Data Auditorio: Towards Intense Interaction, an Interactive Hyper-Directional Sound for Play and Ubiquity

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ABSTRACT

This paper presents the *playful* and *ubiquitous* interaction of sound: *intense interaction*. It aims to realise, in other words, an interactive sound produced in a certain space. It enables audience to participate in a game called *performance play* (e.g. playing piano, playing music, being a play actor, etc.) in order to significantly change and overcome the existing patterns of reality in the space by their own various activities. An interactive hyper-directional sound environment *Data Auditorio* was created to realise the concept. The interactive sound software processes the feedback signals between the microphone and the hyper-directional speaker keeping it under control. It aims to ultimately give rise to a kind of sonic organism; the sound is, in fact, an algorithmic composition entirely derived from the feedback signals in a real-time sonic environment. The installation utilises the format of a performance stage and encourages the audience to interact in a natural fashion with the interactive sound, thereby making the game of *Data Auditorio* a more active endeavour. The result of it can be applied to a hyper-directional sound interface design, as well as works of art and music.

1. INTRODUCTION

1.1 Hyper-Directional Speaker

This paper presents an interactive sound environment optimised to the use of a hyper-directional speaker. It is called SpotDap 450 of RSF, which can send a hyper-directional sound that has a sharp directivity like a sound spotlight; when it hits a flat hard surface, it reflects very significantly and one may also even perceive the sonic formation of it as a site-specific sonic entity in a space.

1.2 Aim of the Research

As researchers of art and music, ultimately, we hope to enact a kind of organic object (e.g. a sonic organism) which ceaselessly changes, interacts one another and constitutes a part of the world.

Concerning this paper, we present an interactive hyper-directional sound produced in a certain space called *Data Auditorio*. It enables the *playful* interaction and the *ubiquitous* interaction. We summarise and call this interaction the *intense interaction* which tries to make an audience activity - that is, an *interactive art* - a more active endeavour [1] [2].

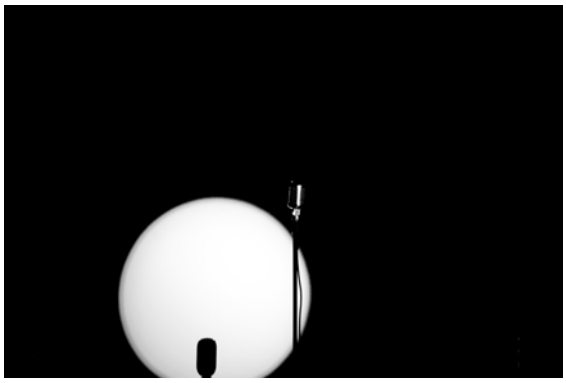

Figure 1. *Data Auditorio*

Figure 2. *Data Auditorio* with a performer

1.3 Intense Interaction: Play and Ubiquity

After creating our former hyper-directional sound installations *Reverence in Ravine* and *Transparent Sculpture* (see the discussions in section 2.2 and 2.3), we wondered "is it possible to present a playful and ubiquitous work that is

[1] The word "active", specifically, means the asymmetry between audiences is flowering (see 3.3 for further discussion)

[2] Although we admit there might be a suitable name more than *intense interaction*, we consider a name of *highly-playful interaction* or *highly-ubiquitous* should not be used, because both terms basically have nothing to do each other. By the same reason, a name *highly-interactive art* should not be used, which may make also confusion between the "highly flexible open" interactivity by Steve Dixon (see the discussion in 3.1).

intensely interactive? [1, 2]" This idea came to the basic motivation of this paper.

Since both installations were participatory or responsive, we could imagine at first simply that it would be more interesting if it introduced a kind of musical complexity into the expression of the hyper-directional sound. For example, if it uses an interactive algorithmic composition software for the sound, which "composes" the real-time sonic environment; in this kind of environment, the audience should be able to trigger the interaction as they play a musical game, or interact with a sonic organism.

Subsequently, we defined its elements as the *playful* interaction and the *ubiquitous* interaction and summarised them in a concept called the *intense interaction* that we invented. *Data Auditorio* (see chapter 6) is an interactive hyper-directional sound environment which was created to realise the *intense interaction*. Towards the *intense interaction*, we will discuss from the next chapter the related factors.

