Regular Paper

Pedestrian Cooperative Autonomous Mobility

- Individual Information Presentation -

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Abstract - When autonomous mobility approaches a pedestrian, it is desirable for pedestrians to become aware of its presence. A common method to make people aware of approaching mobility is to use an alarm sound. Previous studies have largely focused on traffic participants on the roadway, such as the tone of warning sounds and external human-machine interfaces. However, studies considering the impact on non-traffic participants are lacking.

In this paper an information presentation system is proposed to individually notify traffic participants who are considered unaware of the approaching mobility. Face orientation of traffic participants is recognized through image recognition, and if they are potentially unaware of the mobility, a parametric speaker is used to provide individual notifications. The type of sound was adjusted according to the distance from the traffic participants, enabling alertness, recognition of the approaching direction, and perception of the distance during approach.

In the experiment, a five-point evaluation was conducted for information presentation, where traffic participants received an average score of 4 or higher for both "audibility" and "alertness." Non-traffic participants and passengers received an average score of 2 or lower ("slightly audible" or lower) for the "audibility" category.

Keywords: Autonomous Mobility, Human Interface

1 INTRODUCTION

1.1 Research Background

In recent years, the implementation of autonomous mobility has been advancing in restaurants, commercial facilities, and other places. Autonomous mobility is being used for automating luggage transportation and patrolling duties within facilities. These mobility systems operate in environments where pedestrians are present. They need to reach their destination without colliding with pedestrians or obstacles. Pedestrians can avoid collisions by predicting each other's movements through cues like eye contact. However, mobility units face the risk of collisions if they cannot communicate properly with pedestrians or if pedestrians are unaware of their approach. Therefore, it is necessary to explore methods to achieve smooth and cooperative movement when autonomous mobility navigates situations where pedestrians may not be aware of their presence. This discussion considers two examples.

In the first example, consider the scenario of driving a car. Major roads on which cars travel are typically equipped with traffic signals and crosswalks, and there is clear traffic rules based on road signs and traffic laws. This enables cars to navigate smoothly and safely with other vehicles and pedestrians. In the second example, consider a cyclist approaching a pedestrian who is looking at their smartphone while walking. To alert the pedestrians of their approach, the cyclist can ring a bell or maintain a safe distance to avoid a collision.

As seen in these examples, a smooth traffic environment is achieved when humans drive cars or ride bicycles by making judgments based on their surroundings. In contrast, when autonomous mobility travels on residential roads or sidewalks, the routes and traffic rules are not as clearly defined as they are for cars [1]. Therefore, "cooperative movement," where mobility predicts and responds to the movements of others, becomes essential.

Thus, if the mobility itself can predict the state of pedestrians and take appropriate actions, it can achieve cooperative navigation that also considers the pedestrians' sense of security.

1.2 Notification of Approach Using Alarm Sounds

When autonomous mobility or automated guided vehicles (AGVs) in factories approach pedestrians, they often use warning sounds to notify nearby people of their approach for safety reasons (Fig. 1). Recently, the number of incidents involving pedestrians walking while looking at their smartphones, known as " Texting while walking " has increased. According to data from the Tokyo Fire Department, 35.4% of emergency transports due to accidents involve collisions, and 75.9% of these collisions occur on roads or in traffic facilities [2].

The dangers of texting while walking include "narrowed field of vision", "inability to hear surrounding sounds" and "being defenseless" [3]. If pedestrians are unaware of approaching mobility, they might suddenly change their path, leading to collisions. Therefore, using proximity warnings helps reduce the risk of such collisions.

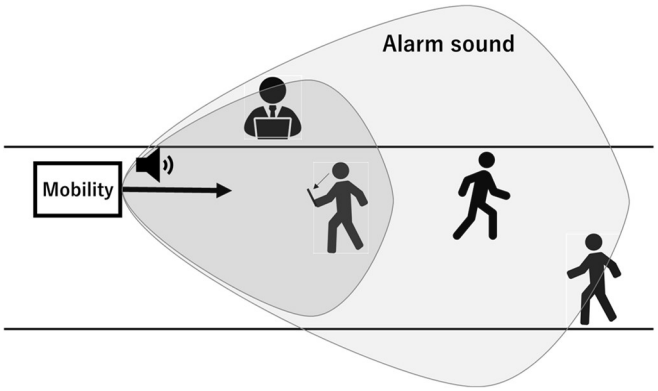

Figure 1 Presenting information to the surroundings using a proximity alarm sound

In automobiles, the installation of an Acoustic Vehicle Alerting System to notify pedestrians and others of the vehicle's approach by sound has been mandated by law [4]. For autonomous mobility, which is expected to operate on sidewalks and residential roads, it is essential to ensure that pedestrians can reliably recognize their approach to maintain safe and secure operations. It is anticipated that similar considerations will advance autonomous mobility in the future.

However, audible alerts can be tolerated in open spaces like roads or factories where noise levels are generally higher. In quieter environments like office settings, frequent mobility movements with loud alarms might be perceived as disturbing or annoying by individuals who shouldn't normally hear them. To address this issue, adjusting the volume of the alarm or using softer tones can reduce the disturbance. Nevertheless, this approach may lead to challenges such as individuals who need to hear the alarm not being able to do so or becoming less attentive to approaching mobility.

1.3 Research on Warning Sounds and External Human-Machine Interfaces

Research on warning sounds and external human-machine interfaces has also been progressing. A study by P. Bazilinskyy et al. [5] demonstrated a strong correlation between the loudness of external mobility sounds and the deterrent effect on road crossing. S. Kayukawa et al. [6] discussed a system that supports visually impaired individuals by emitting sounds in crowded environments. Another study by A. Alhawiti et al. [7] examined the external human interface of robots in environments shared with pedestrians. Additionally, research has been conducted on the effects of music on personal space [8].

