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NOISE CONTROL FOR A BETTER ENVIRONMENT

Global active noise control using collocation of noise source and control speakers

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ABSTRACT

Global active noise control system is proposed in this paper. Proposed global active noise control system includes active noise control algorithm and modelling of control speakers and microphones. For global active noise control we set cost function as acoustic power passing through the sphere surrounding the noise source and control speakers in free field. With this, we can make control speakers generating anti-phase sound field of noise source. Open-loop algorithm is used because it does not need error microphone that can interfere human's lives or passages. To calculate open-loop algorithm's fixed filter we used Wiener filter solution. In modelling part, there are spatial aliasing issued by placement of control speakers and microphones and it affects controllable and measurable radiation pattern and frequency range of interest. Based on above system we do real-time active noise control experiments. Experiment was performed to verify proposed method. Experiment was performed in anechoic chamber that can be assumed free field condition. First, we do preliminary experiment to calculate open-loop fixed ANC filter. After this experiment, we do real-time active noise control experiment using obtained from preliminary experiment. Noise source is a speaker and we can get average 11 dB reduction.

Keywords: Active noise control, global area, acoustic power minimization
I-INCE Classification of Subject Number: 38

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1. INTRODUCTION

Acitve noise control(ANC) is a method to reduce unwanted noise by generating opposite phase sound. Active noise control is divided into two types depending on the control area. One is local active noise control. Control area of local active noise control is limite around point like microphone. The other is global active noise control. Control area of global active noise control is global área. Most of active noise control algorithm including most basic active noise control algorithm, FxLMS is local active noise control. Local active noise control's cost function is square of error signal obtained from error microphone. With this cost function, we can control only limited area around the error microphone. Theses disadvantages makes active noise control difficult to apply situations that the position of the human ear is not fixed. To control global area we must set cost function as acoustic power or acoustic potential energy. In case of acoustic potential energy it used modal characteristic of enclosed spaces. It decides speaker input and position of speaker and microphone with minimization of acoustic potential energy calculated using cacluated using modal characteristics of enclosed spaces. About minimization of acoustic potential energy there are also researches including global active noise control experimental results. It is only effective at small enclosed spaces that have low modal density. In that size of room it is too small to be a space for people to live in. So, we proposed global active noise control system in enclosed spaces big enough for people to live. Basic concept is collocation of noise source and control sources generating opposite phase sound field of noise source's. Fig 1 shows it. To generate opposite phase sound field we set cost function as acoustic power passing through the sphere at far field surrounding the noise source and control spekaers. Global active noise control system is divided into ANC algorithm part and modelling of control speakers and microphones part. It will explained in chapter 2. In chapter 3, experimental result will be shown based on chapter 2's theoretical background.

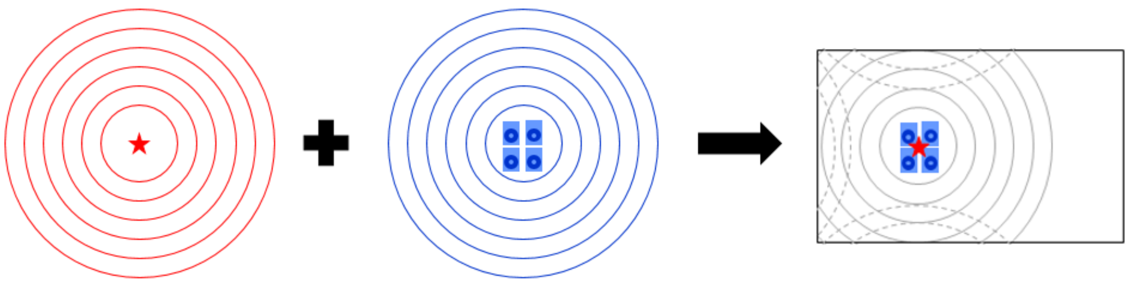

Fig. 1 Sound field of noise source, control sources and new compact sources. Red star and red concentric circles mean noise source and sound field of noise source. Blue speakers and blue concentric circles mean control sources and sound field of control sources. And in third figure, rectangular means enclosed spaces and gray concentric circles mean controlled sound filed.

2. Global active noise control system

Global active noise control system is divided into two parts. One is active noise control algorithm part. In this part, Algorithm's type and cost function will be explained. The other is modelling of control speakers and microphones. Modeling of control speakers and microphones is consist of number and position of control speakers and microphones.

