Multilingual sound sopt synthesis systems

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ABSTRACT

Localized sound zone synthesis, which can generate acoustically bright and dark zones using loudspeakers, is gaining attention as one of important acoustic communication techniques. By superposing multiple localized sound zones, multiple sound spot synthesis can simultaneously deriver different sound signals at different zones using a loudspeaker array. Additionally, it can be implemented as a user interface for real-time speech translation by combining multilingual speech synthesis technology. This paper introduces multilingual sound spot synthesis systems based on spatial Fourier transform implemented by using compact circular array of 16 loudspeakers and linear array of 64 loudspeakers combined with multilingual neural speech synthesis.

1. MULTIPLE SOUND SPOT SYNTHESIS TECHNOLOGY

Compared to parametric arrays of ultrasonic loudspeakers, localized sound spot synthesis [1,2] (Fig. 1(a)), which can realize audible and inaudible areas using multiple loudspeakers, is superior in terms of the synthesis sound quality and sound pressure level, and is an important technology as a sound presentation system [3]. Additionally, multiple sound spot synthesis [4–7] (Fig. 1(b)), which can simultaneously present different sounds in different areas by superposing multiple localized sound spots, is also an important sound presentation technology for multilingual communication, museums, and other speech and audio applications.

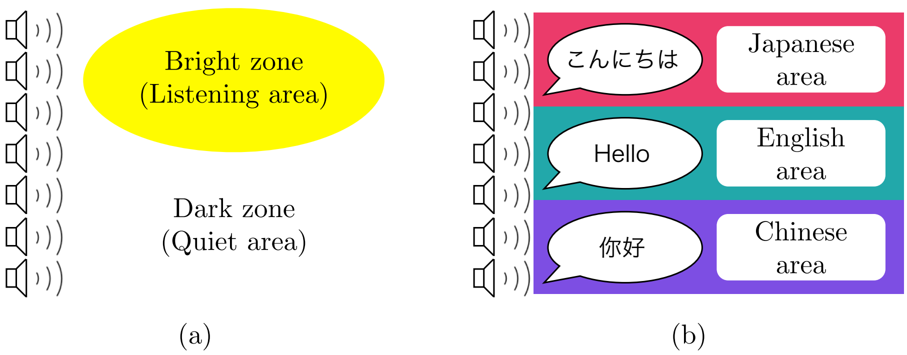

Figure 1: (a) Generating acoustically bright and dark zones with a loudspeaker array, (b) Generating multiple sound zones with a loudspeaker array.

Previously, we have proposed localized sound spot synthesis and multiple spot spot synthesis schemes based on spatial Fourier transforms [8] that can control continuous sound pressure without

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discrete control points [4–6,9–14], instead of multiple control points used in conventional methods [1, 2, 15, 16].

In spatial Fourier transform-based localized sound spot synthesis methods, the sound pressure distribution in reference line or circle is modelled as a rectangular window or a Hann window where the sound pressure in the audible region is 1 and that in the inaudible region is 0, as shown in Fig. 2(a) and (b). The Fourier transforms of the rectangular and Hann windows can then be analytically calculated. The spatial Fourier transform can explicitly remove the evanescent wave component, which is unstable in the acoustic inverse problem [8], and thus can calculate a more stable driving signal than the conventional methods using multiple control points. In the case of using linear and circular arrays, the proposed spatial Fourier transform-based methods [4–6] achieved more accurate control performance than the conventional method using multiple control points [1, 2, 15, 16].

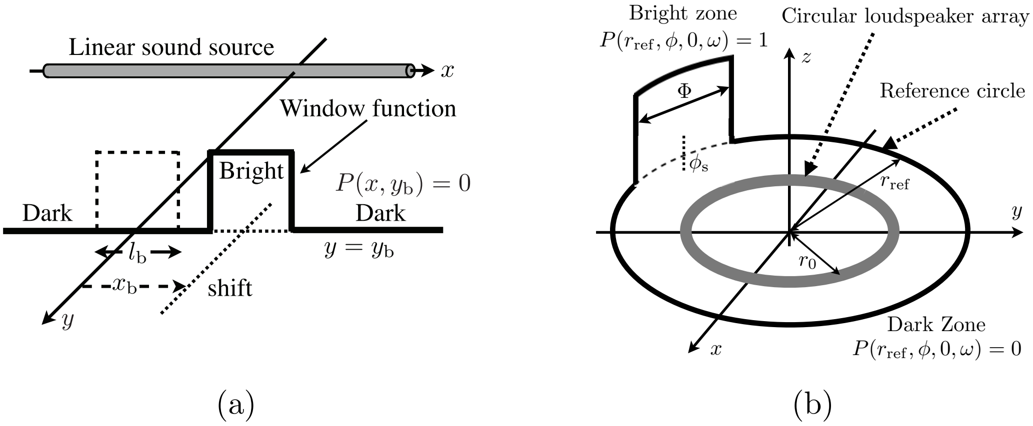


Figure 2: Generating acoustically bright and dark zones based on continuous rectangular sound pressure modeling (a) for a linear array and (b) for a circular array.

2. MULTILINGUAL SPEECH SYNTHESIS TECHNOLOGY

With the development of neural network technology, text-to-speech (TTS) synthesis technology has become capable of producing high-quality speech that is comparable to natural speech [17–19]. Recently, end-to-end models that can generate high-quality speech waveforms directly from text input using a single neural network have been proposed [20–22].

