Toward an editable sound-space system using high resolution sound properties

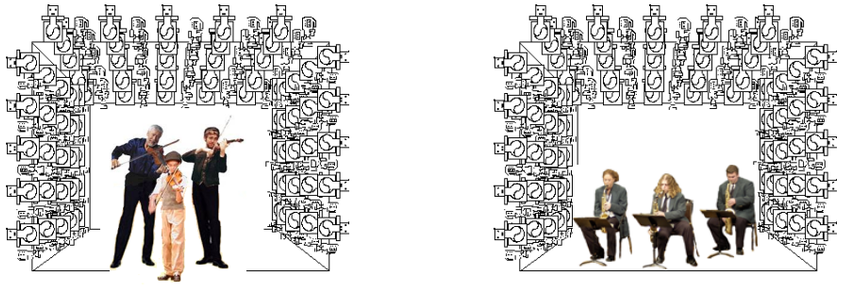
T. Okamoto[1,2], Y. Iwaya[1,3] and Y. Suzuki[1,3] ([1]Res. Inst. Elect. Commun. / [2]Grad. Sch. Eng. / [3]Grad. Sch. Inf. Sci., Tohoku Univ., Japan)

Abstract

Using signal processing and recording with numerous microphones, a sound field can be decomposed into attributes such as original sound source signals, sound source positions, directivity of sound sources, early reflections, and late reverberation. Sound field editing would be highly versatile after such decomposition. Moreover, the original sound field and a modified sound field can be synthesized by modifying and exchanging these attributes. We are developing signal processing techniques based on a surrounding array of 157 microphones. After introducing this system, this report describes estimation of source positions, original sound source signals, and directivity of sound sources.

1 Introduction

Editable sound-space system



1. Recording sound field

Signal Processing　　Signal Processing

2. Extracting sound field properties

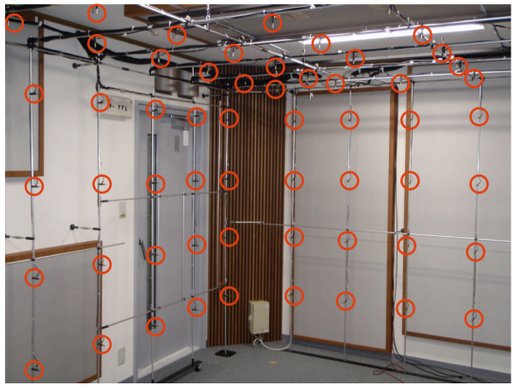
- sound positions
- original sound source
- directivities of sound sources
- early reflection
- reverberation

3. Rendering extracted sound properties

not only original sound field [1]　　but also modified sound field

[1] S. Ise 1999

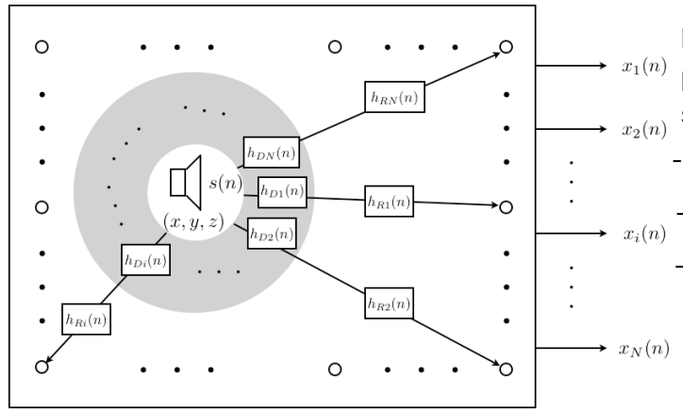
2 Surrounding microphone array [3]



- all 157 channel synchronous recording
- reverberation time : 0.15 s

3 Estimation of sound source properties

3.1 Directivity model of a sound source



Estimating sound source properties from output signals $x_i(n)$

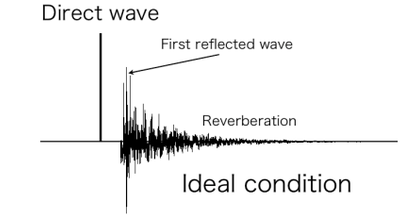
- source position (x, y, z)
- source signal $s(n)$
- directivity $h_{Di}(n)$

