Real-time Mobile-to-Mobile Stethoscope for Distant Healthcare

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***Abstract*-This study presented to insert a small-scaled microphone of the ear-set of a smart mobile (Amazing A6, Taiwan MobileTM) into an eartip of the stethoscope, the sound can be transmitted by the mobile when it dialed to another phone or mobile. In this study, we employed another smart phone (Galaxy R GT19103, SamsungTM) to be the receiver. The results were showed by spectrogram which demonstrated the components of frequencies of the sounds. Finally, we proposed to improve the study by database.**

***Keywords*— acoustic signal, lung sound, heart sound, mobile, smart phone., distant healthcare.**

I. INTRODUCTION

The real-time distant healthcare is always crucial to the patients, especially, to detect the heart and lung sound. The first stethoscope was invented by a French physician, Rene Laennec, in 1816 [1]. The purpose of auscultation is to listen to sounds inside the body. The auscultatory locations are heart, lungs, gastrointestinal tracts and so on. Therefore, auscultation can detect the physiological sounds from circulatory, respiratory, and digestive system. Doctors follow the standards of procedures of auscultation for diagnosis.

Wheezes are continuous and audible. Wheezes are due to airway wall oscillations or bronchus narrowing generated by. The word, continuous, means that the wheezes durations are longer than 250ms and the frequencies of 200Hz [2]. The new definition of the present CORSA guidelines, dominant frequency of wheezes is 100 Hz greater and the duration 100 ms or more [3]. Rhonchi are defined as low pitch continuous sounds with a dominant frequency of about 200Hz or less. Some investigators have proposed that the term rhonchi should be abandoned and modified to use only low pitch wheezes [4,5]. The conditions related to wheezes includes bronchospasm, airway thickening caused by mucosal swelling or muscle hypertrophy, inhalation of a foreign object, tumor, secretions, or dynamic airway compression [6]. Wheezes may be monophonic or polyphonic. Severe status asthmatics patients could be heard the wheezes random monophonic.

Many persons have a fancy for the modern smart phone, such as Galaxy Note III (Samsung), New One (HTC), iPhone 5 (Apple),and so on, because there are so many new applications(APP) in the new generation of the smart phones. Based on the new wireless communication technologies which included blutooth technology, the 3 or 4 G mobile communication system, and modern electronic stethoscope, we developed a mobile based real-time stethoscope (MBRS) for distant healthcare to improve the convenience of the real-time auscultation for the patients.

Fig. 1. the block diagram of the MBRS.

II. Method

Figure 1 presented the block diagram of the MBRS. The input was the electronic stethoscope (3MTM Littmann® Model 3200). The stethoscope was designed by the technologies of ambient noise reduction, frictional noise dampening, electronic amplification, Bluetooth® data transfer, and all-new user interface. The detected sound can be transferred by the Bluetooth® wireless technology to the computer which needed to install the computer software "StethAssist" (3MTM Littmann®) to show and save the visualized sound signals. We inserted a small-scaled microphone of the ear-set of a smart mobile (Taiwan mobileTM, Model: Amazing A6) into an eartip of the stethoscope, the sound can be transmitted by the mobile when it dialed to another phone or mobile. In this study, we employed another smart phone (Galaxy R GT19103, SamsungTM) to be the receiver. If the receiver was embedded a real-time recorder which might be a circuit or a computer software, the detecting sounds can be saved for the further analysis.

As we know, the calibration always needs a golden standard to be the comparison of the measured signals. However, the real heart, and lung sounds are not easy to be defined, so we take the reliability of the well-known brand of the 3MTM Littmann®, and the modern Bluetooth® data transfer technology to define the real sound from chestpiece. The spectrogram is a convenient tool for speech recognition [7,8]. The same applications can be employed in the respiration acoustic signals. In general, the spectrogram can be presented as:

$$\boldsymbol{I}(\boldsymbol{k},\boldsymbol{f})=\sum_{k=0}^{\left\lceil \frac{T}{\ell-t_o}\right\rceil}\boldsymbol{\mathcal{SF}}\left(\boldsymbol{s}^2(\boldsymbol{\tau})\left[\boldsymbol{u}(\boldsymbol{k}\boldsymbol{\ell}+\boldsymbol{t_o})-\boldsymbol{u}\big((\boldsymbol{k}+\boldsymbol{1})\boldsymbol{\ell}+\boldsymbol{t_o}\big)\right],\boldsymbol{\ell},\boldsymbol{t_o},\boldsymbol{F},\Delta\boldsymbol{f}\right) \qquad (1)$$

where k denotes the time in the spectrogram, f is frequency, and I is the intensity of the signal spectrum. $\boldsymbol{\mathcal{SF}}(s,\boldsymbol{\ell},\boldsymbol{t_o})$ represents the short-time Fourier Transform (STFT) of the signal s of the length $\boldsymbol{\ell}$ with the overlapped length $\boldsymbol{t_o}$, and T for the length of the signal s. F is the maximum frequency of STFT. $\Delta\boldsymbol{f}$ is the frequency resolution of the spectrogram. The diagram of the spectrogram is an alignment of individual components of I (k,f) , where the X axis represents k, the Y axis represents f, and the Z axis represents I.

