

音に包まれた感じを考慮したマルチチャンネル再生のためのスピーカ配置

A study on loudspeaker arrangement for multichannel reproduction from the standpoint of listener envelopment

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Abstract:

Although the relationship between the angle of side/rear loudspeakers and Listener Envelopment (LEV) has not been clarified yet, loudspeaker arrangement for multichannel sound reproduction is recommended in ITU-R BS.775-1. The purpose of this study is to clarify the relationship between arrangement of side/rear loudspeakers and LEV, by using SBTs which is proposed in the research area of architectural acoustics.

1. INTRODUCTION

Recently, with the growth of DVD media, digital broadcasting and so on, the demand of multichannel sound reproduction of sound field has been increasing. "Spatial Impression" can be produced by multichannel sound reproduction, which is not fully produced by conventional two-channel stereophonic reproduction. Spatial impression is divided into at least two basic sensations, apparent source width (ASW) and listener envelopment (LEV)[1]. LEV which corresponds to feeling of surround by sounds, is one of the important elements of the effect by multichannel sound reproduction. Although the relationship between the angle of side/rear loudspeakers and LEV has not been clarified yet, loudspeaker arrangement for multichannel sound reproduction is recommended in ITU-R BS.775-1[2]. The purpose of this study is to clarify the relationship between arrangement of side/rear loudspeakers and LEV, by using LG[3] and SBTs[4] which are proposed in the research area of architectural acoustics.

2. INSTALLATION ANGLE OF SIDE/REAR LOUDSPEAKERS

The purpose of this section is to clarify the optimum angle of side/rear loudspeakers to

reproduce LEV at 3/2 format in ITU-R BS.775-1. A sound field for calculation shown in Fig.1 is a diffusing sound field and has 45000 virtual sound sources which mean reflections. This sound field is used as each calculation in this paper. As shown in Fig.2, the virtual sound source distribution is divided into some parts depending upon number of channels. And then each directional response required for reproduction is synthesized from the virtual sound sources of each area. The reflections included forwards 120 degrees are used for

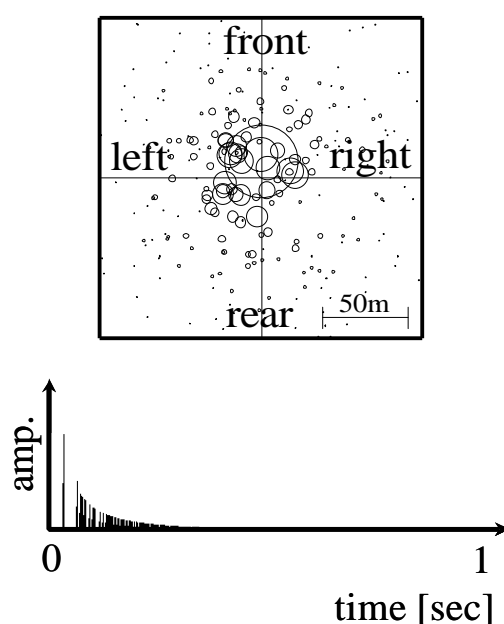


Fig.1 Virtual sound sources and the impulse response of used sound field.

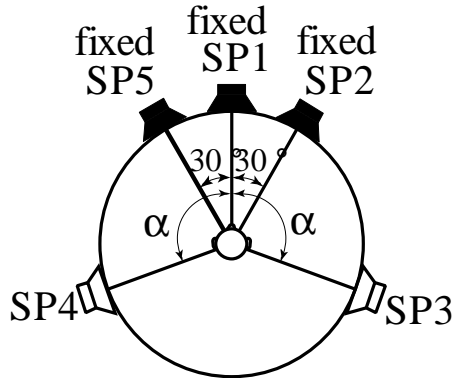
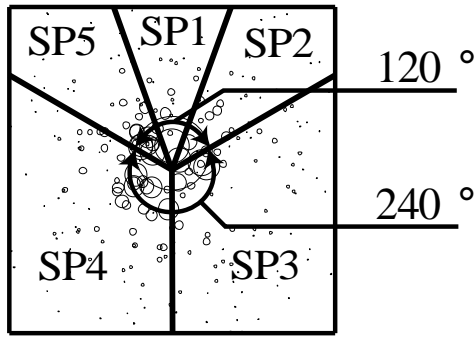


Fig.2 reflections assignment and Loudspeaker arrangement.

