Development of Electronic Stethoscope Analysis System for Early Diagnosis of Pneumonia

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Abstract: This paper is to descript an electronic stethoscope analysis system for early diagnosis of pneumonia by measuring the respiratory sounds. Firstly, a chest piece, microphone and IC recorder are integrated as an electronic stethoscope for respiratory sound acquisition. The characteristic sounds of pneumonia are mainly coarse crackles, fine crackles, wheeze and rhonchi. Especially the coarse and fine crackles are difficult to auscultation with stethoscope even by young doctors and nurses. A high accuracy analysis method of respiratory sound for the diagnosis of pneumonia based on the frequency slice wavelet transform (FSWT) analysis technique is proposed. This system will be useful for home healthcare and convenient for not only physicians but also general users.

Key-Words: *Respiratory Sounds Analysis, Electronic Stethoscope System, Pneumonia Sounds, Coarse and Fine Crackles*

1. Introduction

With the rapid development of aging society, the medical care facilities will not be able to meet the demand [1], especially, in China-Japan-Korea. Therefore, the urgency need is to establish the healthcare system which associated with medical care facilities or in-home healthcare.

Respiratory sound auscultation with a stethoscope is routinely performed in clinical practice. Adventitious sounds auscultation play an important role in the diagnosis of bronchial asthma and pneumonia [2]. However, the effectiveness of this method depends on the physician's training. If the adventitious sounds could be recognized or diagnosed with the support of computer software analysis technique, the above problems will be solved. Thus, this paper is aimed to develop an electronic stethoscope analysis system for early diagnosis of pneumonia by measuring the respiratory sounds.

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2. System and Results

2.1 Development of electronic stethoscope

In order to take an advantage of stethoscope as a high-quality home medical and health care instrument, an electronic stethoscope which is composed of an IC recorder, a microphone and a chest piece with tablet/smartphone is developed (Figure 1). Since the high sensitive microphone and IC recorder can be bought in market the device will be easily built with low cost. The cardiopulmonary data is transmitted to cloud server for deep analysis and learning so that the hospital or home care center could auscultate through internet.

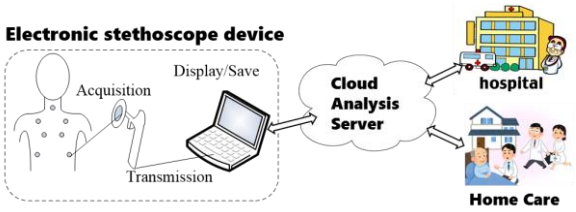

Figure 1 Electronic stethoscope device and cloud analysis remote auscultation system for home care use.

2.2 Respiratory sound analysis

Respiratory sound are non-stationary signals, which makes them both difficult to analyze and hard to distinguish when using traditional auscultation methods, Therefore, the use of an electronic stethoscope together with a analysis system helps to overcome the limitations of traditional auscultation, providing an efficient method for clinical diagnosis [3].

Lung sound are classified as normal or adventitious (abnormal), the time-frequency characteristics of adventitious sounds show the important pathologic information for pneumonia diagnosis, thus, in this study, FSWT [4], which can provide a flexible split frame of time-frequency representation is proposed. For any $s(t) \in L^2(R)$, the Fourier transformation of a window function $p(t)$ exists, and the FSWT is simplified as:

$$W(t,\omega,\sigma) = \frac{1}{2\pi}\int_{-\infty}^{+\infty} \hat{s}(u)\hat{p}^*(\frac{u-\omega}{\sigma})e^{iut}du \qquad (1)$$

where, the scale $\sigma \neq 0$ is a constant or a function of ω and t, in this study, $\sigma=\omega/10$, and the star '*' means the conjugate of a function (the following is same). Here we call ω and t the observed frequency and time, and u the assessed frequency. $\hat{p}(\omega)$ is also called frequency slice function. The original signals of wheeze, rhonchi, coarse and fine crackles and their FSWT results are showed in Figures 2-5. Based on FSWT analysis technique the continuous lung sounds (wheeze, rhonchi) and discontinuous lung sounds (coarse and fine crackles) can be discriminated easily by auscultation with the aid of the image as shown in the figures.

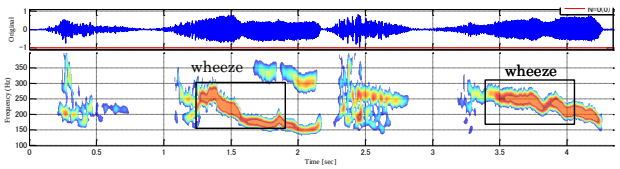

Figure 2 Original signal and FSWT of Wheeze.

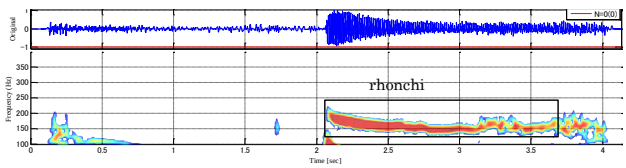

Figure 3 Original signal and FSWT of Rhonchi

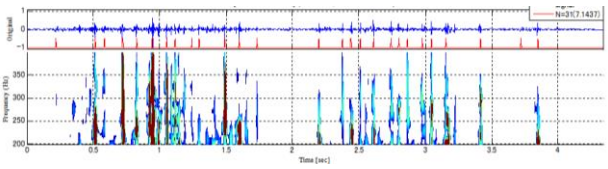

Figure 4 Original signal and FSWT of Coarse Crackles.

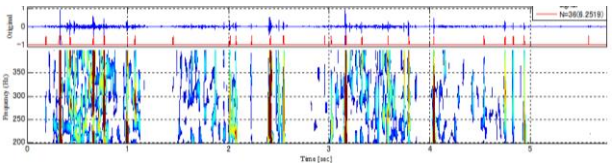

Figure 5 Original signal and FSWT of Fine Crackles

3. Conclusion

The electronic stethoscope and analysis system was developed. The electronic stethoscope can get the high-quality sound data and is very convenient to use at home. Further, the FSWT analysis technique was proposed to obtain the time and a frequency characteristic which is closely related with pneumonia diagnosis. This home health care system is verified to be useful and convenient for not only physicians but also general users.

Acknowledgments

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