1.4 Research Question and Hypothesis

The classification of pedestrians is shown in Fig. 2. Individuals on the path where the mobility travels are termed "traffic participants," while those outside the path are termed "non-traffic participants." Among traffic participants, some may be aware of the approaching mobility while others may not.

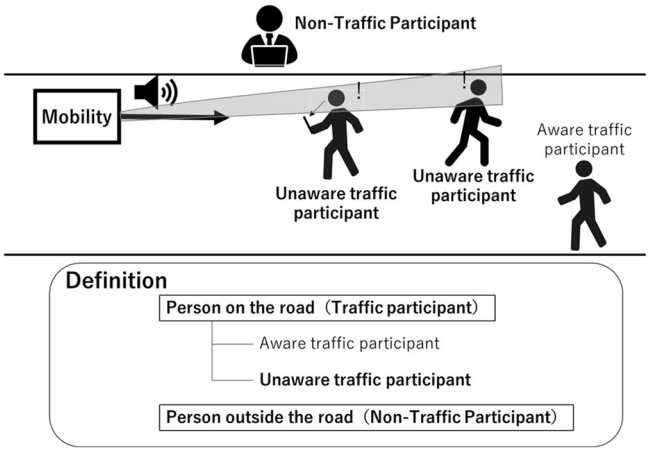

Figure 2 Pedestrian Classification

Factors contributing to lack of awareness include pedestrians walking in front of the mobility or being distracted by smartphones. While it's desirable to issue audible alerts to ensure safety for unaware traffic participants, it's also preferable for non-traffic participants not to hear the sound to maintain tranquility.

Research on approach warning sounds often focuses on the impact of the sound's timbre on traffic participants and its perceptibility. However, studies considering the impact on non-traffic participants are lacking. As a result, approach warnings might provide information to non-traffic participants as well, which can be perceived as noisy. Additionally, traffic participants might not receive sufficient information, making it difficult to notice the warnings.

To solve these problems, this study introduces a method termed "individual information presentation" aimed at delivering information to pedestrians individually, thereby addressing the limitations of proximity warnings. Specifically, the method employs image recognition to identify pedestrian states and subsequently delivers tailored information to them using parametric speakers. This approach aims not only to prioritize safe arrival at the destination but also to consider pedestrians' sense of security. The proposed method was integrated into a mobility system, and its effectiveness was validated through sensory evaluation experiments.

2 METHODS 1

2.1 Proposed Algorithm

To issue proximity warnings individually to unaware traffic participants, the system estimates the position and condition of pedestrians. If it determines that a pedestrian is unaware, it activates the warning sound only in such cases.

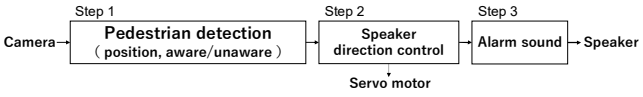

Figure 3 Overview of Information Presentation System

The procedure unfolds as follows:

Step1: Using a camera mounted on the mobility, image recognition detects the position and state of pedestrians.

Step2: Identifying nearby pedestrians who are deemed unaware, the system controls the direction of parametric speakers.

Step3: Based on recognition results and pedestrian positions, audible warnings are emitted.

An overview of the proposed information presentation system is depicted in Fig. 3.

2.2 Pedestrian Location and Condition Detection

The position and state of pedestrians were detected using the image recognition software YOLO v4 [9]. The pedestrian position was obtained by acquiring the lower-bound coordinates of the bounding box (hereafter referred to as bbox) for the "person" class, as indicated in the image recognition results (Fig. 4). Using the coordinates of the acquired bbox, the relative position and relative angle of the pedestrian were calculated through the following steps.

① From the camera image, the pixel value of the lower boundary coordinates of the "person" bbox closest to the mobility is obtained.

② A projection transformation is performed from the image coordinate system to the mobility coordinate system.

③ The coordinates after conversion to the robot coordinate system are taken as the estimated position of the pedestrian, and the relative position and relative angle with respect to the mobility are calculated.

This method allows the estimation of pedestrian position without being dependent on the pedestrian's height. The range of the projection transformation was set to 1280×760 in the image coordinate system and 4 meters in the vertical direction (width direction relative to the robot) and 7 meters in the horizontal direction (front direction of the robot) in the robot coordinate system.

Figure 4 Method of obtaining pedestrian coordinates

Next, to evaluate the detection accuracy of the relative position and angle of the pedestrian, a coordinate system with vertical and horizontal axes set to 7 meters and 1.4 meters, respectively, as shown in Fig. 5, was used. The accuracy of pedestrian position detection was investigated by positioning a male subject (23 years old) in an upright position at each of the coordinates set in . The calculated distance and angle were compared with the actual values. The subject wore long sleeves and long pants, matching the clothing worn during the evaluation experiment. The study was conducted under two conditions: indoors and outdoors. The RMS (Root Mean Square) error was calculated from the 210 data points at the 21 measurement points. The results are shown in Table 1 and Table 2.

The state of pedestrians was assumed to be such that they were not aware of the mobility's presence if they were facing away from the direction of the mobility or if their faces were looking downwards. Therefore, images of pedestrians in various states were captured at multiple locations within Kanagawa Institute of Technology. These images were labeled into four categories: "person", "forward-facing (look)", "backward-facing (no_look)" and "downward-facing (smartphone_ped)" as shown in Fig. 6. A total of 7,548 images were used, and the training took 9 hours and 51 minutes with 8,000 epochs. Jetson Xavier NX was used for training (Table 3) [10]. The recognition accuracy is shown in Table 4.

There is a need to improve the recognition rates for "look", "no_look" and "smartphone_ped" in the future.

