Automatic Volume Control Based on Background Noise Characteristics

Yeong Hwangbo, Chang Jun Park, and Seung Ho Choi*
Dept. of Electronic and IT Media Engineering
Seoul National University of Science and Technology
Seoul, Korea
e-mail:hb_young@naver.com. wolfen27@naver.com, shchoi@seoultech.ca.kr
**Corresponding author: Seung Ho Choi*

Abstract—In this study, we propose a novel technique for automatic volume control (AVC). Contemporary AVC systems operate according to background noise level. This paper presentsan AVC system that adaptively updates the audio volumeconsidering the frequency characteristics of the background noise. From the experiments, we conclude that the developed techniques can be successfully used for various acoustic environments.

Keywords*-automatic volume control, acoustic environments, noise characteristics*

*****

I. INTRODUCTION

Recent studies have proved that there are various advantages in adopting automatic volume control (AVC) in noise environment [1]. Conventional methods control the audio volume based on background noise level [1, 2]. However, human's acoustic system is affected not only by the noise level but also by the noise frequency characteristics. Even though the noise level sound is same, people can feel differently depending on the frequency characteristics of the noise [3]. In this research work, we developedan algorithm that controls the signal volume according to the noise frequency characteristics [4].

II. AUTOMATIC VOLUME CONTROL SYSTEM

A. AVCalgorithm

In the AVC system as shown in Fig.1, $x(n)$ is aoriginalsignal and $y(n)$ is a volume controlled signal. $z(n)$ is abackground noise signal. $Z(k.i)$ denotes the spectra of the noise signal with frequency index i and frame index k. When $g(n)$ is a gain, $y(n)$ is given as follows:

$$y(n) = x(n) \times g(n) \quad (1)$$

B. Gain calculation

Firstly, we analyzed the frequency characteristics of five kinds of noises: street, inside the car, outside the car, inside the subway, and subway platform [5, 6]. For each noise signals, 32frequency bands are calculated based on 1/3 octave bandsand shownin Fig. 2. Eachbackground noise is added to the source signal. Then the noisy signalsare played for listeners. They ranked the backgroundnoise signals with scores. Based on these results, the $g(n)$ iscalculated and shown inTable. 1.

Secondly, we comparedthe frequency characteristics using a log-spectral distance (LSD)measure that is given by:

$$\mathrm{LSD} = \frac{1}{M}\sum_{i=1}^{M}\sqrt{\frac{1}{N}\sum_{k=1}^{N}\left(10\log\left(\frac{|Z_{ref}(i,k)|^2}{|Z(i,k)|^2}\right)\right)^2} \quad (2)$$

where M is the number of frames and$Z_{ref}(i,k)$ is reference noise signal. We obtained the LSD values of the above-mentioned five signals and the noise signals of the microphones. In addition, short-time Fourier transform was performed forthe signals of two seconds. The output signal $y(n)$ is obtained by multiplying a source signal $x(n)$ and gain $g(n)$.

TABLE 1. The gain $g(n)$

5 kinds of noise frequency	$g(n)$
Street	1.7
Inside the car	1.2
Outside the car	2.2
Inside the subway	1.5
Outside the subway	1.9

III. PERFORMANCE EVALUATION

To evaluate the performance of the proposed AVC, we used a woman's voice as the original signal. Also, each noise is divided into 3 parts for 5 seconds to analyze accurately. The audio file is sampled at 16 kHz and we normalized the energy of the audio file. There are 50 listeners participating in the experiment. The age of the listeners ranged from 14 to 80. We conducted the proposed AVC system to compare the original signal with the output signal.

TABLE 2. Comparison results

Unprocessed	Processed
3.7	5.2

Fifty listeners gave the scores from 1 point to 10 points depending on how much they heard easily. The proposed AVC system obtained improved scores. From the experimental results, it is evident that the performance of the proposed AVC system is superior to that of the conventional methods.

IV. CONCLUSION

We described a novel volume control method for AVC system based on the frequency characteristics of background noises. The proposed method adaptively updates gainparameters to consider the various acoustic environments.

The experimental results showed that the developed techniques can be successfully used for the AVC system.

V. ACHNOWLEDGEMENTS

This study was supported by the Research Program funded by the Seoul National University of Science and Technology.