SP1, SP2 and SP5, and included backwards 240 degrees are used SP3 and SP4. To calculate LG and SBTs, the angle α of SP3 and SP4 was varied symmetrically from 5° to 175° at increments of 5° .

The results of these calculations are shown in Fig.3. LG reaches maximum at $\alpha = 90^\circ$ because it is weighted by the angle from binaural axis. Therefore, the optimum angle of side/rear loudspeakers is always 90° when LG is used for the design of side/rear loudspeakers arrangement. On the other hand, SBTs is the maximum value at $\alpha = 100^\circ$. The optimum arrangement of side/rear loudspeaker is a little behind from binaural axis, because some reflections are provided from forward loudspeakers (SP1, SP2 and SP5). This is one of the characteristics of SBTs that takes into consideration the spatial balance of reflections. From this result, we can see that 3/2 format ITU recommended installation angle of loudspeakers LS/RS (SP3, SP4) has potential

to produce LEV fully. Using SBTs which is considered with spatial balance of reflections, we can try what degree is the best angle when we add loudspeakers. On the other hand, if we use LG in this trial, it always answers the best angle is 90° . The relationship between the number of loudspeakers and LEV was described in an article[5].

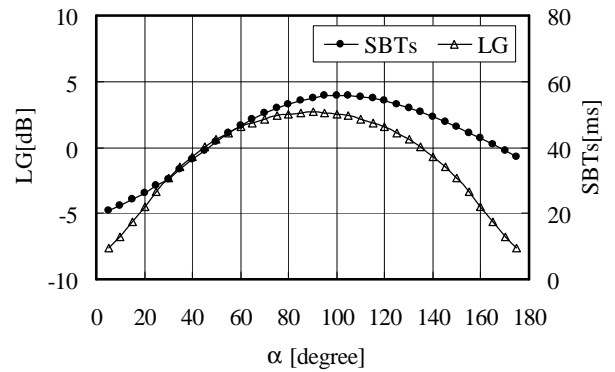


Fig.3 LG and SBTs versus the angle α of side/rear loudspeakers.

3. LISTENING AREA

In this section, the purpose is to clarify the relationship between listening area and loudspeaker arrangement. We examined the variance of LEV when listening point left-right moves from the center of loudspeakers installed on an arc at several

Table.1 Variable angles and radii

condition	
angle [degree]	90, 105, 120, 135
radius [m]	1.5, 2, 3, 4, 5, 6, 7, 8, 9, 10