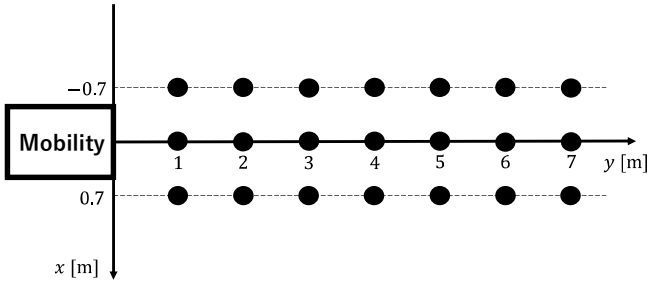

Figure 5 Location where detection accuracy is evaluated

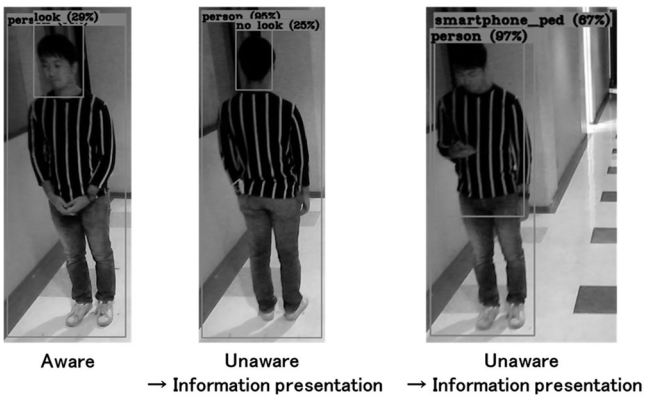

Figure 6 Pedestrian Status Detection

Table 1 Pedestrian location detection results (indoor)

Distance error [m]	0.461
Angle error [deg]	5.75

Table 2 Pedestrian location detection results (outdoor)

Distance error [m]	0.414
Angle error [deg]	4.61

Table 3 Specifications of the Computer

CPU	6-core NVIDIA Carmel Arm®v8.2 64-bit CPU 6MB L2 + 4MB L3
Maximum CPU Frequency	1.9 GHz
Memory Size	8GB 128-bit LPDDR4x, 59.7GB/s

Table 4 Correctness of recognition results (Accuracy)

person	93.4%
look	75.4%
no_look	64.7%
smartphone_ped	69.9%

2.3 Parametric Speaker

To transmit warnings to individual pedestrians, a highly directional parametric speaker was used. The speaker's orientation was controlled by a servomotor to align with the pedestrian's direction. The parametric speaker, which uses ultrasound, is a single-directional audible speaker with a narrower audible range compared to conventional speakers. For this purpose, a parametric speaker manufactured by TriState was utilized (Fig. 7). This speaker generates a 40 kHz ultrasonic carrier wave from each of its 50 ultrasonic transducers, which is frequency modulated with the target sound and emitted. These ultrasonic waves cause nonlinear distortion in the air, allowing the target sound to be heard with sharp directivity [11]. This technology has been applied in previous research to systems providing hands-free environments [12].

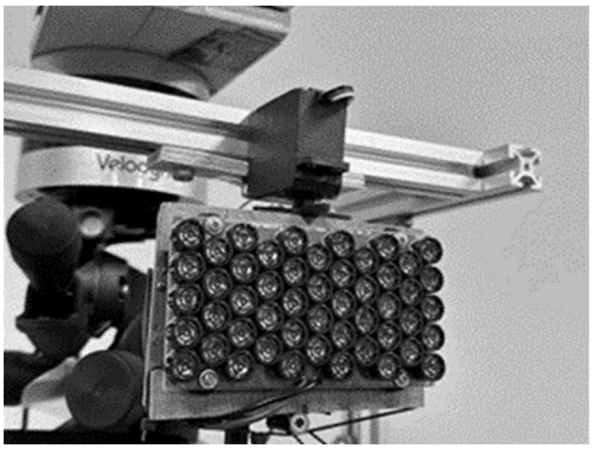

Figure 7 Parametric speaker

To evaluate the characteristics of the parametric speaker used in this study, the variation in perceived sound based on positioning was investigated. Three male subjects (average age: 22.7 years, ranging from 22 to 23 years) were positioned upright at various measurement locations (Fig. 8) in a quiet environment (background noise: 32dBA). They were then asked to respond to a questionnaire evaluating the "audibility of the alert sound." Responses were rated on a 5-point scale: "1. hardly audible", "2. a little audible", "3. audible", "4. well audible", "5. very audible". The parametric speaker was installed at a height of 1.59 meters from the ground, and a warning sound consisting of a sine wave with a fundamental frequency of 880 Hz was continuously played through the parametric speaker.

The experimental results, depicted in Fig. 9, highlight areas where the mean score of the audibility evaluation exceeded 3.0 (indicating "audible"), marked with shading. Despite the angle error in image recognition being 5.75 degrees, the evaluations were consistently in the "audible" range. This suggests that controlling the orientation of the speaker towards pedestrians and transmitting alerts is indeed feasible.

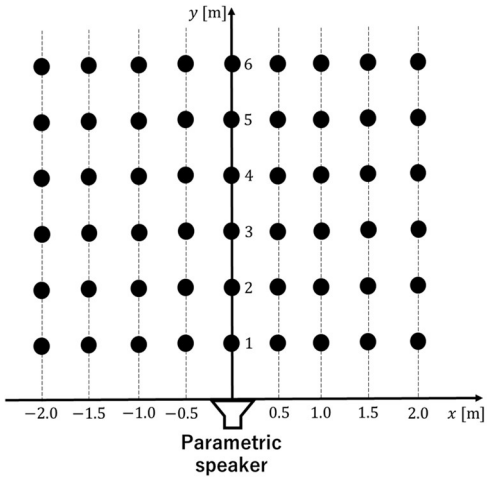

Figure 8 Location of the "Hearing the alarm" rating.

