1Pb4-6

Pilot study of aerial wireless sound sources using parametric loudspeakers

Yohei Iihoshi[1†‡] and Kan Okubo[1] ([1] Grad. School System Design., Tokyo Met Univ)

1. Introduction

When using a small unmanned aerial vehicle (drone) to send sound from above to a specific location, it is necessary to use speakers with the properties of lightweight and directivity; parametric loudspeakers might be promising [1-6].

Latency control is also important when configuring a multi-speaker system with multiple drones.

However, wired connections cannot be used for aerial sound sources, and in the case of wireless connections, it is difficult to control the latency between multi-parametric loudspeakers.

Therefore, a pilot study using a small device connected wirelessly as a client was done, and this paper reports on its possibility for a multi-speaker system connected with parametric loudspeakers for aerial sound sources.

In addition, acoustic sensing technology in air is a promising method for acquiring the shape and/or position of a target, i.e., universal and smart technology [5,6]. We then also investigate the feasibility of an acoustic sensing that combines a super-directional speaker and a wireless network.

2. System Configuration

The flow of the program is shown in Fig. 1. The program was designed using Python 3.8, and python-sounddevice was used as the audio output library. The server sends commands to the client and data to the client, and the client performs playback and other processing in response to commands from the server. Here, the server was Ubuntu and the client was a Raspberry Pi 4 Model B.

By using threading to perform thread processing, we aimed to minimize the latency as much as possible.

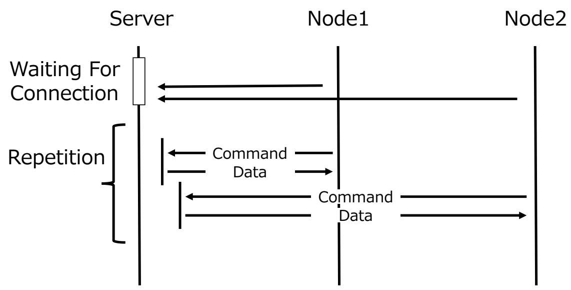

Fig. 1 Program Flow

3. Measurement Method

Two methods were used to evaluate the latency difference of multi-parametric loudspeaker systems. The first method is to measure the audio voltage from the client without connecting parametric speakers. The second method is to connect a parametric speaker and measure the sound.

The schematic diagrams of two evaluation methods are shown in Fig. 2 and Fig. 3, respectively. The second method, shown in Fig. 3, uses a Bruel & Kjar Type 4939 microphone with 768 kHz, 24-bit sampling.

4. Experimental results

For each of the methods in Fig. 2 and Fig. 3,

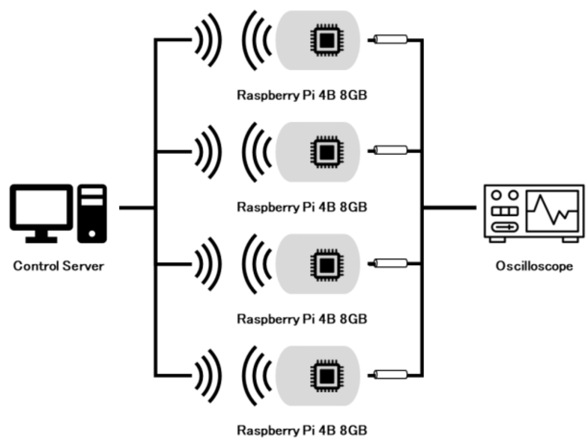

Fig. 2 The first measurement method

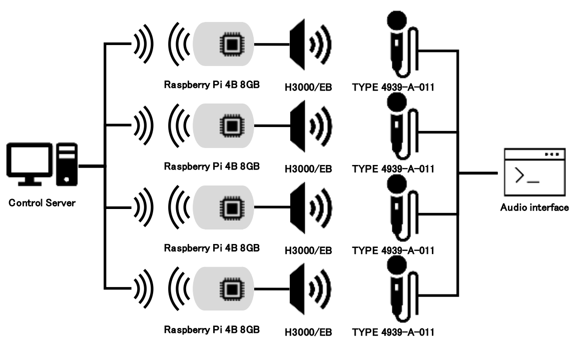

Fig. 3 The second measurement method

we estimated the delay by calculating the cross-correlation between the recorded data.

We verify that the system is able to control latency even when this system is connected wirelessly, by comparing the wired and wireless connections. (See Figs 4-7)

5. Conclusion

Comparing the results of each, it was found that the wired connection was faster by a few milliseconds. In addition, a delay of several milliseconds was found to occur when parametric loudspeakers were connected.

In all cases, we consider that there is still room for latency control from the viewpoint of sound precedence effect since the average value is less than 30 ms [7].

As a future task, we will consider real-world implementation using high-quality wireless networks such as L5G.

