

# Distant Auscultation System for Detecting Lung Sounds of Patients on Ambulances

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**Abstract**—The sound of the siren of the ambulance is for the safety of the road transportation, but interferes the auscultation of the lung and heart sounds. The system implementation is included by (1) ACER Aspire 17 notebook as a server in right side; (2) HwaWei Amazing A6 smart mobile as a hot point in the middle; and (3) ACER Aspire 5 notebook as a client which the settings include IP address of host computer, and client, read and, write privileges of the data sockets, and running of NI data socket manager, and data socket server. Therefore, the parameters in the real-time DAS are verified as the better ones to prepare for the services on the ambulance.

**Keywords**—ambulance, respiration, lung sound, adaptive filter, distant healthcare

## I. INTRODUCTION

The sound of the siren of the ambulance is for the safety of road transportation, but interferes the auscultation of the lung and heart sounds. Auscultations of lung sound and heart sound are traditional schedules of the diagnosis of the medical doctors. The auscultation of the lung sounds can detect some respiration disorders, such as bronchial asthma, and paralysis of breathing muscles, and of heart sounds can find the blood vessel disorders, such as atherosclerosis, aneurysm, and phlebitis. Furthermore, the disorders of other organs or systems influence the lung and heart sounds can be traced by the primary auscultation of the patients in the emergency which can give a direct diagnosis which can guide the preparations of the advanced therapies or diagnoses [1]. Consequently, the design of the filter for the siren sound

cancellation to disclose the original heart and lung sounds is a crucial issue in the emergency medicine.

The designs of modern filters included adaptive filters [3-5], wavelet transform [2, 5-9], artificial neuron network (ANN) [10-14], and so on. However, that the signal processes are all in the time domain presents the advantage of the adaptive filters. In the modern internet or mobile communication, the operation systems handle the multi-task, and always open many programs for the conveniences of the users, and the necessary connected servers. Therefore, the adaptive filter is one of the better solutions for the noise cancellations of the sounds of sirens on the ambulances. The computing performance has been proved in the simulation of Lu et al.s' study [15] which pointed out that the adaptive filter algorithm was presented much traditional analytic and simple. In addition, the study indicated that the application of the traditional adaptive filter to reduce the interference of the sound of sirens (audible warnings) of the ambulance in simulations. Therefore, the system design and implementation of the distant auscultation system (DAS) in this study is referred to the parameters of the previous study [15].

## II. METHODS

The NI LabVIEW system which integrates any hardware with extensive analysis and signal processing libraries is employed to design the system in this study, because the measurement or control systems can be built by using the advantages of performing signal processing and custom analysis within the integrated development environment of NI LabVIEW system design software [16]. The build-in NI data socket is convenient to the client-server internet applications

for the distant auscultation. This DAS is constructed by the LabView 2013.

The functional block diagram is presented in Fig. 1. The client-server internet application is employed in the system which the subsystem on the ambulance performs as a server, and the subsystem in the emergency centers do as clients to satisfy the possibility of the multiple accesses of the target signals.

This electronic stethoscope (3M™ Littmann® Electronic Stethoscope Model 3200) allows the user to select between three different digital frequency filters which are Bell mode, Diaphragm mode, and Extended Range mode to better emphasize the specific patient sounds of interest [17]. Therefore, this electronic stethoscope was the input device of the distant auscultation system.

The server and client can be selected by the switch in the front platform of LabView. A notebook has to set NI DataSocket Server Manager, then run the manager program to be a server on the ambulance. The host IP address should be set, and connected by the clients in the emergency centers. The lung sound was sampled by 8 KHz of frequency, and transmitted as the form of data sockets.

The other notebook was set as a client, connected with the server by setting the server host IP, and received the data sockets whose original information was the lung sound. This client-server structure makes the other clients in other emergency centers can concurrently receive the lung sound auscultation on the same ambulance to cooperate the diagnoses.

The adaptive filter which based on the computation of statistics and weightings is a traditional and efficient method for the noise cancellation. LMS (least mean squares) algorithm which can be employed without complex matrix operations supports the method of cost function optimization in the adaptive filter [18].