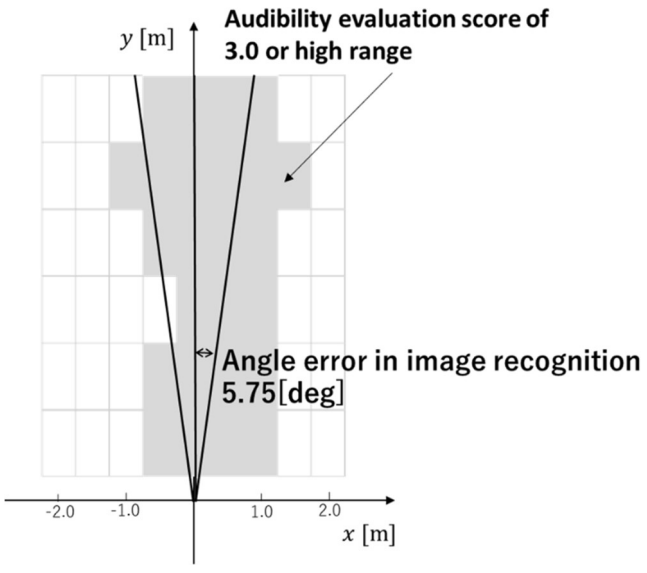

Figure 9 Experimental Results Average

3 EXPERIMENT 1

3.1 Experimental Device

An evaluation experiment was conducted to assess the effectiveness of the proposed method. The autonomous mobility device used was the WHILL Model CR (hereafter referred to as mobility). The mobility is equipped with an omnidirectional laser sensor and a camera for obstacle detection and image recognition, a control computer, and an information presentation system. The control computer uses a Jetson Xavier NX for image recognition and a Shuttle for autonomous movement. The information presentation system employs a parametric speaker manufactured by TriState for sounding warnings and a SONY wireless portable speaker SRS-XB43 for comparison as a general speaker.

The hardware configuration is shown in Fig. 10.

3.2 Experiment Conditions

A subjective evaluation experiment was conducted with an information presentation system installed in a mobility. The experiment was conducted on three male subjects (average age: 22.7 years, ranging from 22 to 23 years). The experiment was conducted under the approval of the Human Ethics Review Committee of Kanagawa Institute of Technology. This experiment was conducted with the assumption of an office environment. The location was the same as where the sound pressure measurements of the parametric speaker were conducted. A course was set up as depicted in Fig. 11, and the mobility was driven at a speed of 0.5m/s with the subjects on board. Pedestrians were instructed to stand upright facing the direction of the mobility, while non-traffic participants were seated perpendicular to the mobility in chairs, with instructions to perform tasks freely, such as using smartphones. Path planning utilized the Dynamic Window Approach [13] (hereafter referred to as DWA), a method originally proposed by D. Fox for static obstacle avoidance. This approach generates candidate paths considering mobility constraints of the mobility and factors like destination arrival time. It evaluates each candidate's path and selects the one with the highest evaluation score to control the mobility.

The mobility navigated from the starting point towards a goal located 13 meters ahead, using DWA to avoid pedestrians encountered along the way.

The participants undertook two trials for each of the three roles: as traffic participants, as non-traffic participants, and as passengers. After each trial, they completed an evaluation questionnaire. Two experimental conditions were employed:

1. Conventional Method: Alarm sound A (a combination of C4, E4, and G4 in Scientific Pitch Notation, each lasting 1 second, with a cycle of 5.5 seconds) continuously played from a general speaker. This method simulates how alarm sounds are presented in actual autonomous mobile mobility.
2. Method 1: In this method, the same alarm sound (alarm sound A) was emitted repeatedly from the parametric speaker.

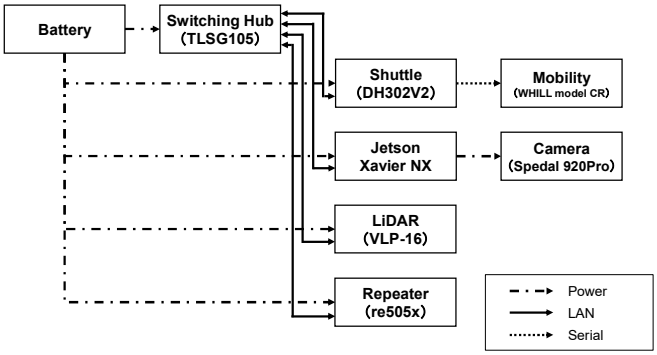

Figure 10 Hardware Configuration

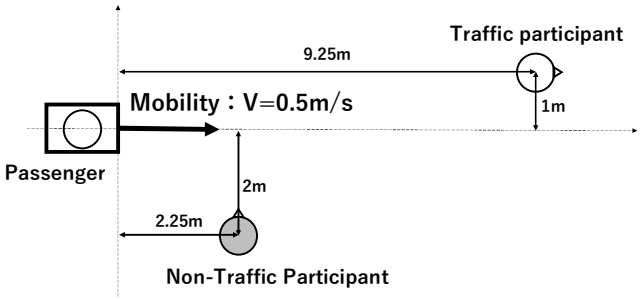

Figure 11 Experimental Layout

Please tell me about the experiment. (Information transmission)

1. How did you hear the warning sound?
   1. hardly audible
   2. a little audible
   3. audible
   4. well audible
   5. very audible

2. Did you feel that you were alerted?
   1. didn't feel it
   2. didn't feel it that much
   3. couldn't say either
   4. felt it a little
   5. felt it

3. Direction of approaching mobility vehicles * answered only by traffic participants
   1. very difficult to understand
   2. difficult to understand
   3. normal
   4. easy to understand
   5. very easy to understand

4. Distance from approaching mobility * answered only by traffic participants
   1. very difficult to understand
   2. difficult to understand
   3. normal
   4. easy to understand
   5. very easy to understand

Figure 12 Evaluation Questionnaire

The evaluation criteria included "Audibility of the alarm sound", "Perception of being alerted", "Direction from which mobility approached" and "Sense of distance when the mobility approached". Participants were asked to rate each criterion on a 5-point scale. The evaluation questionnaire is depicted in Fig. 12.