2. RELATED WORKS

When one tries to design a hyper-directional speaker application, what kind of works should s/he refer to? In this chapter, we discuss the related works towards the *intense interaction*.

2.1 Sounding Objects and Prepared Loudspeakers

Given what is known about the sounding object or the prepared loudspeaker environment like *Rainforest* by David Tudor (see section 4.2 for further information), it is evident that a similar work uses the hyper-directional speaker: *Cloud Forest - Foyer* by Fujiko Nakaya and Shiro Takatani (August, 2010) [3] [3] . It creates loudly propagative "complex sonic carpets" like a fog in space, where audience can listen to the kinetic sound of the hyper-directional speaker outside the installation. In other words, the participation of audience is not an essential element in *Foyer*, even if it is a likely activity [4]. In addition, in terms of ubiquitous participation (see the discussion in the chapter 5), it is evident from the installation design that the hyper-directional loudspeakers, which are placed on a mirror for its optic attraction, may get in the way of the seamless participation of the audience (audience exploration of the space).

2.2 Participation of Audience

Contrasting with the *Foyer*, we name as a participatory installation *Reverence in Ravine* by Daichi Misawa (January, 2011) [1]. It necessitates the audience exploration of the space as an essential element to appreciate the hyper-directional sound - that is, it aims to present the very structure of the hyper-directional sounds (as well as the visual structure) as a kind of "transparent sculpture", instead of the prepared speakers. In fact, its space is nearly empty, except some necessary equipment and asks the audience explore the space as an essential element. In this regard, we may name another work presents a "wall" structure of hyper-directional sound, *Between You and Me* by Anke Eckardt (November, 2011) [5] [4] .

2.3 Interactive Hyper-directional Sound

As an *interactive art* uses the hyper-directional sound, we mention the *Transparent Sculpture* by Misawa (August, 2012) [2]. As *Ravine*, it presents the hyper-directional sound structure which is interactive above the empty stage. The interactive sound is, in fact, a real-time audio feedback of the space like a "mirror of [the hyper-directional] sound." In other words, it was a responsive audio feedback environment [5] .

3. PLAY

3.1 Interactive Art

What is *interactive art*? We define it as an indeterminate state of a connective [6] . It is continually reorganised and embodied by all audience and changes the audience's status (role) involved in the work [7, 8]. We consider audience in the *interactive art* is not separated from the work, but connected and embodied. In other words, an activity between audience and interactive interface is interrelated, which is the very work of art.

According to Söke Dinkla, interactive art is a *floating work of art* that "is no longer the expression of a single individual. Neither is it the expression of a collective, but it is the state of a 'connective' - a web of influences that are continually reorganised by all participants [9] [7] ."

3.2 Playful Interaction

The *intense interaction* is, in this paper, based on the game called *performance play*. We define *playful interaction* as an interaction that can be a performance and a mindset to overcome an existing patterns of reality [8] . It is based on the following definitions.

Steve Dixon said play is a fundamental element of the interactivity and it "encourage[s] playful, childlike fascination [11]." According to Brian Sutton-Smith, "almost anything can allow play to occur." He defined *Performance play* as playing piano, playing music, being a play actor, playing the game for the game's sake [12]. Based on Roger Caillois's discussion, the *Performance play* can be related to the game of *mimicry* [13]. On the other hand, Georg

[3] As written on the website, the title is a reference to the *Rainforest*.

[4] Young and Zazeela's *Dream House* (see 5.1 Auditory Interfaces) might be a former example of a kind of sound and light installation in an empty space, although it used loudspeakers such as Leak Mark II Sandwich speakers, Argus-X Custom 450 speakers, etc. [6].

[5] Linear sounds were also played in the version 1, 2012.

[6] An interface with tuned determinate responses can be considered as a musical instrument, rather than the *interactive art*, in this paper.

[7] We mention some informative definitions. Katja Kwastek defined the interactive art as an interactive processes that "need not be digitally mediated" [10]. Steve Dixon stated an interactivity ranges "from simple stimulus-response closed modes to highly flexible open models," and categorised as *1. navigation, 2. participation, 3. conversation, 4. collaboration*, ranking them in ascending order by their own openness of interaction [11].

