Study of the approach vehicle detection by the supersonic wave

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Abstract

The elderly population is increasing, and the traffic environment surrounding elderly people is not safe. The rate of elderly people falling victim to fatal traffic accidents has become more than half. We can prevent traffic accidents at an early stage by jumping out of the way if we perceive that the approaching vehicle may collide with the walking elderly person. Therefore, we think that it would be useful if we could build a system to inform us of the approaching vehicle by a supersonic wave. In this paper, using a supersonic wave loudspeaker attached to a vehicle, we proposed the technique to detect approaching vehicles on the sidewalk. We found that we could detect areas around 50 m with a high probability of more than 80% by using a tone burst as input to the supersonic wave loudspeaker.

Keywords: supersonic wave, parametric loudspeaker, vehicle detection

1. Introduction

The elderly population is increasing, and the traffic environment surrounding elderly people is not safe⁽¹⁾. The rate of elderly people falling victim to fatal traffic accidents has become more than half and is tending to rise so that the damage degree becomes serious. As for the traffic accidents involving elderly people, a delay in the drop of the athletic capability due to aging and dangerous evasion movement is regarded as a factor⁽²⁻³⁾. If elderly people can perceive the approaching vehicle at an earlier stage, they can prevent being involved in a traffic accident by unexpectedly jumping out of the way

Therefore, we think that it would be useful if we could build a system to inform us of approaching vehicle by a supersonic wave. In this paper, using a supersonic wave loudspeaker attached to a vehicle, we proposed the technique to detect approaching vehicles on the sidewalk.

Fig. 1 Image of vehicle detection system

2. System overview

Figure 1 is the overview of this system. We attach a supersonic wave loudspeaker to the side of the vehicle. Figure 2 is a block diagram of transmission mechanism. Attached supersonic wave loudspeaker sends a supersonic wave to detect vehicles. Figure 3 is a block diagram of the receiver side. Walker received the wave using a broadband microphone on the sidewalk. Received supersonic waves were converted into the audible range. When converted signals turned into background noise level +3dB, walker stated that they were able to detect the approaching vehicles.

2.1 Parametric loudspeaker

In general, a plurality of side-by-side unit of the ultrasonic transducer, it is called parametric loudspeaker. Ultrasonic waves are generated at an angle of a few degrees from the parametric loudspeaker. Ultrasonic wave straight and very little spread around. Seeing from a point of view called the use to our life, the supersonic wave does not cause radiation damage, but influence by the distance decrement is very high. Therefore, we thought to overcome the problem of the distance decrement by using the parametric loudspeaker which formed a very high directivity. Figure 4 is Parametric Loudspeaker we have used.

Fig. 2 Block diagram of the transmission side

Fig. 3 Block diagram of the receiver side

Fig. 4 Parametric loudspeaker

2.2 Transmission mechanism

The transmission mechanism uses a parametric loudspeaker (it carries AT40-10PB3*102 made by Nippon Ceramic, Figure4). Figure 2 is a Block diagram of the transmission mechanism. The modulation device uses a supersonic carrier wave as 40 kHz, located at an irregular time of 31.5 Hz by a cover abnormality signal (a band pulse and tone burst). Because the device makes detection easier and has less influence on human beings, this system uses a band pulse and a tone burst concentrated in terms of time.

2.3 Reception mechanism

Figure 3 is a block diagram of the receiver side. At first, the supersonic wave converts into the audible range by mixing the received information in a broadband microphone with a local oscillation, and then passes through a low-path filter (Heterodyne method). We consider that we could detect an approaching vehicle when converted signals are turned into the background noise level of +3dB in the supersonic wave domain.

3. Input waveform to the parametric loudspeaker

The IRPA (International Radiation Protection Association) established the regulation that is located in Table 1 for international permission value about the supersonic wave domain revelation, and there is a description that 3 dB may raise a permission level if revelation time becomes half ⁽⁴⁻⁶⁾. According to this regulation, we set the sound pressure level at 109 dB (distance 1m from the parametric loudspeaker) to influence hearing ability by the revelation. In order to the device makes detection easier and has less influence on human beings, we uses a band pulse and a tone burst concentrated in terms of time.