3.3 Experimental Results

The trajectory of the mobility is illustrated in Fig. 13, while the subjective evaluation results of traffic participants are shown in Fig. 14, Fig. 15, Fig. 16, and Fig. 17. The subjective evaluation results of non-traffic participants are presented in Fig. 18, and those of passengers are shown in Fig. 19.

In the graph, the bars indicate the maximum and minimum values, while the circles indicate the average.

The results of the subjective evaluation by the subjects were analyzed using a t-test to examine whether there were significant differences in the mean values. In the significance test results, a significance level of 5% is indicated by "*", and a significance level of 1% is indicated by "**".

Regarding the results for traffic participants, both the conventional method and Method 1 showed that the alarm sound was rated as "4. well audible." Additionally, compared to the conventional method, Method 1 was found to provide a significantly stronger sense of alertness. However, the perception of approach direction and distance was rated as "3. normal," with the distance perception score falling below 3. This may be attributed to the small distance attenuation characteristic of the parametric speaker, making it difficult to judge distance.

For non-traffic participants and passengers, Method 1 was rated as "1. Barely heard," achieving the intended outcome.

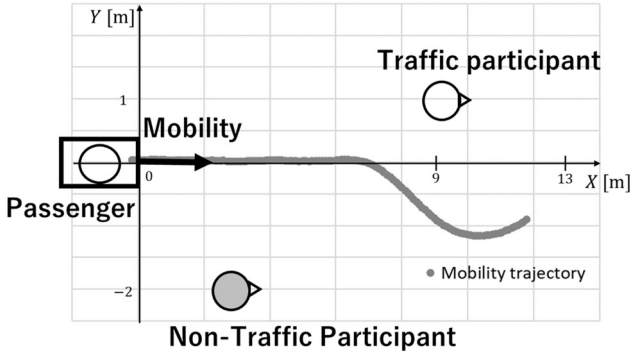

Figure 13 Trajectory

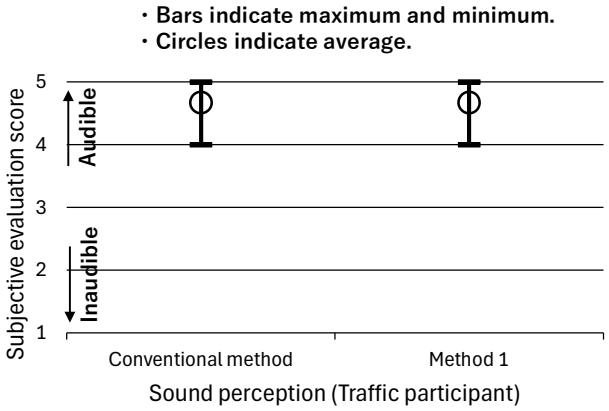

Figure 14 Comparison results of sound perception audibility (Experiment 1, Traffic participant)

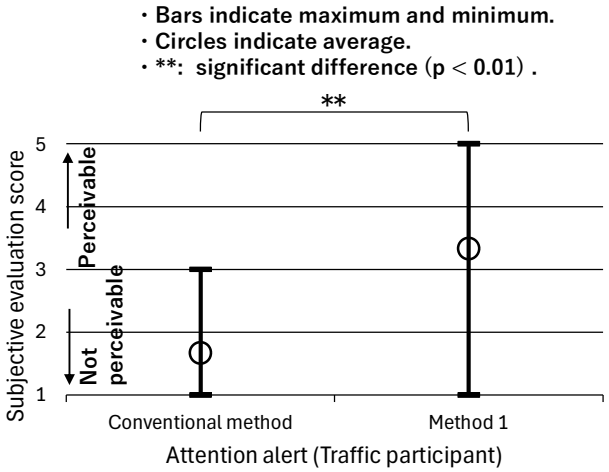

Figure 15 Comparison results of attention alert sensitivity (Experiment 1, Traffic participant)

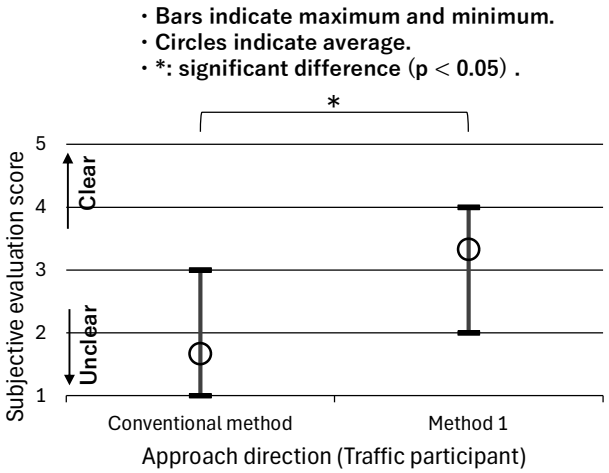

Figure 16 Comparison results of approach direction clarity (Experiment 1, Traffic participant)

