performance



Similar to the previous event, the iPhone application was implemented as a general event application, and audiences can start "Sense of Space" as one of the contents of the application. The application displays the visual content synchronized with incoming sound – if sound IDs are received then it plays music pieces and also shows the visual changes. The demonstration web pages are available at the Sense of Space website [10]; you can try the demonstration version by downloading the application from Apple AppStore. Figure 5 shows screenshots of the application.

## 6. DISCUSSIONS

We could not do a perfect performance at the first event because of some troubles, such as light rain. In spite of the troubles, we had experiences that achieved a sense of unity within integrated music consisting of the main melody and rhythm from the PA, the

surrounding ambient sounds from iPads and the music from the iPhones in the audience. Audience members who participated in the performance also had feel music experiences surrounded by music and the sense of participate in. However there was a problem in that the 8 IDs assigned to each iPad and iPhone were not enough to compose music. It is difficult to make sufficient variations of music.

In the second performance, we tried to increase the flexibility of composing music by assigning all 16 IDs to the iPhones instead of the iPads. As a result, the quality of the music had improved. However this brought out other problems, such as the volume of the sound from the iPhone was too weak to hear. We needed to listen to the music from the iPhone by placing it near our ear, so we could not see the visuals on the application. Audience members also seemed confused about how to enjoy the application. Of course, the music was composed carefully so as to keep the balance of the volume from the music from the PA system and the iPhones. We still need more volume for the music from the iPhones to get excited in music experiences such as these.

In the system of "Sense of Space", careful setup and placement of the sound equipment, as well as composition of the music with consideration of the acoustic environment, becomes increasingly important.

## 7. CONCLUSION

We have achieved novel music experiences that enable the participation of the audience into the performance by utilizing high frequency sound IDs which are easy to use for musicians. This also shows a way to solve the difficulty of collaboration between the performer and the audience in music performances. Our methods enable high quality music composition synchronized between sound devices such as smartphones and the main music which is played by the PA system, just as artists intend. This is done by utilizing characteristics of sound IDs that can automatically synchronize the ID and the music as the carrier of the ID.

We will try to improve the quality of the music and the flexibility of composition by increasing the number of sound IDs in USC. We also plan to combine USC and WiFi or Bluetooth LE to cooperate with the visuals and lighting at venues in order to develop a method to achieve a sense of unity at the venue's music experience.

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