III. Results

Figure 2 showed the experimental devices of this study. A microphone inserted in the one of the eartubes of the electronic stethoscope (3MTM Littmann® Model 3200) to send the sound to the mobile (Amazing A6, Taiwan

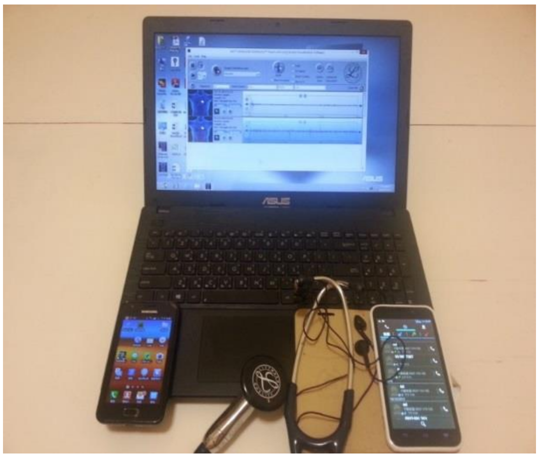

Fig. 2.The transmitter of the system.

MobileTM). Concurrently, the digitalized data of sound was transferred to the notebook (X551, ASUSTM) which was installed computer software "StethAssist" (Littmann®, 3MTM) to show and save the visualized sound signals in time domain. The wave shape, and its spectrogram of the lung sound was shown in Fig.3, and Fig.4 which were the cases of normal subject and getting cough subject, respectively. From the differences of the two cases, we can ensure the reliability of the system. The spectrogram in Fig. 4 presented the higher frequency components were more than that in Fig. 3. If fact, the subject in Fig. 4 has gotten a cold. He had a headache, and a running nose. By the signal transmission, the heart and lung sound can be listened by the receiver of smart phone (Galaxy R GT19103, SamsungTM). The quality of the sound can be improved by listening of using the earphone which was the original auxiliary of the smart phone.

IV. DISCUSSION

An excellent stethoscope can aid the doctors to detect the problems of hearts or air ways of the patients. However, the abnormal sounds are not always occur. When the patients go to hospital, their chief complains were frequently described by the histories of their daily-life. This system of this study supports the possibility of the real-time diagnosis to enhance the precision of the auscultation.

The electronic stethoscope amplified the detecting sound with high fidelity by electronic amplifiers. Although, we heard the sound aloud, the quality of the sound was guaranteed. This is the key device of this study. Because the heart, and lung sounds can aid the diagnosis of cardiac murmur, mitral regulation, wheeze, and other cardiovascular and respiration diseases. The sampling rates of the whole communication processes were listed as follows: The electronic stethoscope was 4 KHz of sampling rate, and the mobile communication was 8 KHz of sampling rate. In our

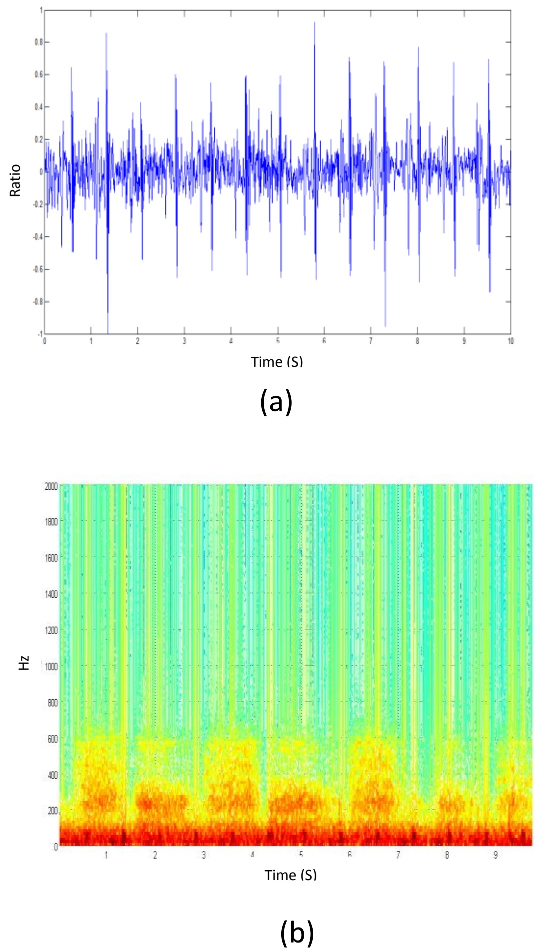

Fig 3. Normal subject: (a) the recorded lung sound, (b) corresponding spectrogram