[8] One might be possible to find examples of the *playful* activities from the role of "the fool" in the *King Lear* by William Shakespeare and Puhua in the *Record of Linji*, though they are both extreme examples and we suppose most of the people can not behave witty and humorous like them.

Russegger added that "the ability of playfulness is becoming a powerful tool and mindset for individuals to overcome existing patterns and standards," and " 'I am playing.' means 'I can do something that I am not otherwise doing [14].' "

3.3 Audience Activities and Asymmetry

In terms of audience activities in the *performance play*, *Auditorio* tries to flower the asymmetry between audience activities, e.g. an unexpected and distinctive activities. We consider the asymmetry is based on the difference between the *codes* of audience members.

According to Stuart Hall, an audience can be categorised into the three codes (positions) in a communicative exchange: the *dominant-hegemonic code*, the *negotiated code* and the *oppositional code*. Each audience member can be considered as a personalised code (for a communicative exchange; that is, for an encoding / decoding process) and the positions can be asymmetrical and various [15] [9] .

For example, an audience member may be categorised into the *oppositional position*, when they behave untraditional, non-standard and experimental - that is, *playful*, or in any fashion that they are far from being *dominant-hegemonic* [10] . Based on the asymmetry between the *codes*, what can be claimed here is, in the course of *playful interaction* (*performance play*), *Data Auditorio* depicts the significance of the audience asymmetry as a work of art.

4. MUSICAL ISSUES

Musical element plays an important role to "compose" the *playful* interaction (*performance play*) of *Data Auditorio*. In this chapter we discuss the related works towards the *intense interaction*.

4.1 Body of a Performer

What is the role of body in *Data Auditorio*? As we discussed in 3.1 (*interactive art*), we consider the activity of body in the *performance play* as a work of art. It is a variable and a transformable, in which there is little boarder between an audience, a performer and an observer [11] .

4.2 Algorithmic Composition

Noticeably, some artistically significant achievements to take advantage of sound processing were made before the advent of the digital age. In the first version of his *Rainforest* (1968), David Tudor "established a means of sound transformations" using not electronic modulation, but the resonant nodes of a variety of physical objects [16]; this would be one of the earliest examples of sound-processing installation.

It is also suggestive that the theoretical basis of granular synthesis was pioneered in the very analog age. It was 1960 when Iannis Xenakis developed a compositional theory for grains of sound for the first time, and 14 years later in 1974, Curtis Roads accomplished "the first computer-based implementations of granular synthesis" [17]. Though David Cope refers to John Cage's *Music of Changes* (1951) as one of the modern prototypes of algorithmic composition [18], it is also true that the algorithmic procedures of electronic sound processing have motivated composers to adopt the systems as both macro and micro structures of their works especially after the mid-1960s.

4.3 Use of Audio Feedback

Robert Ashley's *The Wolfman* (1964), for voice, tape and vocal feedback, is an early example of a composition using audio feedback [19]. This music was incredibly powerful, but at the same time, it was inevitable that its excessive sound pressure level terrified many audiences by threatening their aural "health" [20]. Steve Reich's *Pendulum Music* (1968) also takes advantage of the feedback sounds that occur between loudspeakers and the microphones swinging back and forth over them. Working along his "phasing" technique quite effectively, the audio feedback is conceptualised in very inspiring ways; since it keeps the sonic phenomenon naked, it could motivate composers and sound artists, specifically us, to raise an important question: "then, how would you manipulate this powerful energy?"

In this context, the significance of the software, *Feedback Grain*, of which details are discussed in 6.3, is that it provides a systematic set of methods to utilize the very powerful energy of feedback sounds, keeping it under control. The use of dynamic-range compressors enables one to manipulate the feedback loop without taking too much risk of terrifying audiences or blowing up loudspeakers. The complex feedback system can also work as a meta-structure of an algorithmic composition.