The computation procedures of LMS adaptive filter are presented as follows:

Step 1: Computing the output signal  $y[n]$  by using the following equation,

$$y[n] = \hat{w}^H[n-1]u[n] \quad (1)$$

Step 2: Calculating the error signal  $\varepsilon[n]$ ,

$$\varepsilon[n] = d[n] - y[n] \quad (2)$$

Step 3: Updating the filter coefficients as follows,

$$\hat{w}[n+1] = \hat{w}[n] + \frac{u[n]}{\alpha u^H[n]u[n]} \mu \varepsilon^*[n] \quad (3)$$

where  $n$  denotes for the current iteration;  $u[n]$  denotes for the buffered input samples at step  $n$ ;  $\hat{w}[n]$  represented for that the vector of filter-tap estimates at step  $n$ ;  $N$  is the number of the weighting tap;  $\alpha$  is a coefficient;  $y[n]$  represents for the filtered output at step;  $\varepsilon[n]$  is for the estimation error at step  $n$ ;  $d[n]$  is for the desired response at step  $n$ ; and  $\mu$  is the adaptation step size.

### III. RESULTS

The front panel of the server was presented in Fig. 3. The testing lung sound was shown in the panel simultaneously. The sampling rate, number of channel, and bit per sample are all adjustable. The IP should be set in advance by following

the specific processes for the connections of all of the clients, and the lung sound transmits in the form of data sockets to the clients.

The front panel of the client was presented in Fig. 4. The testing lung sound can be output as (a) the original sound; (b) the sound has been processed by low pass filter; and (c) the sound has been processed by adaptive filter; which the sounds can be totally selected to record by a bottom. The sampling rate, number of channel, and bit per sample should be followed with the parameters of server.

The implementation of the adaptive filter is presented in Fig. 5. The design is referred to the previous simulation [15]. To achieve the clearer sounds of auscultations, the lower order of low-pass filters are frequently inserted in the stethoscopes to reduce the higher frequency environmental noises. In the adaptive filter, the parameters which  $N = 64$ , and  $\alpha = 0.05$ , have been tested as a better parameters for the noise cancellation. Therefore, the settings of the implementation of the LabView graphical program are cited by the results of the simulations [15].

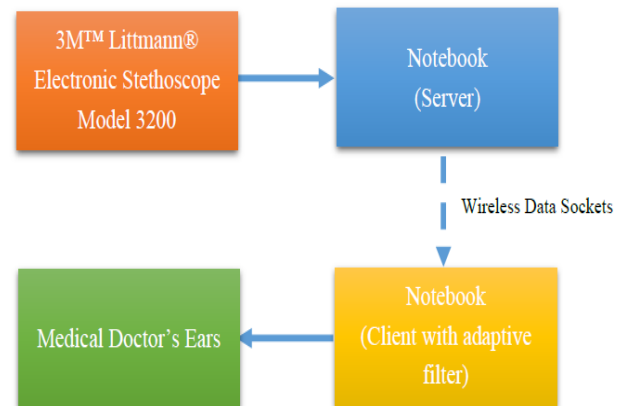


Figure 1. The functional block diagram of the distant auscultation system (DAS)

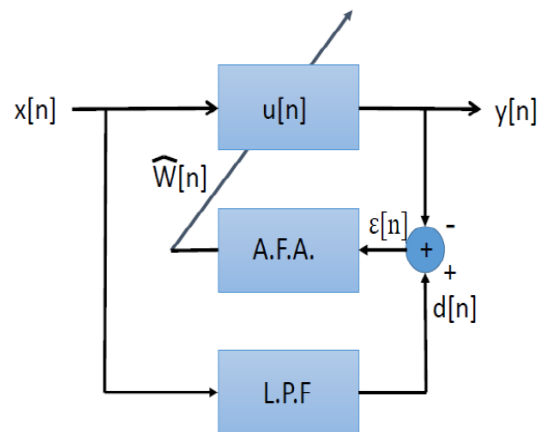


Figure 2. The block diagram of the adaptive filter. (A.F.A: adaptive filter algorithm; L.P.F: low-pass filter)