3.1 Band pulse

Figure 5 is the waveform of band pulse. Pulse is that of the signal to a steep change in a short period of time. In other words, signal change is a general term and sudden presence short time. We have used the 1/1 Octave band pulse at 31.5Hz.

Table 1. Aerial Supersonic Permissible Level

Center of the 1/3 Oct. band [kHz]	Sound pressure level [dB]
20	75
25	110
31.5	110
40	110
50	110
63	110
80	110

3.2 Tone burst

Figure 6 is the waveform of tone burst. The tone burst signal is a test signal consists of sine and silence of the fixed period only. It is used to measure the transient characteristics representing the rising and falling edge of the signal. We have used the tone burst multiplied by Hamming window to sine wave (12 waves, 31.5Hz).|

4. Influence of the background noise

In this experiment, we recorded the background noise of three patterns, a quiet environment (45dBA), an uncrowded street (55dBA), and a crowded street (65dBA) to check the influence of the background noise in the supersonic wave domain. After recording, we calculated power from waveform of the background noise in the supersonic wave domain (39-41 kHz). As a result, a change in the spectral envelope waveform was only seen in cases where a vehicle or a bicycle passed beside us (2-3m). We found that there is almost no influence in any condition by the background noise.

5. Detection performance

We performed a detection experiment in the range of 60 m from 5 m under the environment of a background noise of 45 dBA. There is almost no influence in any condition by the background noise. Therefore, we performed a detection experiment in a quiet environment (45dBA). We show the experimental conditions in Table 2.

Fig. 5 Waveform of band pulse

Fig. 6 Waveform of tone burst

Table 2. Experimental condition

Microphone	SPM0404UD5 (made by KNOWLES ACOUSTICS)
Microphone position	60 cm from the ground
Parametric loudspeaker	AT40-10PB3*102 (made by Nippon Ceramic)
Sound pressure level	109 dB (distance 1 m)
Directivity	11 degrees
Input signal	2 patterns Band pulse (31.5 Hz, 0.74 sec) Tone burst (31.5 Hz, 0.38 sec)
Weather	Sunny
Temperature	27 °C
Wind	0 m/s
Background noise	45 dBA
Distance	12 patterns 5 m, 10 m, 15 m, 20 m, 25 m, 30 m, 35 m, 40 m, 45 m, 50 m, 55 m
Number of trials	For each 10 times

5.1 Results of analysis recorded signal

Figure 7 is the spectrum of recorded signal. After analyzing the spectrum of recorded signal, a peak was seen at around 900-1100Hz (Relative value of 39 kHz) in any distance about tone burst, although a peak of band pulse is still uncertain. By focusing on the frequency band of around 900-1100Hz (Relative value of 39 kHz), it may be able to detect the approaching vehicle around 50m. Therefore, we simulated a detection experiment which set the background noise level to +3 dB for the threshold at 900-1100Hz (Relative value of 39 kHz).

5.2 Results of detection performance experiment

Figure 8 is the rate of detection when we set the background noise level to +3 dB for the threshold at 40 kHz. As a result, detection rates provided 80% at around 50 m when we used a band pulse. However, when we used band pulse, lower detection rates provided at over 20m. Therefore, band pulse is suitable for the approach vehicle detection.

(a) Distance 15-25m

(b) Distance 30-50m

Fig. 7 Comparison with spectrum of recorded signal

6. Conclusions

In this paper, we proposed the technique to detect oncoming vehicles along the sidewalk, using a supersonic wave loudspeaker attached to a vehicle. We found that we could detect around 50 m with high probability of more than 80% by using a bandpulse input to a supersonic wave loudspeaker. However, as the number of trials in this experiment was slight 10 times, there is a possibility which is actually lower than the really detection rate. If we are increasing the number of attempts, the detection rate will be further improved. We are going to perform the evaluation under various conditions and increasing the number of trials in future.

References

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(a) Number of trials 5 times

(b) Number of trials 10 times

Fig. 8 Rate of detection depending on distance

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