5. UBIQUITY

5.1 Auditory Interfaces

While we use the hyper-directional speaker as a primary tool, we hope it is not a controversial approach. Given the history of art and music, one can realise "designers" have utilised a diverse range of auditory interfaces. For example, we name Luigi Russolo's interface *Intonarumori* and can also note that John Cage's *4'33"* (1952) implied a social and environmental activity as an interface, and La Monte Young and Marian Zazeela's *Dream House* (1962) used the air in a room as an interface [21, 22, 6] [12] .

5.2 Technology that Disappears

Concerning the design of an auditory interface, we clarify here that we designed the *Data Auditorio* for *ubiquitous interaction*. We define it as a rational interaction which seamlessly and intuitively enables people to experience its

[9] We admit audience are not only asymmetrical, but also has a symmetrical character, to some extent.

[10] In other words, when an audience follows a certain traditional fashion, instruction and manual, they are categorised into *dominant-hegemonic* position.

[11] By the way, although *performance play* necessitates the use of body of audience, the use of radio wave and electronic signals of body might be a different field where, e.g., Alvin Lucier's *Music For Solo Performer* (1965) would be one of prominent works.

[12] *Dream House* is *a continuous frequency environment* of sound and light which established "the pattern of high and low pressure area" by a single sine wave; that is, variable loudness.

essential function and to accomplish their purposes. It is based on the Mark Weiser's thought of making novel technologies.

Weiser described in 1999 that the *ubiquitous* technologies are those that "disappear" and "fit the human environment" [23]. As auditory interface designers, in this paper we try to design a seamless interaction and do not want to present something which may get in the way of a rational audience experience [23].

6. DATA AUDITORIO

6.1 Equipment

Data Auditorio takes advantage of a computer, an audio interface, a hyper-directional speaker [24], a dynamic or condenser microphone, a loudspeaker (optional), a spotlight (optional), a mirror (optional). The size of the installation is at least, 4 meters by 4 and 3 (width, depth, height) though it is scalable as it is a site-specific installation. The computer is 4GB memory and 2GHz Intel core i7 CPU on Mac OS X (10.7) or equivalent.

6.2 Interaction Design

In *Data Auditorio*, all interactions are reflected upon the machine-system-output in real-time, and concurrently they also become the immediate feedback to the machine-system-input, in which the unique radiance of momentary sonic events is preserved and involved into the circular structure of the audio signals.

As a human system, audience can interact with *Auditorio* basically through the 3 processes (see figure 3). The first process is the hearing of the sound at their standing spots within the installation (hearing). The second is the positioning of their own bodies at the space which influences the third process (positioning). It is the sound altered by their own activities such as clapping, stepping, speaking, muting, breathing, playing instruments, and so forth (sound control).

As we said already in section 4.1, the performer as a variable can seamlessly transform into the audience, and vice versa. The interactive sound is also processing the sound from people who do not recognise themselves as they are performing (as well as the sound from animal and environment).

The next section discusses the detail of the process of software which was built by Kiyomitsu Odai until 2012 and subsequently utilised for the process of musical composition layer (see section 6.4) of *Data Auditorio*, 2013.

6.3 Software I: Feedback Grain

The software working inside *Data Auditorio* involves and processes the real-time sonic environment in which the installation is placed, and the processed sound is thrown back to the environment consistently (Figure 4 draws the diagram). This software, named *Feedback Grain*, mainly features two techniques: Compression Feedback Generation Synthesis (CFGS) and Granular Synthesis (GS). CFGS is

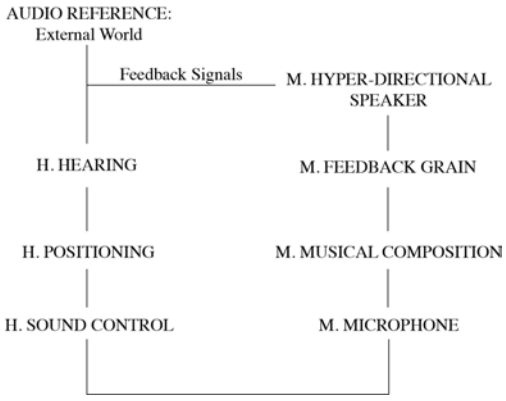

Figure 3. Diagram of Interaction in *Data Auditorio*. "H" means the human system and "M" is the machine system.

