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Analysis of Pulmonary Diseases Using Genetic Programming

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Abstract:

Pulmonary sounds have information about diseases. Sound signal processing can be considered as a helpful tool for physicians in diagnosis. Since it is necessary to filter environmental sounds and other body sounds, analog filtering is necessary. The first step in this study is analog filtering. Then, the band including disease information is preserved by digital filtering. The spectrum obtained by applying fast fourier transform (FFT) is processed using genetic programming method. A classification is done using different disease information.

Keywords: lung sounds, signal processing, classification, asthma

INTRODUCTION

Auscultation of lung sounds is a simple and important way of diagnosis of pulmonary diseases. [1]. This type of listening gives direct information about the system and diseases [2-7]. The stethoscope used by the physicians has some advantages and disadvantages such that it is simple, cheap, however it depends on experience, there is no record and it filters sound signals higher than 120 Hz. Human ear is not too sensitive for sound signals lower than 120 Hz. Pulmonary sounds extends to 2000 Hz [8]. The developments in electronics and computer methods and technology enhanced usage of different methods in pulmonary sound analysis. Power spectrum and effects of signal acquisition type using FT [9-13], comparison of FFT and Autoregressive method, [14], Shabtai-Musih algorithm [15], spectrum and spectrogram analyses [14,16], sonogram [17], Gaussian mixture models (GMW) [18,19] and cepstral analysis approach [20], wavelet transform method [21,22] and artificial neural networks (ANN) is used for classification [21]. Continuous wavelet transform [23] and linear regression analysis normal sounds [24], for classification ANN [24,25], multi layer perceptron, radial based function network, to reduce highly indefinite predictions constructive probable neural network [26] are used. A circuit designed for acquisition of sound signals is used and a classification is performed using ANN [27-29]. Genetics programming (GP) which is an extended version of genetics algorithm can also be used in addition to these methods [30]. In this study, lung sound will be classified using genetics programming.

MATERIALS AND METHODS

This section consisted of signal acquisition and processing, and application of genetic programming.

Signal Acquisition and Processing

A circuit was designed and realized for lung sound acquisition (Figure 1) [27]. The circuit was composed of a battery, an amplifier, a band pass filter of 14th order, final amplifier and switching filter. A Sony ECM T150 microphone was used for input device. Environmental sounds, hearth and muscle sounds were analog filtered with this circuit. Then digital filtering was applied to the sound signals. The filtering process filtered the signals whose frequencies lower than 100 Hz and higher than 2000 Hz. Later, the signals were divided and grouped as inhalation (breathing in) and exhalation (breathing out). Spectrum of frequencies was obtained by using FFT analysis. Since the file generated by sound signals was too big and FFT only decreased it to its half, it was necessary to decrease the size of the file by finding averages of frequency values section by section.

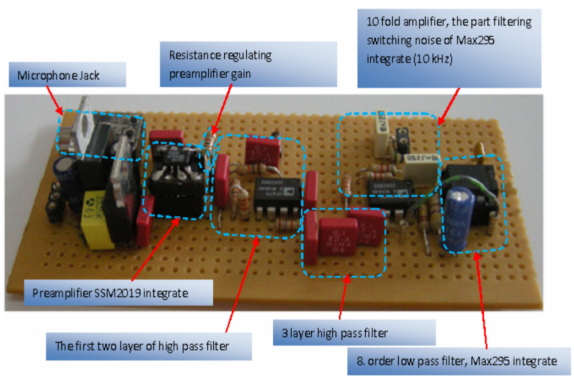
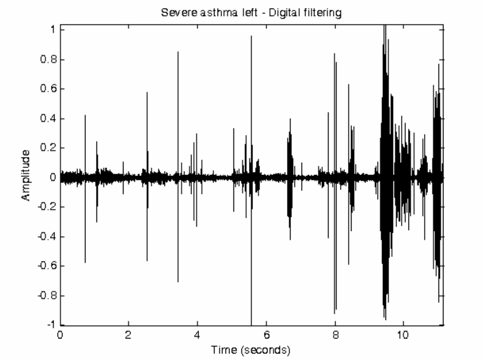


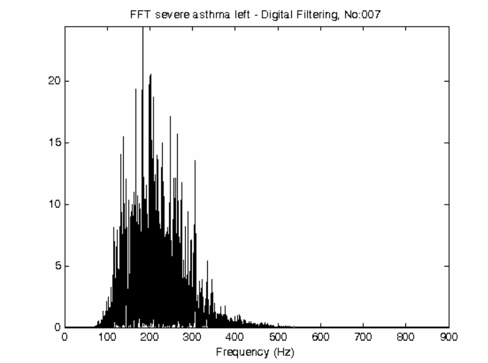
Figure 1. The circuit designed and realized for sound acquisition

Sound signals were recorded from patients with severe asthma (1), moderate asthma (5), mild asthma (1), and three apparently normal subjects. The sound signals were obtained from the back, right and left. After analog and digital processes, the signals were separated and recombined as inhalation and exhalation sound signals. Consequently 40 sound signals belonging to 10 persons were obtained.

Some examples for sound signals and processed ones were given here. In Figure 2, filtered signal for severe asthma (a) and its FFT (b) was depicted. In Figure 3, inhalation signal (a) and exhalation (b) was shown. FFT of these signals was shown in Figure 4. It was not easy to process these signals due to their huge size (about 100.000 data). FFT decreased this value to 50.000 data. Since the GP program used in this study had some limitations and also it was unnecessary to use all frequencies at the same time, the data was decreases by taking averages in different intervals.

