Architecture of Automatic Warning System on Urgent Traffic situation for Headphone Users

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Abstract

As audio players become smaller in size and more portable, users can play and listen to music anywhere. More people are using headphones outdoors, and this leads to a higher frequency of traffic accidents. In this paper, the study proposes an architecture of automatic warning system on urgent traffic situation for headphone users. This study proposes a method of warning pedestrians wearing headphones so that they can quickly respond to external sounds and detect an approaching accident. The system was evaluated to be effective in processing living noises and car horn sounds through the simulation of an urgent traffic situation.

Keywords: *Warning System, Headphone, Car-Horn, Urgent Traffic, mp3*

1. Introduction

With advancement of IT, mobile audio players have grown smaller in size so that people can easily carry them in order to listen to music. Moreover, the emergence of the Smart Phone—the third wave of the IT revolution—combined the functions of a phone and an mp3 player to further enhance portability. However, there is a rising danger as users become distracted by music and often fail to notice the surrounding traffic situation. This may pose a greater threat in our time as it is important to notice and process complicated traffic situations so as to ensure safety.

According to a report from researchers at Children's Hospital at the University of Maryland, the number of pedestrians wearing headphones during traffic accident has tripled in six years. According to the report, the number of casualties was 16 in 2004 and 2005, and jumped to 47 in 2010 and 2011; all of them were wounded by a car, train, or other vehicle while wearing headphones. Researchers warned that wearing headphones could be dangerous because it slows down and limits visual and auditory reactions to the surroundings [1]. There has been an increasing number of cases in which individuals become involved in traffic accidents while using a mobile audio player or wearing headphones connected to a Smart Phone. Nevertheless, it seems that the pedestrians' use of headphones will become more widespread with the increasing use of mobile audio players, and therefore, the issue of traffic accidents needs to be addressed.

In this context, this study proposes a method of warning pedestrians wearing headphones so that they can quickly respond to external sounds and detect an

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approaching accident. The pedestrians cannot effectively respond to external noises, like a car horn, while they are listening to music on headphones. This study proposes a method to detect the sound of a car horn, control the music play accordingly, and warn the pedestrians of the danger.

2. Daily Living Noises and Car Horn Sounds

According to an article on the Institute of Webcasting, Internet and Telecommunication, daily living noise is ranged 60dB to 80dB[2]. And as the criteria of noise and vibration regulation in daily living or the Noise and Vibration Control Act ("Control Act") in Korea, daily living noise should be 73dB(A) or lower, and the permissible noise of an accelerating car should be 77dB(A) or lower. This is in accordance with the revised standard for measuring a car's driving noise, which was created by the International Organization for Standardization [3]. Allowable traffic noise limits on the roadside by the WHO is in range of 55dB to 70dB at nighttime and daylight time[4]. It shows several standards for the maximum allowable noise in daily living, and they are presented as approximations. A research paper presented at a conference of the Korean Society for Noise and Vibration Engineering in 2006 presented the current noise condition on the roadside during the daytime and nighttime and also according to different spaces—residential, commercial, and industrial areas. Among the various kinds of living spaces, the maximum noise turned out to be lower than 74dB [5]. When a pedestrian walks by a traffic road, the normal level of ambient noise is likely to be 77dB or lower. Meanwhile, a car horn or other similar sound makes a certain level of noise so that the other cars or pedestrians can detect and avoid accidents; they sound different from the noise of daily living so that they can be easily noticeable. According to the Control Act, the maximum allowable level of a car horn is 115dB(C), and the safety range is set between 90 and 115dB(C) [6].

3. Architecture of Automatic Warning System for Headphone Users

3.1. Analysis of Car Horns

The noise level of a car horn on the roadside and other warning sounds are as loud as or louder than the noises of daily living.

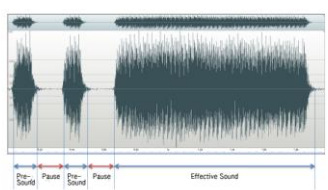

Figure 1. Pre-sound, Pause, and Effective Sound of a Car-Horn

The noise level of a car-horn or other warning sounds on a pedestrian street should be louder than the noises in daily living, and they should be sustained for a certain length of time in order to be effective. Figure 1 shows an analysis of a car- horn sound.

As shown in the measured data (Table 1), in a normal traffic condition, both short and long horns of type A and B are used. In a more urgent situation, samples were measured in which a short horn of type C, D or E is beeped first, followed by a pause and an effective sound. The pre-sound lasted only 0.17 seconds on average, so the second horn sound that came after the pause was used as the effective sound in the simulation.

Table 1. Length of Car Horn Samples

Situation	Car horn sample	Sound	Measured time (sec)		
			Pre-sound	Pause	Effective sound
Ordinary	A (short)	*honk*	-	-	0.35
	B	*honk*	-	-	0.60
Urgent	C	*honk, honk, honk-*	0.18	0.25	0.64
	D (long)	*honk, honk-*	0.16	0.23	3.75
	E	*honk, honk, honk-*	0.17	0.16	1.24

The effective sound lasted for 0.35~3.75 seconds. The longest case was left out as an outlier, and the results showed that the length of a car-horn used to give a warning on the roadside usually lasted for 0.35~1.24 seconds.