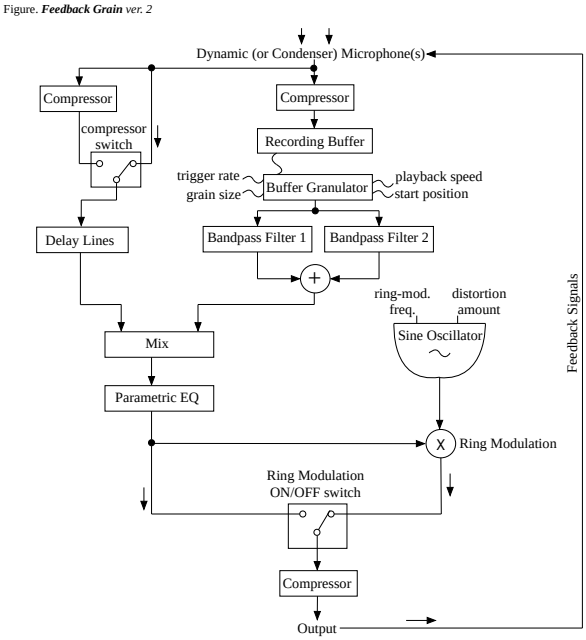

Figure 4. Diagram of *Feedback Grain version 2*.

the real-time algorithmic engine to use dynamic-range compressors in order to establish the feedback loop occurring between the microphone and loudspeaker [25]. Then, GS is utilised to transform a feedback stream into arranged or scattered "grains" of sound [26]. Significantly, *Feedback Grain* realises the radiance that is unique to the real-time audio feedback; specifically, the sound quality is quite similar to the audio feedback, which recording engineers always struggle to eliminate, but its amplitude level is controlled so that it does not rise infinitely while its powerful quality, which we call "radiance," is maintained. Along with the real-time feedback, the sounds from which the granulated ones derive are continuously recorded in real time and are stored in the buffers, which are updated all the time, preserving the radiance. Musically, the granulated sounds add a rich variety of rhythmic verticality to the horizontal, or drone-like, non-granulated feedback sounds; in addition, being capable of triggering quite a wide range of pitches enabled by the flexible manipulation of the playback speed of each triggered sonic grain, the

granulator enhances the variety in the frequency domain as well. Though it is mostly a digital software constructed in a computer, the connection between the input and output is quite analog and always interfered with the audiences and/or the space.

Here, in the relationship among the sound system, the audiences, and the space, the quality of the interactivity is complex yet quite organized. Firstly, the parametric sound by itself is highly interactive because the patterns of its direct flow and sharp reflection are altered drastically when they experience intererence. Secondly, the inner quality of the sound can also be altered all the time because its source is always picked up by the microphone to which audiences are encouraged to feed their sounds, hence another interactivity. Thirdly, the CFGS that employs the compressor enhances the interactivity, picking up and boosting up the sounds with a very low amplitude level. The use of compressor, fourthly, also maintains the feedback loop that it establishes and controls; the feedback loop is constantly updated in real time and is also physically open toward audiences. By involving its own audiences, conceptually, *Auditorio* is to provide the game to "play": that is, the installation is the artistic playground where "[they] can do something that [they] do not usually do. [14]" The game is actually serious and intense so that it challenges them in a way. Despite the unique beauty, the feedback sound is not euphonic in conventional senses, but it has the intensity to question their aesthetics on sounds. Therefore, we call the interaction to be realised here, *intense interaction*. Of course, interactive sound art is not new at all today, but the concept the *Auditorio* attempts to realise, significantly, is rather the high integration of those different layers of interactivity into the relatively simple-looking installation than interactivity by itself.

6.4 Software II: Musical Composition Layer

In *Data Auditorio*, furthermore, there is a higher-level structure over *Feedback Grain*: the composition layer to manipulate the parameters of the feedback granulator. The composition takes the form that circulates rather than having the beginning and end, and the triggers to change the modes of interaction are mapped on its timeline, of which a cycle generates the next one near its own end, avoiding the exact repetition of itself. The circular structure is, obviously, designed so that it is analogous to the feedback engine, and also its musical timeline, based on the Fibonacci series to converge onto the golden mean in the larger scales of it, corresponds to the algorithmic delay lines (within *Feedback Grain*), of which variables are smaller Fibonacci numbers.