VI. REFERENCE

[1] Saligrama R. Venkatesh, Alan M. Finn, Ronald K. Reich, Automatic volume control for communication systeml, Lear Corporation,

[2] N. Raine-Fenning, K. Jayaprakasan, J. Clewes, I. Joergner, S.Dehghani Bonaki, S. Chamberlain, L. Devlin, H. Priddle, I. Joshson, SonoAVC: a novel method of automatic volume calculation, ULTRASOUND, 2008, pp. 21-26.

[3] Nilsson, Johan, Real-Time Control Systems with Delays, PhD Theses TFRT-1049, 1998, p. 6-10.

[4] Olav Egeland and Jan Tommy Gravdahl, Modeling and Simulation for Automatic Control, Norwegian University of Science and Technology Trondheim, Norway, 2002, p. 16-27.

[5] Nancy Hitschfeld, Maria-Cecilia Rivara, Automatic construction of non-obtuse boundary and/or interface Delaunay triangulations for control volume methods, vol55, issue7, 2002, p. 142-153.

[6] John Kean, Eli Jognson, Dr. Ellyn Sheffield, Study of Audio Loudness Range for Consumers in Various Listening Modes and Ambient Noise Levels, NPR Labs, Washington DC, Towson University, Towson MD, 2015, pp. 2-5.

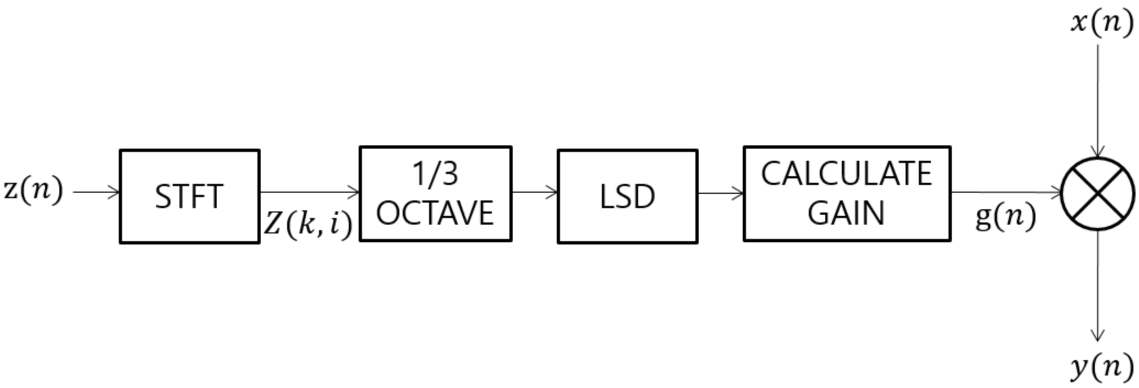

Figure 1. Block diagram of the proposed method.

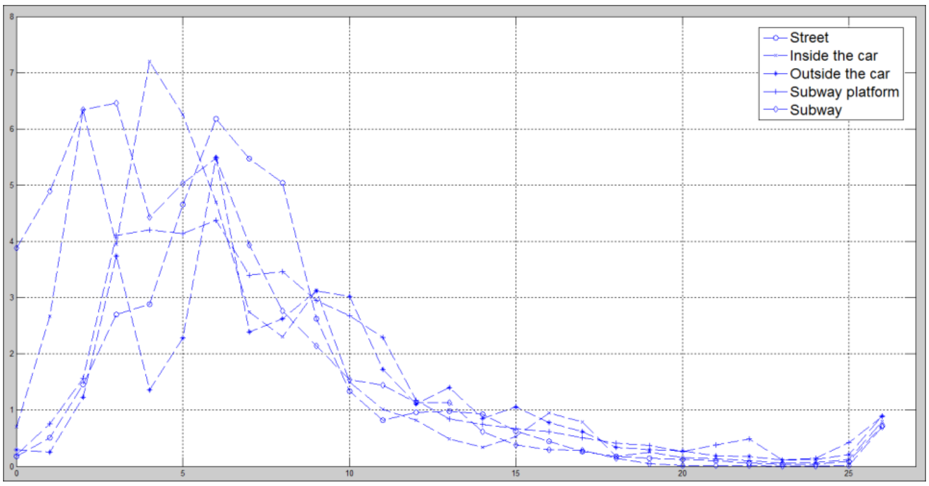

Figure 2. The frequency characteristics of background noise.