3.2. Architecture of Automatic Warning System

Figure 2 describes an automatic warning system model for headphone users, which consists of an audio sensor to detect the external noise, a filtering module to separate a car horn from other noises, and a control module that sends a warning signal to the pedestrian.

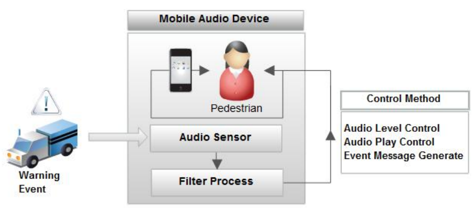

Figure 2. Audio Detecting Architecture

The proposed model can activate the warning system for pedestrians wearing headphones to listen to music. The audio sensor monitors the external sounds, and when a noise of a certain level occurs, it determines whether it is a car horn or another noise and controls the music play accordingly by stopping the music, turning down the volume to lessen auditory isolation, or generating a warning message on the player.

When a noise of certain level occurs, the filtering module measures its level and length and transmits the data to the control module.

Since the effective length of a car-horn is 0.35~1.24 seconds, a car horn can be effective if the sound is detectable after 0.35s. In Figure 3, checkpoints are set at the interval of 0.35s from the Starting Point(SP) of a noise in order to decide whether an effective noise is generated.

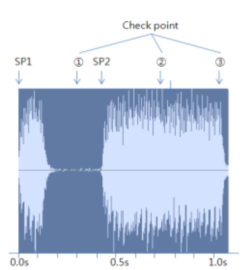

Figure 3. Extraction of Sound Length

The first sound was not perceived as an actual horn sound because after the sound was perceived at SP1, there was no follow-up sound at the first checkpoint (①). At SP2, a horn sound is perceived, and it is perceived again at the first checkpoint(②); accordingly, the 'danger' is detected, and the data is sent to the control module. The follow-up sound data at the second checkpoint (③) is transmitted to the control module, which in turn sends the warning to the pedestrian. The control module either stops the music or adjusts the volume to signal a "danger" to the pedestrian for the designated time and then resumes playing the music.

4. Simulation and Evaluation

Several simulations were performed to assess the effectiveness of the warning system model, and whether the proposed method enhanced the detection of danger for headphone users was examined. In the simulation, the roadside noises were measured with a simulator, and the input was made using a non-directional MIC installed on a laptop. The sounds were converted into sample files and classified into living noise and car-horns. These were used as input sound, such as about 102 dB as car horn average level, in a condition of 2~5m in front of a small/medium-sized car.

Figure 4. Warning Message and Audio Control

In an enabled state for external sounds, the simulation was set to generate a visual warning message (Figure 4) if the sound input rose above a designated level(dB). Monitoring was repeated on the effective, external warning noises, and if the noises reached a certain amount of dBs and time, the filtering process detected it as a "danger", immediately triggering a control mechanism. More specifically, in the simulation, if the input of the external noises exceeded a certain level(dBs), the player stopped playing music and generated a warning message.

Considering that people's audible range is between 0 and 120dB, the living noises (70dB) and a car horn sound (102dB) were measured to examine the number of effective automatic detections and whether they correctly detected the sound of car horns (Table 2).

Table 2. Results of Car Horn Detection at Different Noise Levels

Noise level (dB)	No. of attempts	No. of detections	Success rate (%)	Error rate (%)
70	25	23	94	6
80	25	24	97	3
90	25	23	94	6
100	25	21	84	16
105	25	20	80	20
110	20	1	5	95

The number of noise detections indicates how many times the model automatically detected the sound input as being a car horn, and the success rate indicates how many of these were correct. The error rate indicate show often the model failed to detect a car horn sound. The simulation results showed that at a noise level over 110dB, only 5% of the sound inputs were detected as a car horn. The success rate was 80% at the noise level of 105dB, 84% at 100dB, and over 90% at 90dB and lower; in other words, the noise was correctly detected in most cases. At the noise level of daily living, 70~80dB, the detection was mostly successful, though the system was interrupted several times by the living noises.

5. Conclusion

The study proposed a method to control a mobile music player in order to warn a pedestrian wearing headphones of a dangerous situation by detecting the external sounds. A simulation was conducted to apply the model in various conditions, and its effectiveness was verified because the model helped to improve the safety of pedestrians while maintaining the use of a mobile audio player. Adding a sound sensor to an audio player or using the built-in microphone of a Smart Phone can be a convenient way to send a warning message to pedestrians and trigger timely responses. As the percentage of Smart Phones rises among mobile audio players, the proposed model will be easy to implement, without any need to add new hardware.

The proposed process is a kind of a prototype and needs to be tailored to individual audio players for broader use. It can be a useful guideline for designing mp3 players. Further research will be made in order to warn the pedestrians of the direction of danger as well.

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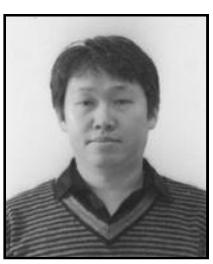

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