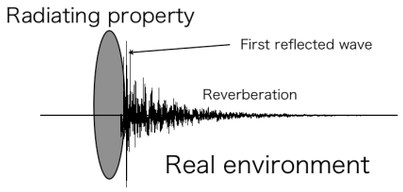
3.2-3 Estimation of sound source positions and sound source signal

We have developed a estimating source positions method as RAP-MUSIC [2,3] and a dereverberation method as White-LIME [4,5]

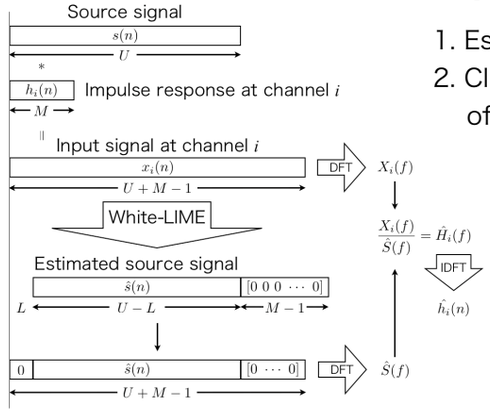
[2] RO. Schmidt *et. al* 1986　[3] T. Okamoto *et. al* 2007
[4] M. Delcroix *et. al* 2007　[5] T. Okamoto *et. al* 2009

3.4 Estimation of directivity of a sound source





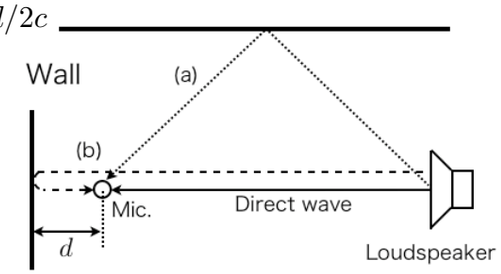
Room impulse response



$\hat{h}_i(n)$: Estimated impulse response at channel i

Estimation impulse response

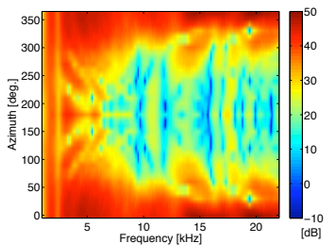
1. Estimating impulse responses using sound source
2. Clipping estimates impulse responses at a section of $t = d/2c$



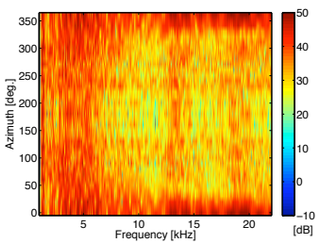
(a): First reflected wave (oblique-incidence)
(b): First reflected wave (head-on incidence)

Propagation interval difference between a direct sound wave and the first reflected wave

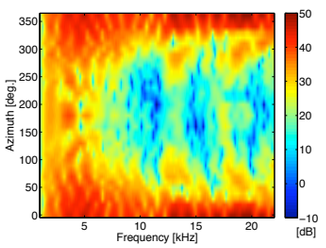
Measurements and estimation results of directivity of a sound source



Measured in anechoic room

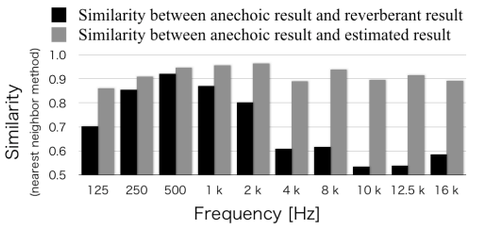


Measured in actual room



Proposed method

$$S_{1,i} = 1 - \frac{|\boldsymbol{P}_1(\tau) - \boldsymbol{P}_i(\tau)|}{|\boldsymbol{P}_1(\tau)|} \qquad (i = 2, 3)$$



Acknowledgement: This study was supported by the GCOE program (CERIES) of the Grad. Sch. of Eng,, Tohoku Univ.