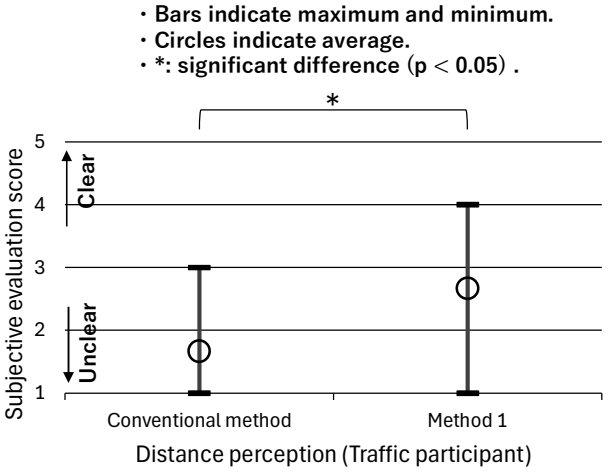

Figure 17 Comparison results of distance perception clarity (Experiment 1, Traffic participant)

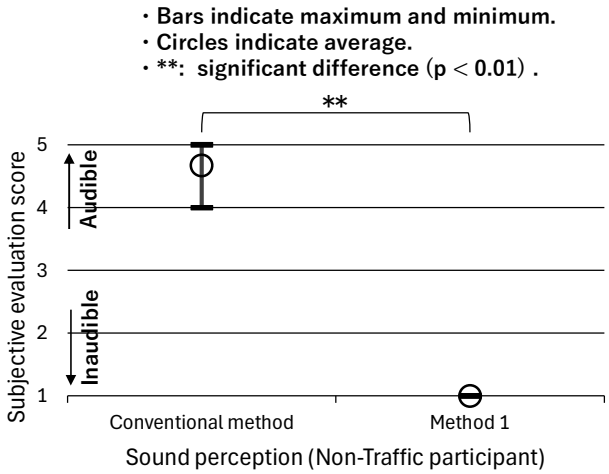

Figure 18 Comparison results of sound perception audibility (Experiment 1, Non-Traffic participant)

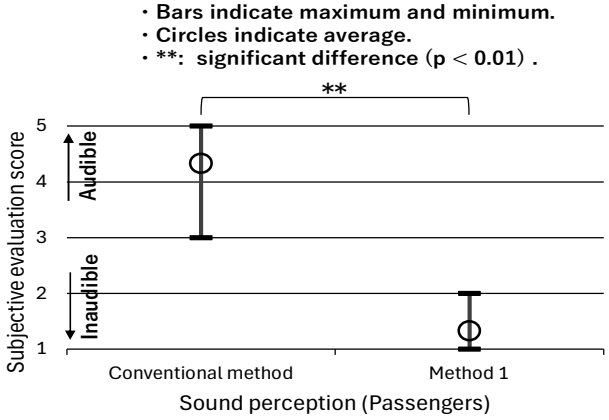

Figure 19 Comparison results of sound perception audibility (Experiment 1, Passengers)

4 METHOD 2

From the results of Experiment 1, it was revealed that Method 1 has the issue of "traffic participants finding it difficult to perceive distance." Therefore, the system was adjusted to enable distance perception by varying the intermittent period of the alarm sound according to the distance to the pedestrian. This approach was guided by the property where humans perceive varying levels of urgency based on sound characteristics such as fundamental frequency and intermittent period [14]. A sine wave with a frequency of 880 Hz was used for the sound, and the intermittent period of the alarm sound B varied according to the distance to the pedestrian, as shown in Table 5. The waveform is illustrated in Fig. 20.

Table 5 Distance to pedestrian and type of alarm sound B

Distance	Warning Sound	Intermittent cycle
5m~6m	Once	1.2 [s]
4m~5m	Twice	0.5 [s]
3m~4m	Four times	0.25 [s]
Within 3m	Continuous sound	Continuous sound

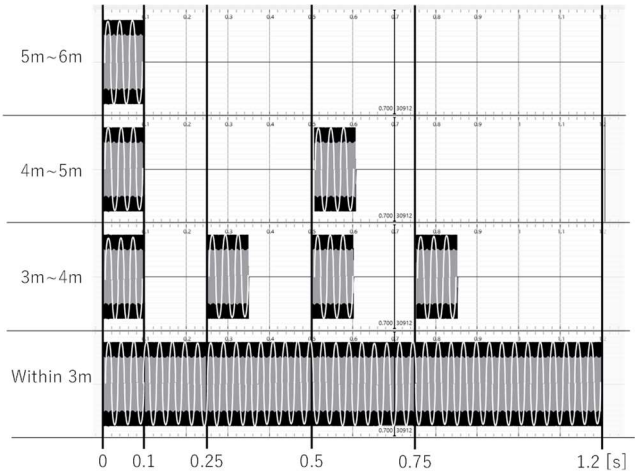

Figure 20 Waveform of alarm sound B

5 EXPERIMENT 2

5.1 Experiment Conditions

To compare the conventional method with Method 2, a sensory evaluation experiment was conducted in the same location as Experiment 1. The experiment involved nine male participants (average age: 22.4 years old, ranging from 21 to 24 years). Two experimental conditions were employed:

1. Conventional Method: Alarm sound A (a combination of C4, E4, and G4 in Scientific Pitch Notation, each lasting 1 second, with a cycle of 5.5 seconds) continuously played from a general speaker. This method simulates how alarm sounds are presented in actual autonomous mobile mobility.
2. Method 2: In this method, the alarm sound B was played gradually from the parametric speaker.

The experimental setup and evaluation criteria were the same as those used in Experiment 1 with Method 1.

Table 6 shows a comparison of methods.