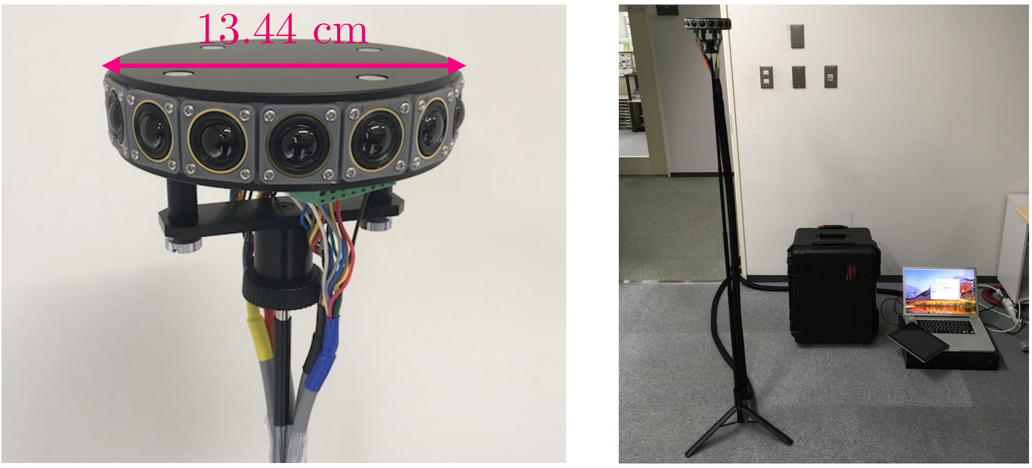
In NICT, we have been conducting research on neural network-based speech waveform generative models and TTS models [23, 24], and currently high-quality neural speech synthesis in 10 languages is available through our speech translation application, VoiceTra.[2]

3. IMPLEMENTATION OF MULTILINGUAL SOUND SPOT SYNTHESIS SYSTEMS

To promote the use of multiple sound spot synthesis technology, we have implemented a portable multiple sound spot synthesis system with a compact circular array of 16 loudspeakers [25] (Fig. 3 and Fig. 4(a)). Additionally, we have also implemented a multilingual sound spot synthesis system as a novel user interface for speech translation by integrating the spatial Fourier transform-based multiple sound spot synthesis technology and multilingual neural speech synthesis ((Fig. 4(b))).

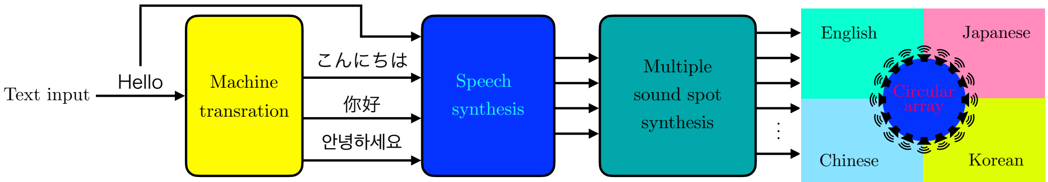
A demonstration experiment using the implemented multilingual sound spot synthesis system was conducted at Miraikan in December 2022 ((Fig. 5(a))). In the demonstration experiment, an alternative multilingual sound spot synthesis system with a linear array of 64 loudspeakers was additionally implemented ((Fig. 5(b))).

[2] https://voicetra.nict.go.jp

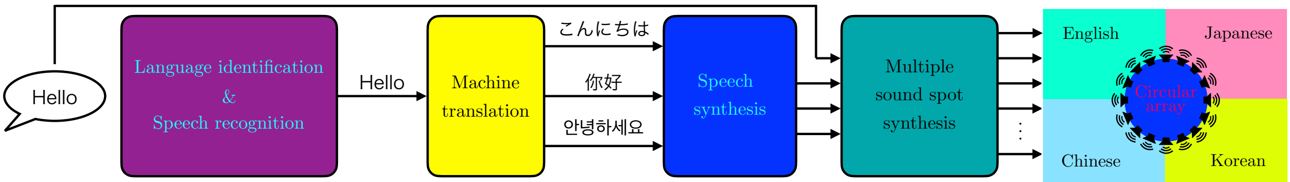


(a) (b)

Figure 3: Implemented small circular array of 16 loudspeakers.



(a) with text input



(b) as user interface for real-time speech translation

Figure 4: Implemented multilingual multiple sound spot synthesis systems.

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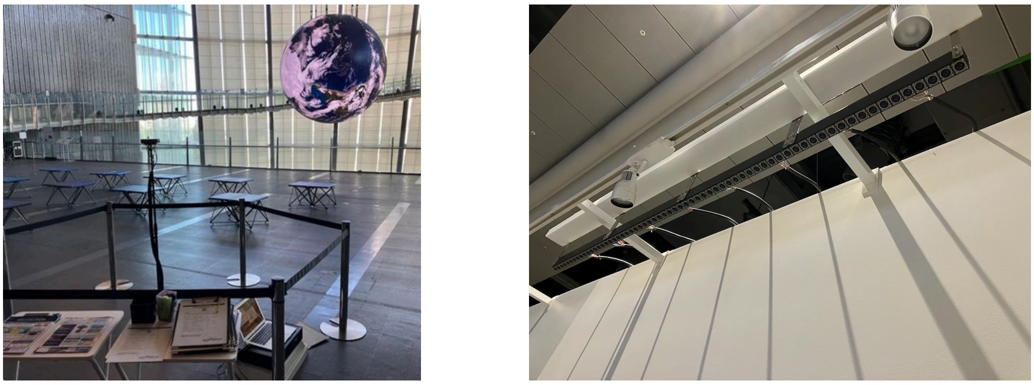

(a) (b)

Figure 5: Demonstration experiments with (a) implemented compact circular array of 16 loudspeakers and (b) implemented linear array of 64 loudspeakers in Miraikan.

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