Here, it is quite important that the composition layer is not only to add a time axis to the installation, but also to employ its interactivity as a parameter; in its timeline, the degrees of interactivity, as well as the modes of interaction, are varied. Thus, the goal that the *Auditorio* tries to achieve is not interactivity by itself, but the intense structural complex of which interactivity is one of the elements.

6.5 Installation Design

First of all, the installation is designed through viewing the affordable space as a virtual coordinate space, like the *Reverence in Ravine* [1]. Then the hyper-directional sound structure is constructed in it. Therefore, the structure is site-specific, yet it can exist discretely at a certain area of the space owing to the directivity of hyper-directional sound. Like virtual spatial coordinates are positioned in a virtual coordinate space, the sweet-spots (listening area) made with the hyper-directional sound structures are invisibly deployed.

The installation utilises the format of performance stage to complement the "invisibility" of hyper-directional sound structure (that is, for the *ubiquitous* interaction). For example, a microphone stand and a spotlight can be left in the space. It aims to encourage the audience to interact in a natural fashion, although it is possible to present an empty space as *Transparent Sculpture*. Figures 5 and 6 show the illustration of the installation and the sketch.

We use the spatial reflection of hyper-directional sound concerning the effective sound design, since the hyper-directional sound is clearly perceptible from a certain distance. According to the user's manual of the parametric speaker, "the ideal height is above 4 meters from the ground [27]" when it is positioned on the ceiling. In other words, that a hyper-directional sound is reflected in a space means it is utilising the summed-up distance in a way.

The conventional loudspeaker can also emit white noise to offset the random propagative reflection of the hyper-directional sound within the space, or some sounds if they may enhance the audience interaction (optional). Light (spotlight) can be also used to visualise the structure of sound (optional). In addition, a flat board like a mirror can be used for the effective reflection, since the wall or ceiling is not flat often (optional).

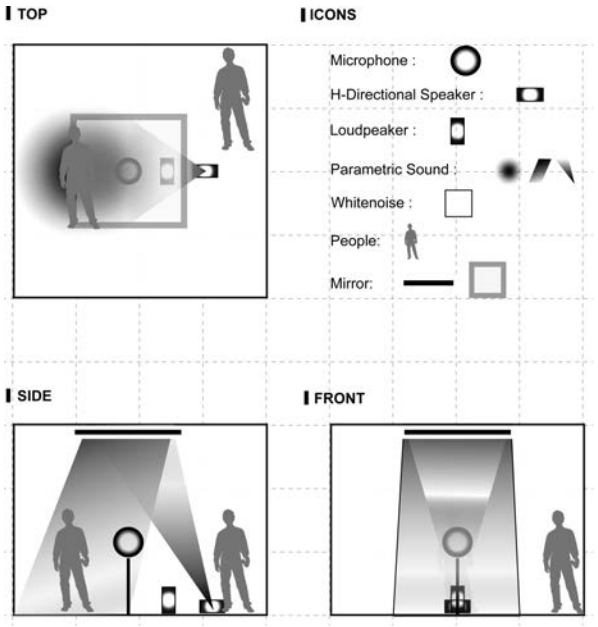

Figure 5. Installation Design of *Data Auditorio*.

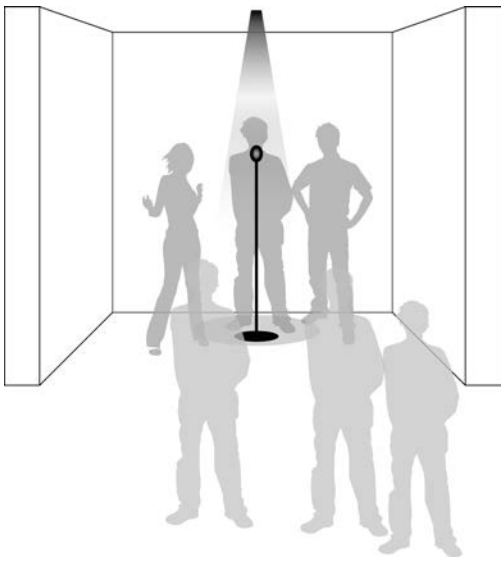

Figure 6. Installation Sketch of *Data Auditorio*.