Table 6 Comparison of Methods

	Speaker	Alarm sound
Conventional Method	conventional speaker	Constant sound
Method 1	parametric speaker	Constant sound
Method 2	parametric speaker	Sound that changes with distance

5.2 Experimental Results

The subjective evaluation results of traffic participants are shown in Fig. 21, Fig. 22, Fig. 23, and Fig. 24, those of non-traffic participants are presented in Fig. 25, and those of passengers are shown in Fig. 26.

In the graph, the bars indicate the maximum and minimum values, while the circles indicate the average.

The results of the subjective evaluation by the subjects were analyzed using a t-test to examine whether there were significant differences in the mean values. In the significance test results, a significance level of 5% is indicated by "*", and a significance level of 1% is indicated by "**".

Regarding the results for traffic participants, adjusting the alarm sound according to the distance to pedestrians improved the distance perception rating beyond "3. normal" and made distance perception significantly easier compared to the conventional method.

For non-traffic participants and passengers, the same effect as Method 1 was observed.

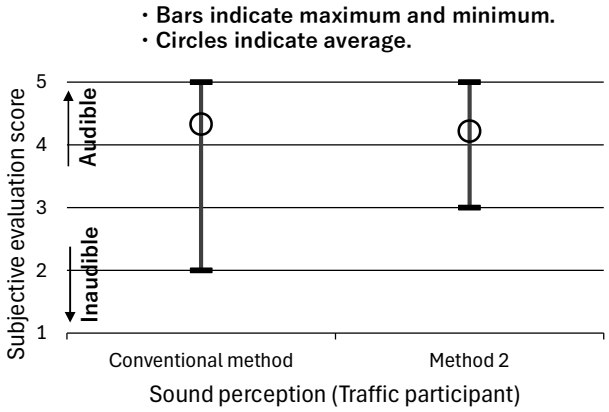

Figure 21 Comparison results of sound perception audibility (Experiment 2, Traffic participant)

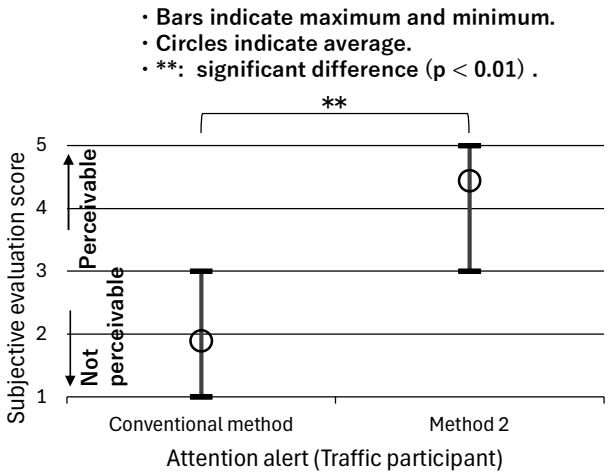

Figure 22 Comparison results of attention alert sensitivity (Experiment 2, Traffic participant)

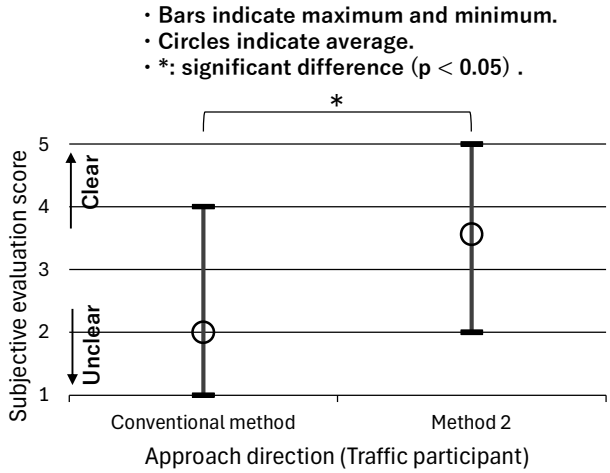

Figure 23 Comparison results of approach direction clarity (Experiment 2, Traffic participant)

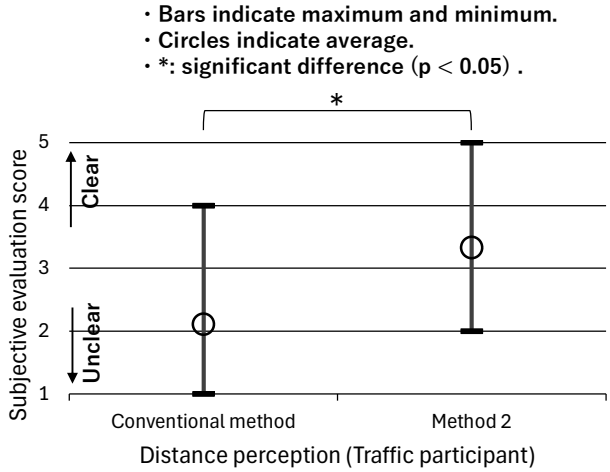

Figure 24 Comparison results of distance perception clarity (Experiment 2, Traffic participant)

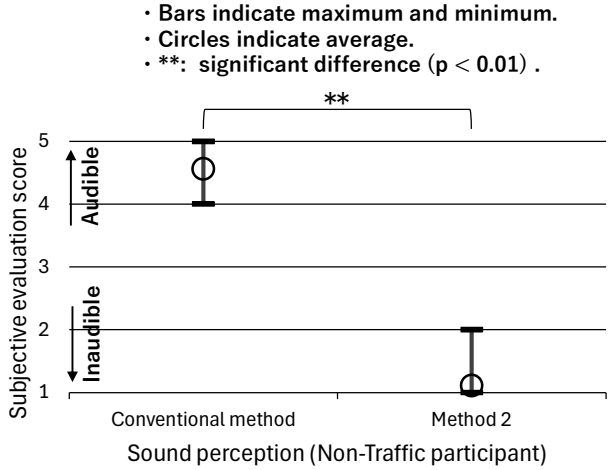

Figure 25 Comparison results of sound perception audibility (Experiment 2, Non-Traffic participant)

