

# Acoustic Detection of Vehicles Outside the Field of View at Intersections

- Identifying Against Oncoming Vehicles-

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Many serious traffic accidents are head-on collisions at intersections. This is caused by vehicles suddenly appearing from the blind spot of drivers entering the intersection. To prevent this inconvenience, this research focuses on utilizing acoustic signals emitted from vehicles approaching from blind spots. Specifically, we evaluated the effectiveness of a method that selectively detects the main components of tire noise from intersection corners that obstruct the view, using beamforming with a microphone array placed across the vehicle front end. First, we derived a sound propagation equation for sounds diffracting from the corners of buildings from the wave equation, and derived mathematical expression of the diffracted sound source intensity when the intersection corner was modeled as the sound source. (Fig.1, Equation 1, 2)

$$\hat{p} = \hat{S} \int_C f(\zeta) G(\zeta - \phi) d\zeta$$

[1]

$$G(\zeta) = \frac{1}{R(\zeta)} e^{jkR(\zeta)}$$

[2]

Next, we numerically calculated the propagation of sound waves near the intersection using the finite difference method to obtain the wavefront propagation pattern moment by moment.(Fig.2)

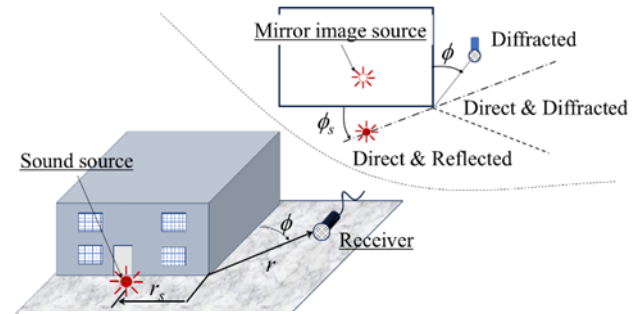


Fig.1 Sound source and diffracted wave receiving point near the corner of a building

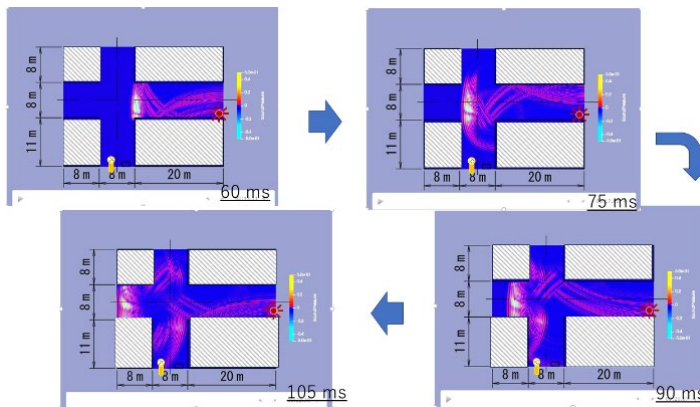


Fig.2 Temporal progression of sound wave propagation

Then, we evaluated the directivity of microphone array with delayed sum beamforming algorithm. (Equation 3, Fig. 3)

$$|p_{sum}| = \left| \frac{\sin(n\pi fd \sin \phi / c)}{\sin(\pi fd \sin \phi / c)} \right| \quad [3]$$

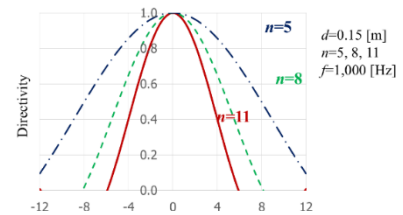


Fig.3 Microphone array direction sensitivity using simple delay adding beamforming.

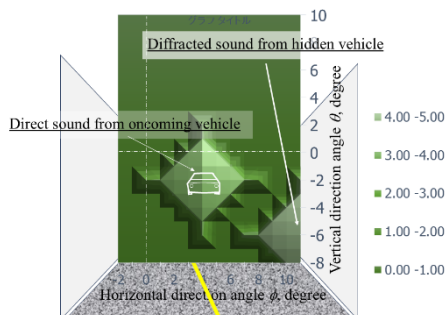


Fig.4 Simulated sound intensity distribution

When the microphone array was placed in the obtained sound field, we calculated the direction of arrival from the difference in arrival times of the sound waves. As a result, we confirmed the possibility of distinguishing between oncoming vehicles and vehicles approaching from blind spots. (Fig.4)