# Single Input ANC for Suppression of Breath Sound

Yunjung Lee, Pil Un Kim, Gyhyoun Lee, Jin Ho Cho, and Myoung Nam Kim



***Abstract*****—**Various sounds generated in the chest are included in auscultation sound. Adaptive Noise Canceller (ANC) is one of the useful techniques for biomedical signal. But the ANC is not suitable for auscultation sound. Because the ANC needs two input channels as a primary signal and a reference signals, but a stethoscope can provide just one input sound. Therefore, in this paper, it was proposed the Single Input ANC (SIANC) for suppression of breath sound in a cardiac auscultation sound. For the SIANC, it was proposed that the reference generation system which included Heart Sound Detector, Control and Reference Generator. By experiment and comparison, it was confirmed that the proposed SIANC was efficient for heart sound enhancement and it was independent of variations of a heartbeat.

***Keywords*****—**Adaptive noise canceller, Auscultation, Breath sound suppression, Signal enhancement.

## I. Introduction

A heart sound acquired by a stethoscope provides important information for heart diagnosis. But it is easily distorted by a breath sound and motion. So, a diagnostician often asks to a patient to stop a breath during diagnosis. But, in specific cases such as children or emergency, it is hard to acquire a clear heart sound.

In this paper, Single Input Adaptive Noise Canceller (SIANC) is proposed to enhance a heart sound by reducing breath sounds in a cardiac auscultation sound. The Adaptive Noise Canceller (ANC) needs basically multi-channels [1],[2], a primary signal and a reference signal, a stethoscope can provide just one input sound. So, the proposed SIANC employs a single input and the reference signal was generated by proposed reference signal generating system. By comparison using Adaptive Line Enhancer (ALE), it was confirmed that the proposed SIANC can effectively enhance a heart sound in an auscultation sound.

Yunjung Lee is with Dept. of Medical & Biological Eng., Graduate School, Kyungpook National University, Korea (e-mail: whitegleam@paran.com).

Pil Un Kim is with Dept. of Medical & Biological Eng., Graduate School, Kyungpook National University, Korea (e-mail: piluny@knu.ac.kr).

Gihyoun Lee is with Dept. of Medical & Biological Eng., Graduate School, Kyungpook National University, Korea (e-mail: gihyounlee@gmail.com).

Jin Ho Cho is with Dept. of Biomedical Eng., School of Medicine, Kyungpook National University, Korea (e-mail: jhcho@ee.knu.ac.kr).

Myoung Nam Kim is with Dept. of Biomedical Eng., School of Medicine, Kyungpook National University, Korea (corresponding author to provide phone: +82-53-420-5266; fax: +82-53-420-5539; e-mail: kimmn@knu.ac.kr).

## II. The Proposed Single Input ANC (SIANC)

ANC removes noise in a reference signal which is similar to the original noise. An adaptive filter is a transfer filter that is time varying and self-adjusting by adjusting the filter parameters for desired response [1]. By the stethoscope, only one signal can be acquired at a time. So, it is hard to apply ANC to the stethoscope because it needs two input signals. So, the proposed SIANC used the reference generation system which generated a reference signal using a primary signal. The reference generation system included Heart Sound Detector, Control, and Reference Generator. A Heart Sound Detector was based on properties of heart sound. Heart sounds are periodic and the amplitude of heart sound is larger than the others in an auscultation sound. A Heart Sound Detector estimated heart sound in the primary input by analyzing the variation of the maximum in the fixed section. A Control was used to control the transference of a primary input. The Control stopped transference of the primary input and transferred the replacement signal from the Reference Generator, when heart sound was estimated. So, the heart sound could be excluded in the output of Reference Generator.

Heart sound ($h$) is generated when a heart beats. An auscultation sound can be divided into two as a heart sound part and a noise part. A heart sound part involves first heart sound, second heart sound, and noise. A noise part involves only noises such as a breath sound. A noise part can be replaced with the reference signal in ANC because it is correlated with breath sound ($b_0$). If a noise part is uncorrelated with primary input, the SIANC could be designed as shown in Fig. 1.

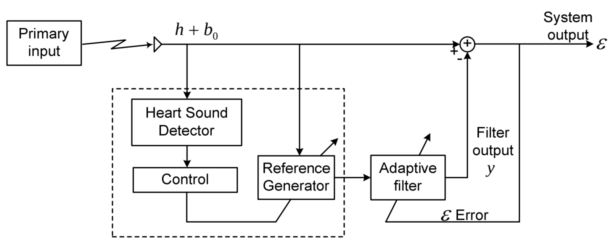


Fig. 1 The proposed Single Input ANC (SIANC)

Let $x(k)$ and $x_{max}(k)$ be the primary input and the maximum in the fixed section $L$, respectively,

$$x_{max}(k) = \max(|x(n)|^2), \quad k - L \le n \le L \tag{1}$$

where, $L$ is 256 samples. Equation (1) shows that $x_{max}(k)$ is affected by the intensity of the input. $x_{max}(k)$ is slightly changed in a noise part, unlike an auscultation sound which is usually stable. But, when a heart sound is generated, $x_{max}(k)$ is rapidly raised. Let $E_{max}(k)$ be an expectation of $x_{max}(k)$ within a period $M$,

$$E_{max}(k) = \frac{1}{M}\sum_{n=k-M}^{M} x_{max}(n) \tag{2}$$

where, $M$ is 256 samples. Equation (2) shows that $E_{max}(k)$ is less affected in transition of amplitude than $x_{max}(k)$ because it is based on mean of $x_{max}(k)$. Therefore, although the amplitude of $x_{max}(k)$ is rapidly increased when a heart sound is generated in an auscultation sound, it is possible to detect a heart sound by $E_{max}(k)$. Refer to (3), the control signal $S_{cnt}(k)$ is generated by

$$S_{cnt}(k) = \begin{cases} 0, & \text{if } x_{max}(k) > E_{max}(k) \\ 1, & \text{otherwise} \end{cases} \tag{3}$$

Finally, the reference signal can be generated by excluding a heart sound and replacing it with the output of Reference Generator.