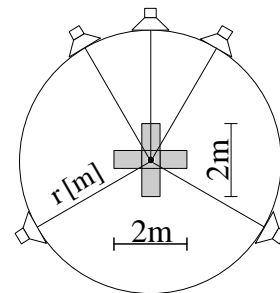


Fig.4 Calculation points of standard deviation

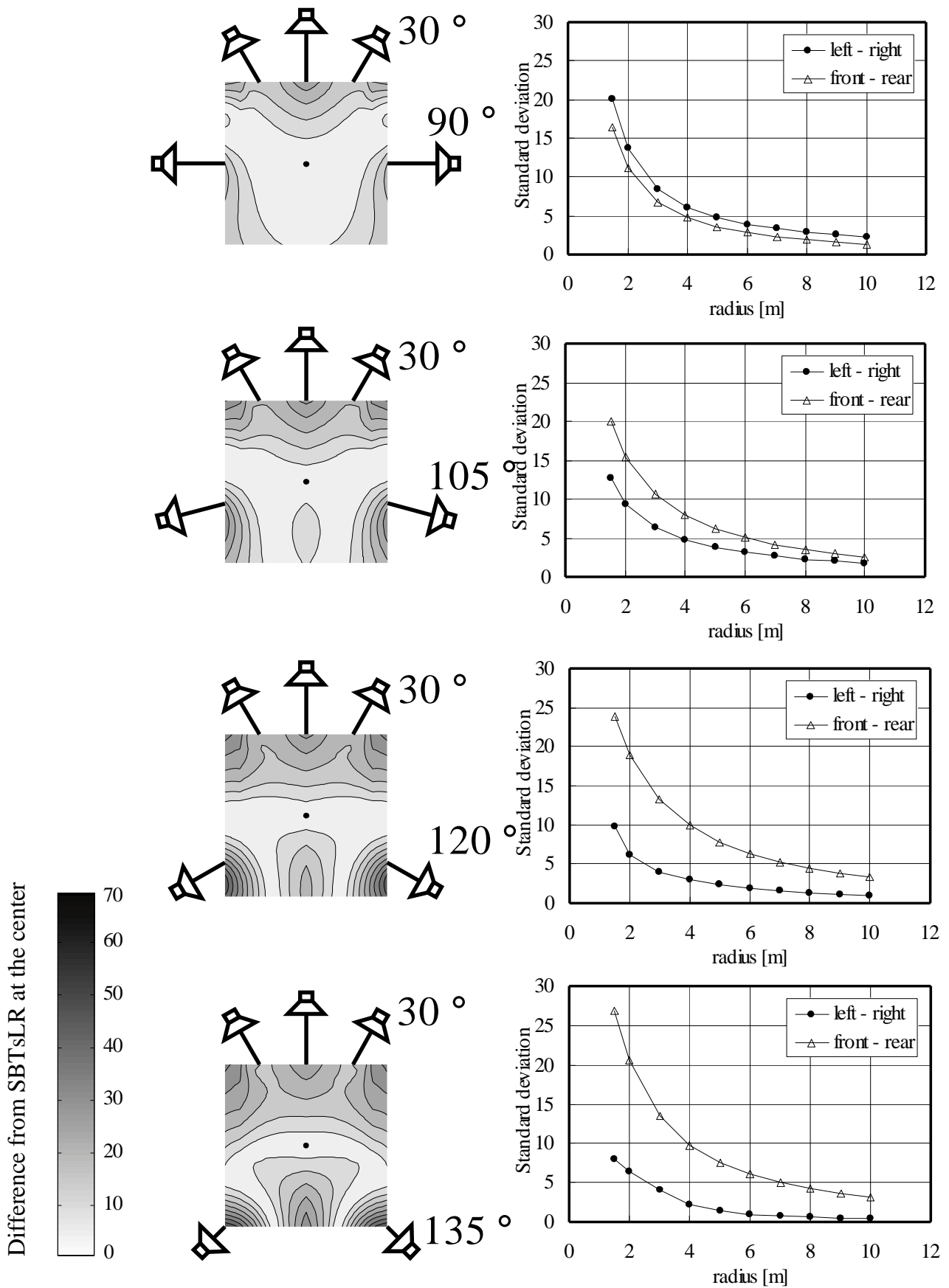


Fig. 5 Left figures: Contour of the difference from SBTsLR at the center in each condition. Right figures: Standard deviation of SBTsLR versus radius.

conditions given in Table.1. Use of loudspeaker arrangement and reflections assignment is shown in Fig.2. We used here the SBT_{SLR} [6] which had be revised by considering the balance of incident reflections on binaural. SBT_{SLR} is calculated at each point of grid inside the arc. The size of the grid is 0.1m. And as shown in Fig.4, the standard deviation of SBT_{SLR} values at 0.1m intervals in the left-right 21 points ($\pm 1m$ from the center) and that in front-back 21 points are calculated.

The results of the calculations are shown in Fig.5. On the left side of this figure, contours of difference from SBT_{SLR} at the center in the arc of $r = 3m$ conditions are indicated. Graphs of standard deviation versus radius are shown on the right side of this figure. The larger the radius makes standard deviation smaller. These results suggest that when the side/rear loudspeakers move toward the back, the deviations of SBT_{SLR} in left-right area decrease and the deviations of SBT_{SLR} in front-back area increase. These results suggest that the backward installation of side/rear loudspeakers expands lateral listening area and at the same time it reduces longitudinal listening area.

4.CONCLUSIONS

In this study, we examined the optimum arrangement of side/rear loudspeakers by using SBTs. This study makes the following things clear. SBTs supports the angle of side/rear loudspeakers in ITU Recommending 3/2 format. The results that we examined by using SBTs are as follows:
1. When the radius of the arc of loudspeakers arrangement is expanded, listening area where optimum LEV is obtained is expanded. 2. The backward

installation of side/rear loudspeaker expands lateral listening area and at the same time it reduces longitudinal listening area.

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