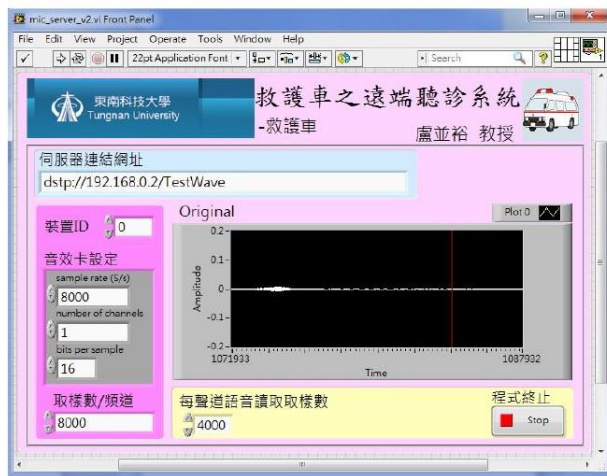


Figure 3. The front panel of the server



Figure 4. The front panel of the server

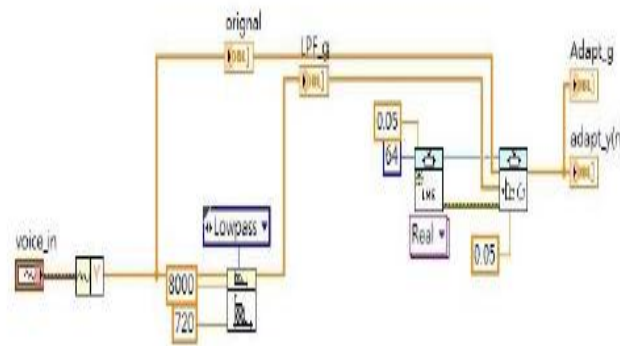


Figure 5. The front panel of the server

#### IV. DISCUSSIONS

The real-time DAS has been realized by using NI LabView graphical programming language to reduce the noise of siren on the ambulance. However, the settings of the parameters are not short. Fortunately, all the settings can be saved which supports the possibility of the one-touch for running all of the processes. The results of the DAS have shown the performance of the system, and disclosed the following discussions, and examinations,

In 2015, Lu and Wu [17] have proposed a real-time mobile-communication auscultation (RMA) system to deliver the lung sound by using the mobile telecommunication system. The RMA is very easy to use, especially the elders, because of the processes is the same to phone by smart phone. However, the insertion of the filtering algorithm in the real-time telecommunication mode is not easy to realize, but can be modified to connect the notebook of the operating model of DAS in this study. It is very possible to employed on the ambulance, because of the mobility of the ambulance will change the IP settings in DAS, and make some problems in programming, and in applications in the real world. Therefore, the telecommunication can avoid the mistake, and deliver the sound data to the emergency centers very smoothly. Reversely, the expenses of DAS, and RMA are quite different. DAS is free, but RMA is not, which is reason that DAS is necessary to develop for the free services of the internet communications.

The telecommunication system is feasible to access the sound signals, especially the mobile communications. Therefore, the possible solution is to implant the adaptive filter in the mobile. However, this is the other path of the distant auscultation. The approach will be presented in the other study of the research group.

#### V. CONCLUSIONS

A real-time DAS has been realized to reduce the noise of siren on the ambulance. The procedures of signal processing is rapid, and reduces the noise of siren efficiently. That the NI data socket server supports the conveniences of the data communication in the internet applications is the most crucial mean of this study. The reduction of the siren noise by the real-time adaptive filter is close to the simulation in the previous study [15]. Therefore, the parameters in the real-time DAS are verified as the better ones to prepare for the services on the ambulance.

Because auscultations of lung sound and heart sound are traditional schedules of the diagnosis of the medical doctors, the adaptive filtering provided the possibility of the clear auscultation. Furthermore, the sound of the siren of the ambulance is for the safety of road transportation. It can be employed as usual, but the interferences of the auscultation can be much reduced.

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