7. EXPERIMENT AND EVALUATION

This chapter describes the evaluation of the demonstrations and the experiments of the *Data Auditorio*, in which the demonstration at the NTT InterCommunication Center (ICC) was conducted by Odai and the other demonstrations and experiments were conducted by Misawa.

7.1 Audibility Demonstration

Data Auditorio was demonstrated in May 26, 2013 at our private studio in Linz, Austria, from 2:00 to 5:00 AM. It was recorded with binaural microphones and video in order to demonstrate the different audibility and interactivity of *Auditorio*. The size of the whole space was approximately 4 meters by 8 and 3 (width, depth, height); there was no audiences then. As the recording shows, the environmental sound was nearly silent. The loudspeaker was not used. The course of demonstration was plotted previously.

We pick up some remarkable events. During the demonstrating, when the author was in front of the microphone under the spotlight, the feedback sound was clearly audible and was also nearly inaudible at approximately 2-3 meters away from the spotlight. Yet, the amplitude level depended on the distance and the response mode of the feedback system. That is to say, when the system's output gain was high, it was actually to some extent audible even from 2-3 meters away (though the musical details were not clear).

Another audibility demonstration was made in a conference room at NTT ICC in Tokyo. It was a large rectangular-shaped space with hard walls, and there, we found that the sound from the hyper-directional speaker was capable of becoming a discrete pattern of the sonic beam that reflects around the space. This particular demonstration was done with ICC curators on August 20, 2013, and both of them seemed interested, especially in the distinctive pattern of the sound.

7.2 Experiment for the Intense Interaction

In the experiment on April 7, 2014 where we did a lecture and a performance for the audience (students), we could observe ourselves that by the own performance we were trying to alter the existing patterns of the reality in the space significantly for the audience, though no one asked us to do it - that is, we did not just demonstrate the interactive algorithmic sound and how it works, but also pursued an *playful* patterns of reality through the performance, singing, etc. (as a *playful* interaction of an *interactive art*).

An interesting event happened during the performance that can be a very example of the *intense interaction*, in which an audience member surprisingly passed me a tambourine to play it and enhance our performance (*playful* and *ubiquitous* interaction). Subsequently, we changed the mode of *performance play* from a singing into a more instrumental and rhythmical performance and pursued a *playfully* interesting performance. If there was an obvious boarder between the performer and the audience, this event would not happen.

On June 27, 2013, from 4:30 to 5:30 PM, an interaction experiment for the *Auditorio* took place in Linz, Austria. The size of the entire space was approximately 6 meters by 10 and 4 (width, depth, height). There were about 10 people around the installation, and some of them were voluntarily communicating with it. It was also documented in the video, where three people's interactions were sampled.

From the audience interaction, we know that the audience took little time until starting their performance (*ubiquitous* interaction), was speaking about their experience and singing a song that they knew as a performer (*playful* interaction). For example, some people sang different foreign songs that they knew, even though no one asked them to sing it (*audience asymmetry*). These songs were mirroring their existing knowledges and experiences (that is, they were the songs related to the countries that they stayed more than a few or several years.)

7.3 Evaluation

In terms of the *ubiquitous* interaction, we could see some notable facts. Firstly, they took a few moments to step toward the microphone and perform in front of it. Secondly, most of the audience soon became aware that their own voices were fed back to themselves and audience interaction was overall quite smooth (seamless and ubiquitous transformation into a performer).

In terms of *playful* interaction, sometimes, we observed that performers looked tense, embarrassed and not used to doing a performance (acting, speaking and singing). The reason seemed to be that they were in fact asked to interact with the audience in addition to the machine system of *Auditorio*. We could see this tension and seriousness in the *performance play* of audience could be a proof of the *playfulness*. It would be evident that they were struggling with the indeterminate state (e.g. sound pattern, reactions of people, atmosphere) in the space to change its existing patterns significantly. That is to say, they were quite rational in the *performance play*, rather than just being funny.