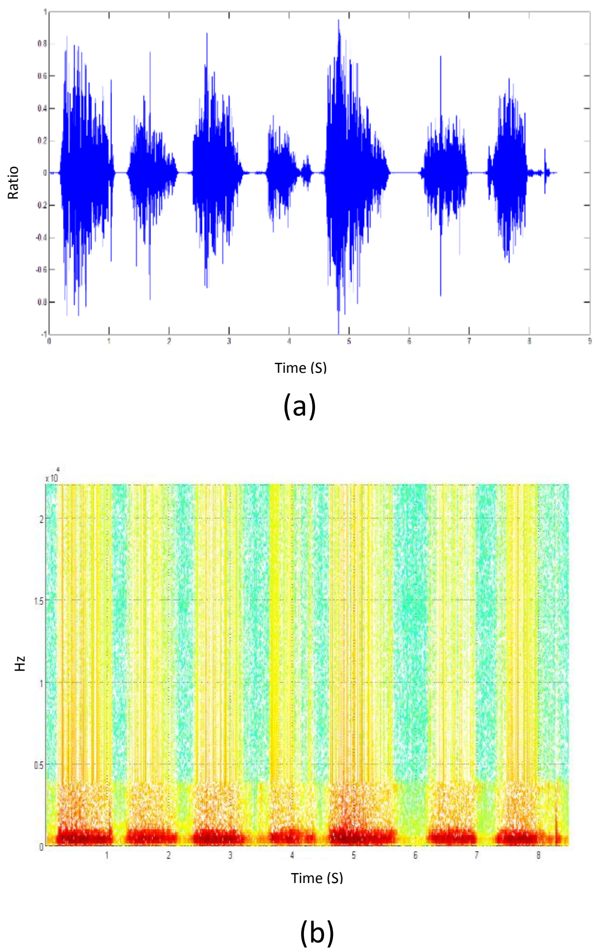

Fig 4. Having a cold subject: (a) the recorded lung sound, (b) corresponding spectrogram

previous studies [8-11], the theoretical proof was performed by Fourier transform, as well as the statistical analysis was operated by computer simulation to achieve the box plot of the root-mean-square (RMS) errors from 100 trials for each variable. The sampling rates were 44.1(Group 1), 22.05(Group 2), 11.025(Group 3), 5.5125(Group 4), and 2.76125(Group 5) KHz. The statistical results were presented in Box-and-Whiskers display. The input signals were sine waves whose amplitude was equal to 1, and frequencies were 200, 400, 600, 800, 1K, 1.2 K, 1.4 K, and 1.6 KHz. The signal-to-noise ratios (SNR) were 30 dB for the subjects of normal breath, and 35 dB for that of wheezing. In summary, we propose the 11.025 KHz to be fixed sampling rate for noise reduction of wheezing sound recording, and time-variant adjusting sampling rate for the optimal noise cancellation. By the way, the 8 KHz sampling rate of telephone and VoIP has been evaluated to record wheezing sound well. The sampling rate of the study was identified and supported the results of our previous studies [8-11]. In addition the reasons of noises in physiologic signals are usually band-limited, therefore, the optimal sampling frequency can be used to simplify the system design.

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The signals in Fig. 3, and 4 had been verified by medical doctors of the authors of this study. The confirmed that the sound is good enough for distant application. In this study the electronic stethoscope was seriously selected for a precise acoustic signal to test the experimental system.

V. CONCLUSION

This distant electronic stethoscope is a very good tool for the health care. Based on the tests, we believe that the system is reliable. The system can be improved by the management of database for the hospitals' business model. Therefore, our study will invite the medical doctors to authorize the quality of sounds, and will build a server to manage the sound files.

ACKNOWLEDGEMENTS

The authors thank for the valuable comments from the reviewers and the supports from the project numbers of NSC101-2221-E-562-004, and NSC102-2627-E-002-005, National Science Council, Taiwan, Republic of China.

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