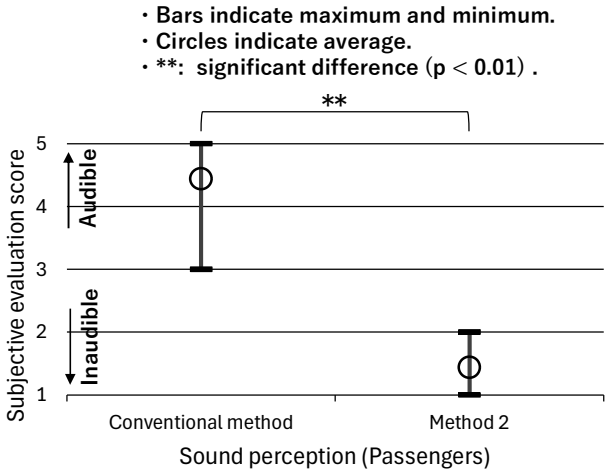

Figure 26 Comparison results of sound perception audibility (Experiment 2, Passengers)

6 DISCUSSION

6.1 Research Findings

One of the challenges in conventional proximity warning systems is that the alarm sound is also presented to unrelated non-traffic participants, leading to perceived noise. To address this issue, the use of a parametric speaker enabled the presentation of information exclusively to traffic participants, thereby reducing noise for non-traffic participants. However, the second challenge—pedestrians being unaware of the approaching mobility—was found to be only partially mitigated by the parametric speaker. Therefore, a method was introduced to gradually change the type of alarm sound based on the distance to pedestrians. As a result, compared to conventional methods, this approach was newly confirmed to improve pedestrians' recognition of both direction and distance when the mobility approaches.

6.2 Challenges of the Information Presentation System

A newly identified issue in this study was observed during a preliminary experiment conducted in an open lobby with glass windows and concrete pillars. In this setting, the alarm sound from the parametric speaker was heard from directions other than the intended one. This phenomenon is likely caused by the straight-traveling nature of parametric speaker sound, with reflections occurring from surrounding walls. This issue requires further investigation.

Additionally, in pedestrian position detection using bbox from image recognition, fluctuations in bbox stability were observed when the floor was made of reflective tile material or when lighting conditions varied. Considering mobility operation in outdoor environments, it is necessary to enhance detection accuracy by integrating pedestrian detection using LiDAR.

6.3 Individual Information Presentation and State-adaptive Path Planning

In this study, pedestrian state estimation using image recognition and the use of parametric speakers enabled individual information presentation. However, if traffic participants are using smartphones or wearing earphones, alarm sounds alone may not sufficiently convey information to unaware traffic participants, potentially failing to reduce the risk of collisions.

In such cases, it is necessary to implement "State-adaptive Path Planning," which incorporates pedestrian state detection results into mobility path planning. Specifically, if pedestrian state detection determines that a pedestrian is unaware of the approaching mobility, individual information presentation is performed while simultaneously generating a path with a larger avoidance margin than the usual avoidance path, thereby reducing collision risks.

6.4 Validity of the Experiment

In the sensory evaluation experiment conducted in this study, 3 participants took part in Experiment 1, and 9 participants in Experiment 2. All participants were male, and their ages were in their 20s. The experiments were conducted in an office environment, which was a relatively quiet indoor setting.

To increase the generalizability of the experimental results, it would be desirable to include participants of different genders, ages, and heights. Additionally, conducting experiments in open spaces or outdoor environments would be beneficial.

7 CONCLUSION

This study developed an information presentation system to propose a method for individually alerting pedestrians who are deemed to be at risk of collision and may not be aware of the approaching mobility. Furthermore, the effectiveness of this method was confirmed through sensory evaluation experiments. In the future, driving in real environments with both traffic participants and non-traffic participants will require advancements in pedestrian recognition and information presentation methods. Additionally, implementing path planning that prioritizes pedestrian safety will be essential. Implementing this system into mobility would enable cooperative autonomous mobility operations with pedestrians.

8 FUTURE WORK

8.1 Pedestrian Behavior Prediction and Individual Information Presentation

Proposing a method for individual information presentation even in environments with multiple pedestrians or high congestion. In this implementation, information was

presented to a single individual based on the results of image recognition. Therefore, it does not consider how to handle situations where there are multiple pedestrians or where pedestrians are obscured by obstacles.

Future enhancements should consider applying Kalman filter [15] to predict pedestrian movements. This advancement would enable prioritizing information presentation to traffic participants at greater risk of collision.

8.2 Considerations for Participant Subjective Evaluation

Feedback from the participants revealed that traffic participants, when using Method 2, noted that they were aware of the mobility approach but could not determine whether it would overtake them from the left or right. Non-traffic participants mentioned that "the alarm sound was completely inaudible, and if focused on something, they wouldn't even notice the presence of the mobility." Furthermore, onboard participants pointed out that "the servo and ultrasonic mosquito-like sound was bothersome."

In Method 2, the type of alarm sound was changed based on the distance to the pedestrian, making it possible to perceive the distance to some extent. However, the limited distance attenuation of the parametric speaker and the difficulty in discerning the direction of the sound likely caused challenges in understanding which side the mobility was passing on.

As an improvement, it was considered that utilizing the reflection characteristic of the parametric speaker and oscillating it toward the direction of overtaking could help deduce the direction based on the lingering sound.

Regarding the audibility of the information alert sound for onboard participants, using the parametric speaker helped reduce noise.

Additionally, for non-traffic participants, the results were as expected. From this, it can be concluded that using this method, it is possible to prevent the presentation of mobility approach information to non-traffic participants.

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