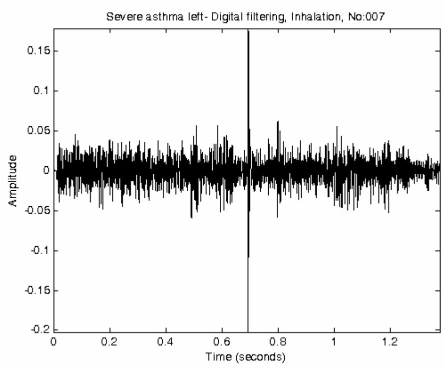


(a)

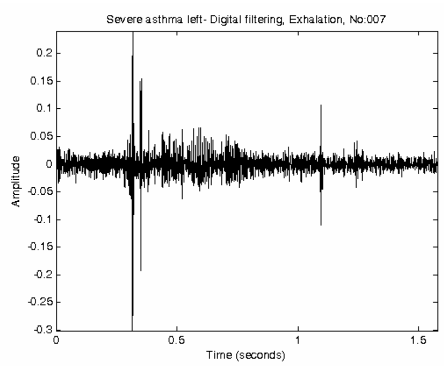


(b)

Figure 2. Sound signals for severe asthma (a) and FFT (b)

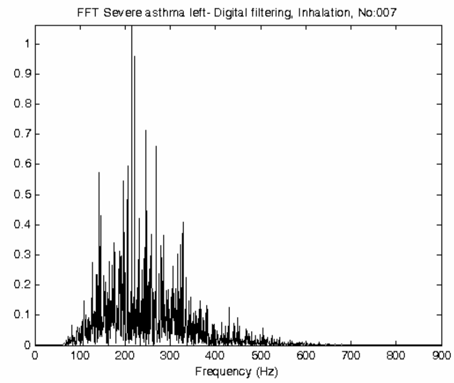


(a)

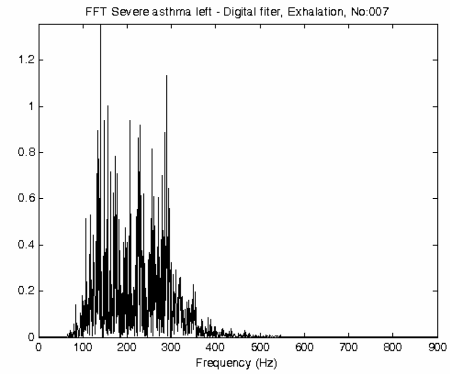


(b)

Figure 3. a) Inhalation, b) exhalation sound signals



(a)



(b)

Figure 4. a) Inhalation, b) Exhalation FFT's

Application of Genetics Programming

Genetics algorithms (GA) was proposed by Koza and Genetics programming is an extension to it. Genetic programming is a domain-independent method. It genetically breeds a population of computer programs to solve a problem. This problem is based on reproduction and survival of the fittest. It is similar to naturally occurring genetic operation, e.g. crossover and mutation. The steps are defined by Koza [30], and an example is given by Arslan can be found in reference [31].

In this study a classification of sound signals was performed using GP. Four samples which belong to left, right, inhalation and exhalation signals of a patient were entered to the program. In the database, there were 10 different patients; there were 7 patients with asthma, 3 apparently normal subjects. The training data set consisted of (8 patients * 63 data) 6 asthma and 2 normal people. Test data set consisted of (2 patients * 63 data) 1 asthma and 1 normal person. As a result, the training set consisted of 32 sets, test set consists of 8 sets. The parameters used in GP were given in Table 1. The data set was divided into two as the training set and the test set. The results were presented in Table 2. In Table 2, sensitivity is the ability of the classifier to measure disease; specificity is the ability of the classifier to measure normal.

Table 1 The parameters used in GP

P1	Number of generation	3000- 20000
P2	Function set	+,-,*,/
P3	Chromosome	30-55
P4	Number of genes	3, 4, 5, 6, 7, 8
P5	Head size	8, 10, 15
P6	Connectivity function	+,*
P7	Mutation rate	0,044

Table 2- Statistical parameters for training and test set

Statistical parameter	Training set	Test set
Accuracy	100%	87.5%
Sensitivity	100%	100%
Specificity	100%	75%

RESULTS AND DISCUSSION

In genetics programming method, the training set is classified by 100% success rate and the test set is classified by 87.5% success rate as shown in the statistical parameters given in Table 2. The mean square error (MSE) and mean absolute error (MAE) are used to show the convenience of the desired output and obtained values. MSE value for the test set is 0.125 and MAE value is 0.125. MSE and MAE values for the training set are 0.

CONSLUSION

In this study genetic programming is used to analyze lung sounds. The sound signals are acquired from people with asthma and normal subjects. Firstly the signals are analog prefiltered, then digitally filtered. This processes filters environmental, hearth and muscle sounds. Later, the signals are grouped as inhalation and exhalation sound signals. Power spectrum is obtained using FFT analysis. Genetic programming is applied to the data obtained. In the classification obtained using GP, the accuracy for normal and ill persons is 100% in the training set. In the test set, normal and ill persons are classified 87.5 % right and 12.5% wrong. The most convenient method will be searched by comparing different classifiers in future studies.

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