2.1 Active noise control algorithm

In ANC algorithm part, we set cost function as acoustic power in free field as we mentioned above. So, experiment to calculate filter will be performed at anechoic chamber. Most of ANC algorithms are adaptive algorithm. Adaptive ANC algorithms is robust to acoustic changes like temperature. But, it needs error microphone on control area. Even if we use the virtual microphone method physical microphone is needed at other position. For global active noise control we need numerous number of microphones. It can interfere human's work and rest. So, we decided to use open-loop ANC algorithm. It is poor at robustness. But there is no need to place error microphone during real-time active noise control. Figure 2 shows flow chart of open-loop ANC algorithm. To calculate open-loop ANC filter we must do preliminary experiment. This experiment is performed at anechoic chamber that can be assumed free field condition. With this experiment data, finally we can get open-loop ANC filter by using Wiener filter solution. With Wiener filter solution we can get causal optimal filter and we can do real-time experiment.

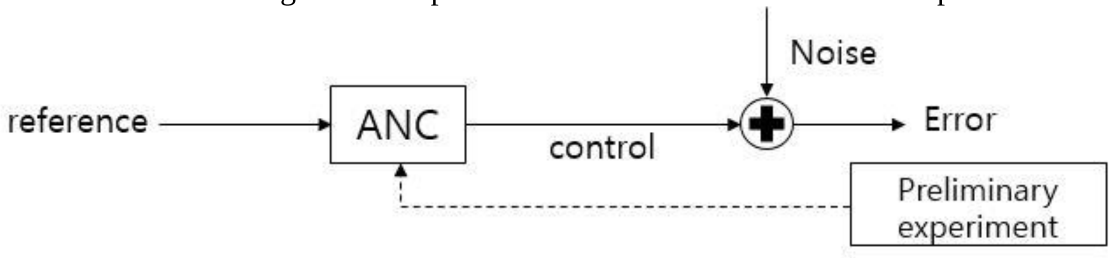

Fig. 2 Flow chart of open-loop ANC algorithm

2.2 Modeling of control speakers and microphones

Modeling of control speakers and microphones is consist of number and position. Spatial aliasing is important issue in generating or measuring sound field. Spatial aliasing is caused by discrete distribution of speakers and microphones. It can affect to measurable and controllable radiation pattern and frequency range of interest. Figure 3 and 4 shows spatial aliasing effect by speakers and microphone array.

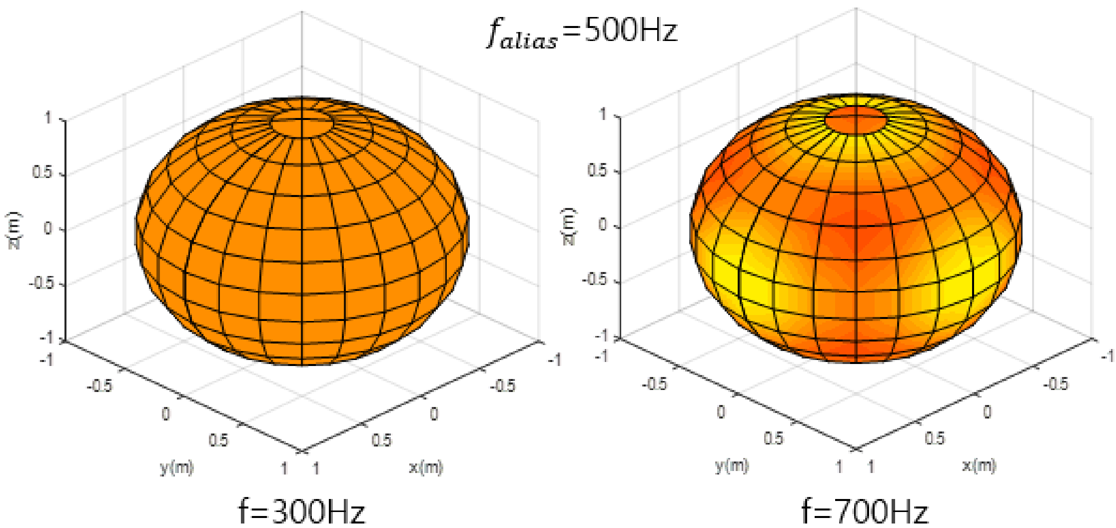

Fig. 3 Spatial aliasing effect by control speaker array

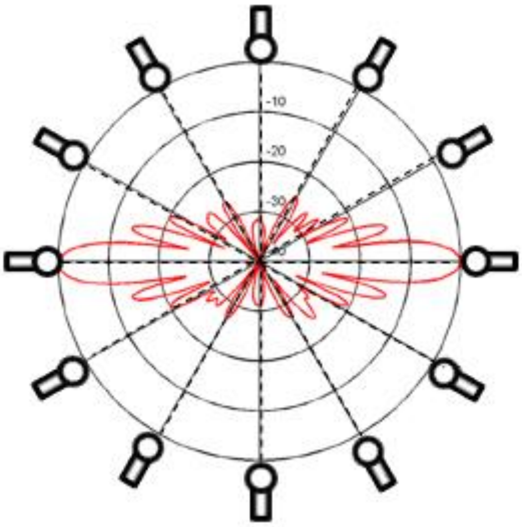

Fig. 4 Spatial aliasing effect by microphone array

So, we have to consider it for modelling of control speakers and microphones.