References

1. P. J. Westervelt: J. Acoust. Soc. Am. **35**(1963) 535
2. M. B. Bennett and D. T. Blackstock: J. Acoust. Soc. Am. **57**(1975) 562
3. M. Yoneyama, J. Fujimoto, Y. Kawamo, and S. Sasabe:J. Acoust. Soc. Am. **73**(1983) 1532
4. T. Kamakura and S. Sakai, IEICE Tech. Rep. EA-105-556, (2006), p. 25[in Japanese].
5. Y. Asakura and K. Okubo: Jpn. J. Appl. Phys. **56** (2017) 07JC14.1
6. S. Koyama and K. Okubo: Jpn. J. Appl. Phys. **60** (2021) SDDB09
7. Gardner, M. B.: J. Acoust. Soc. Am. **43**(1968) 1243

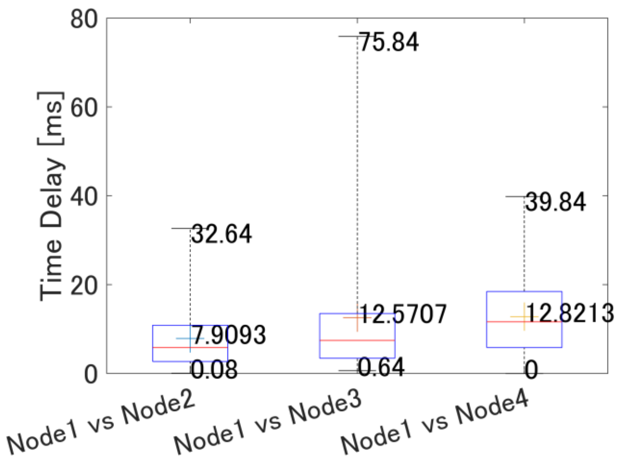

Fig. 4 Wireless connected voltage time delay

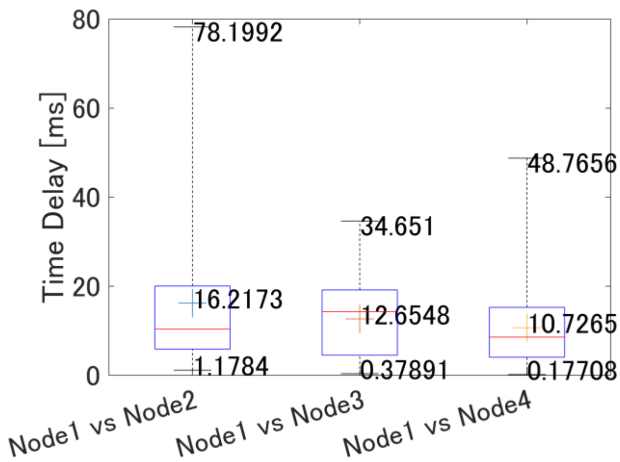

Fig. 6 Wireless connected recording data time delay

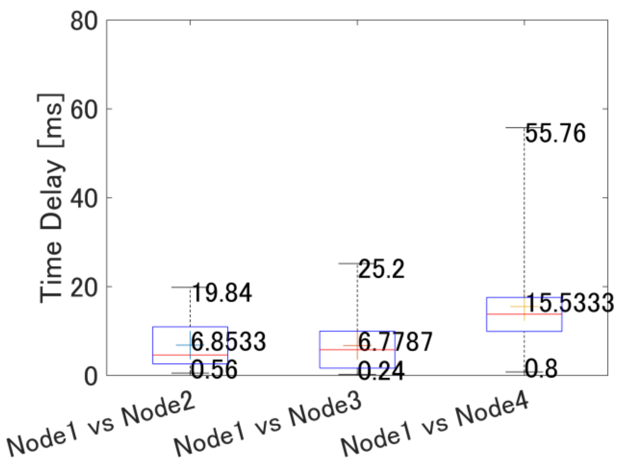

Fig. 5 Wired connected voltage time delay

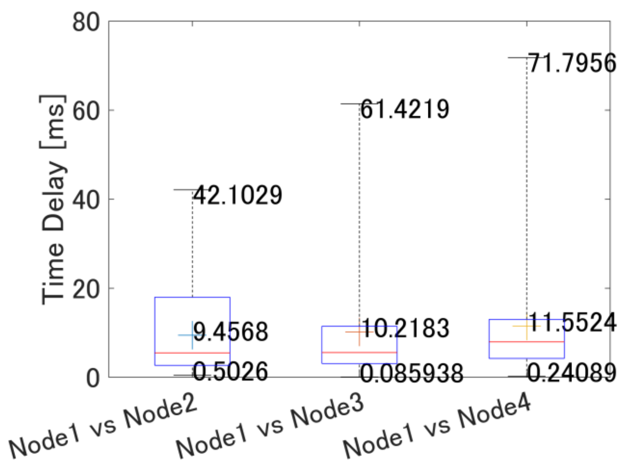

Fig. 7 Wired connected recording data time delay

iihoshi-yohei@ed.tmu.ac.jp, kanne@tmu.ac.jp