It might mean when people are exposed in front of the others, they often became *playful* and *Data Auditorio* used this tendency. In addition, the interactive sound based on the musical composition (*Feedback Grain*) was also another element influenced the change of the mode of *performance play*, at least in the performance with a tambourine.

In addition, in terms of the asymmetry of audience activities that can influence the degree of significance of the *performance play*, we could observe an interesting asymmetry. Some audience members were unexpectedly singing different foreign songs reflecting their own existing knowledges and experiences and the audience activities were not only singing, but also descriptive speech for other audience and instrumental performance using a tambourine, etc. That is, in the *performance play*, in addition to the physical involvement, the verbal activities of audience were the very interactive performances depicting the asymmetry between the audience activities (the differences between people). In this regard, the *performance play* was often active, thereby making the *intense interaction* a flowering endeavour.

8. FUTURE WORKS AND CONCLUSION

Based on these evaluations, we conclude *Data Auditorio* succeeded in presenting the *intense interaction* to some extent that the activity of people came to be part of an *interactive art* in a form of *performance play* (*playful interaction*) in a natural fashion (*ubiquitous interaction*).

The outcome of this research can be applied to any interaction design that uses the hyper-directional speaker. Specifically, when the system aims to present *playful* and *ubiquitous* interaction.

As a future work, it might be fair to say, although this paper presented one of the ideal designs, the speaker position and other details can be redesigned carefully again, since the installation is site-specific installation and the space of exhibition varies every time.

In addition, *Data Auditorio* can be extended and/or applied to some large-scale installations or performances, although its design is compact by itself. Figure 7 shows an example of the designs, in which each *Auditorio* can function as a node, introducing a MIDI player piano.

We would also admit that it could lead to interesting results to introduce the physical interfaces for parametric sound with various components, sensors, and/or actuators, being aware of the *ubiquity* of technologies. We list up the possibilities as follows. Microphones: cardioid condenser, omni-directional condenser, hyper-directional condenser, contact microphone, hydrophone, etc. Photoresistors or cameras: LEDs, light bulbs, etc. Motors: brush motors, stepper motor, serve motors, etc. Other objects: fans, magnets, fluids, musical instruments, loudspeakers, natural objects, etc.

Acknowledgments

Data Auditorio would not be realised without many mentors, observers, and audiences. We gratefully acknowledge Professor Christa Sommerer, Martin Kaltenbrunner, Michael Schweiger, Laurent Mignonneau, Michaela Ortner in Interface Cultures Lab and Sound Studio K2 at Kunstuniversität Linz, Austria for supervising this paper and *Auditorio*. We also appreciate Professor Curtis Roads very much for supervising the development of *Feedback Grain*, the software working inside *Data Auditorio*. We also thank Minoru Hatanaka and Yasuko Yubisui for observing and commenting on a prototype of this work at NTT InterCommunication Center.

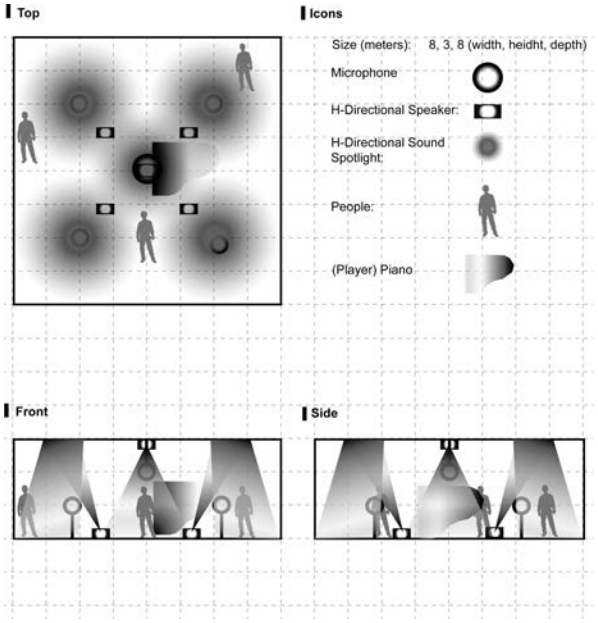

Figure 7. Installation design of the extended *Data Auditorio*.

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