3. Experiment

We performed experiment at anechoic chamber. We used loudspeaker as noise source. Because we can get accurate reference signal. With this accurate reference signal we expect that we can get the best experimental control performance. We used 4 number of loudspeakers as control sources. Based on modelling part loudspeaker can be considered as monopole source in our frequency range of interest. To control monopole source 4 number of control speakers is enough. And we used 128 number of microphones to calculate fixed control filter.

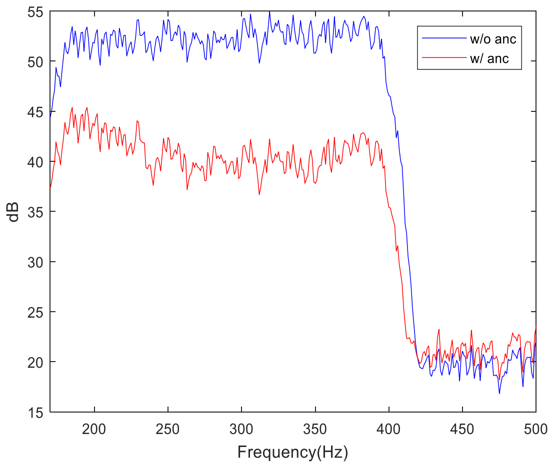

Fig. 5 Experimental ANC result in frequency domain.

Figure 5 shows frequency domain ANC result. It is averaged of 128 microphones. It shows average 11.2dB reduction in our frequency range of interst.

Figure 6 shows spatial domain ANC result. It is averaged result in frequency range of interst. Although there was a slight difference, it was confirmed that the noise was controlled in the entire spherical surface surrounding the noise source.

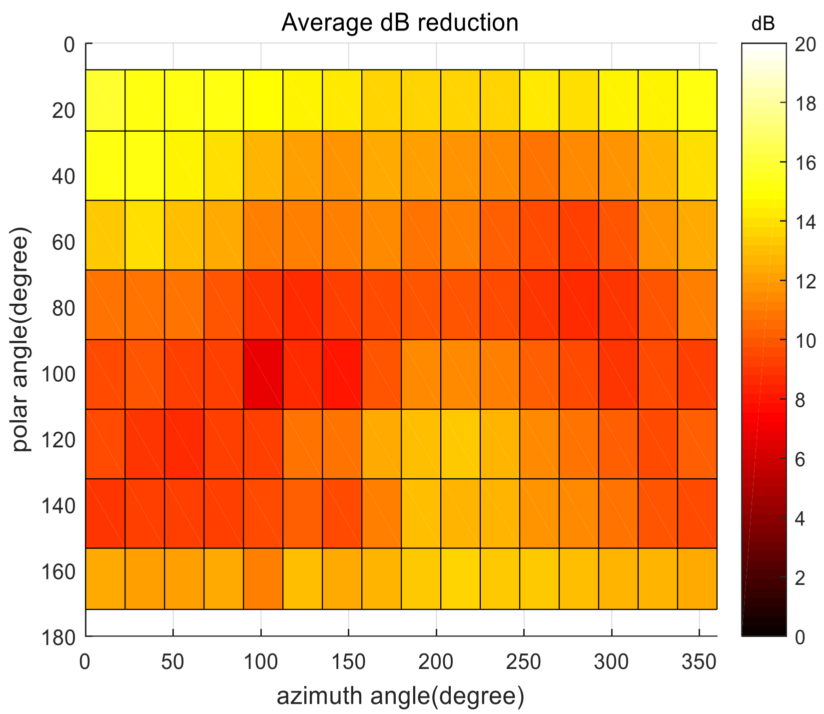

Fig. 6 Experimental ANC result in spatial domain

4. CONCLUSIONS

We proposed global active noise control system in this paper. Global active noise control system is consist of ANC algorithm part and modelling of control spekaers and microphoens part. Based on this global active noise control system we do real-time active noise control experiment in anechoic chamber. We used loudspeaker as noise source. As a result, we can get average 11.2dB reduction and we can confirmed noise in all of points on sphere surrounding the noise source can controlled.

5. ACKNOWLEDGEMENTS

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