## III. Experiment

Equipments for acquisition of auscultation sound were BIOPAC MP36 and Electric Stethoscope [3]. The sound acquisition point was on a left parasternal 2nd intercostalspace. The measurement time was ten seconds, the bit rate was 16 bits, and sampling frequency was 10 kHz.

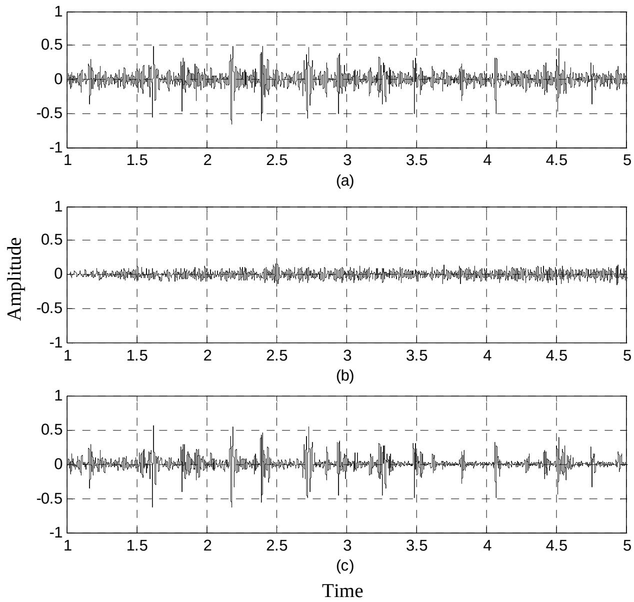


Fig. 2 One of experiment results (a) original sound (b) reference signal generated the proposed method (c) output signal

Fig. 2 shows one of experiment results. An original auscultation sound shows in Fig. 2 (a).

As shown in Fig. 2 (b), the output of the reference generator excluded a heat sound. Fig. 2 (c) shows the output signal of which most of breath sounds and noises were suppressed by SIANC.

Actually, if an original signal with periodic noises was periodic and its frequency was known, ALE, which has a single input, could effectively suppress noises [1],[4]. Therefore, heart sound can be enhanced by ALE. But ALE is not suitable to enhance a heart sound, because heart beat rate changes rapidly. Fig. 3 shows comparison result. The primary input, shown in Fig. 3 (a), was mixed signal. The signals were the cardiac sound measured from the aortic valve and the pulmonary sound of auscultation database for a clinical education. The heart rate of cardiac sound was 80BPM. Fig. 3 (b) shows the output of ALE when the delay of ALE was 0.75 second which was same with the heart rate. Fig. 3 (c) shows the output of ALE when the delay of ALE was 1 second which differed from the heart rate. As shown in Fig. 3 (b) and (c), the output of ALE was affected by the heart rate. But the output of the proposed SIANC was stable regardless of heart rate as shown in Fig. 3 (d).

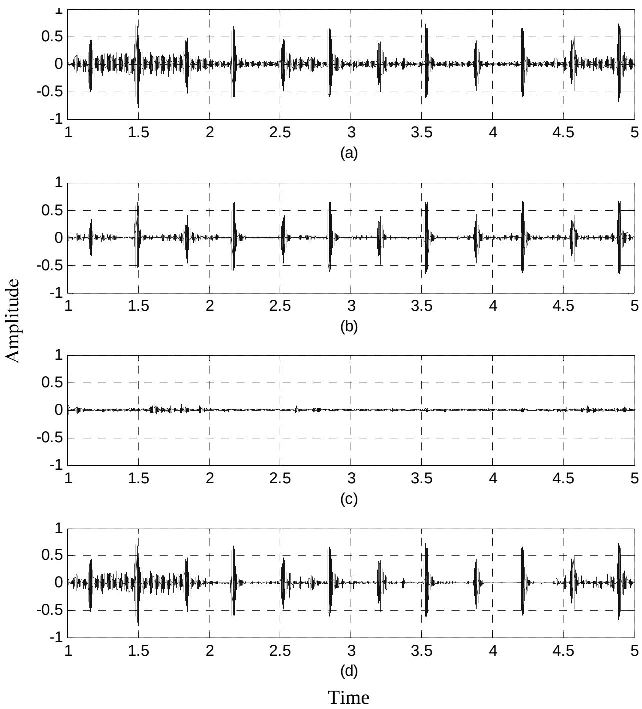


Fig. 3 Comparison result (a) primary input (b) output of ALE when the delay was 0.75 second (c) output of ALE when the delay was 1 second (d) output signal of the proposed SIANC

## IV. Conclusions

In this paper, SIANC was proposed for suppression of a breath sound in an auscultation sound. To modify the ANC based on two-channel input, a reference signal was generated from the primary input signal by the proposed reference generation system. By experiment, it was confirmed that

SIANC efficiently removed noises. Also, the performance of SIANC was better than it of ALE. Moreover architecture of proposed method is simple so it is easy to implement in mobile. Therefore, it is expected that SIANC is widely used in various portable devices for elder people and patients who need to continually observe a heart condition and monitoring emergency.

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