Fuzzy Classification of Congenital Heart Valve and Septum Defects using Phonocardiogram

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Abstract

In this paper we have used the most useful processing and analysis methods to classify two congenital heart defects. The most important congenital valve disease is the congenital aort stenosis(AS) and of septum diseases is Ventricular Septal Defect(VSD). In this research, we managed to fuzzy classification of three groups of healthy, and AS, and VSD patients with the use of PCG.

1. Introduction

Firstly, the white noise and other existing noises such as pulmonary and environmental noises were removed using wavelet denoising, and then the signal push was extracted using the 1st capstral coefficient. Further, in order to extract the limit of the 1st S1 sound of heart was segregated using Markov's Secret Model; and in order to extract the effective features, the two methods of calculation of Wavelet Coefficients Mean and Multiscale-PCA (based on Wavelet Analysis) were used. In the last stage, using the fuzzy C-Mean Algorithm, the sounds were classified in to three groups of healthy, AS, and VSD. Fig.1 illustrates the stages of the above-said process.

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2. Wavelet-denoising

Since the existence of some soufflés and murmurs in PCG signal prevented us to consider this signal as a non-deterministic or non-stationary signal. Therefore, the methods such as signal averaging will make no favorable results[1]; thus we used the noise removal method based on the wavelet (in this method we used the command 'wden' in MATLAB software). The correct selection of cases such as type of Wavelet, number of decomposition levels, and thresholding method is necessary. Using a wavelet with 5 levels will make favorite results. Also, we used the 'Regrsure' thresholding method in order to select threshold for removing noise.

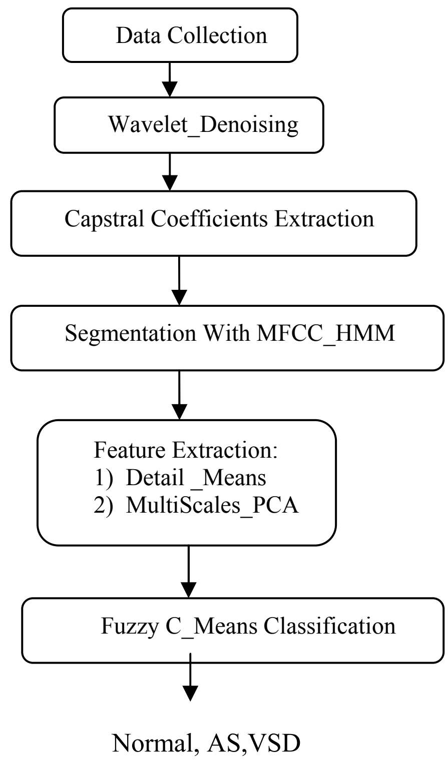

Figure 1.

3. Segmentation with MFCC_HMM

After removing the noise, the capstral coefficient of each signal was extracted through the process of Figure 2 below.

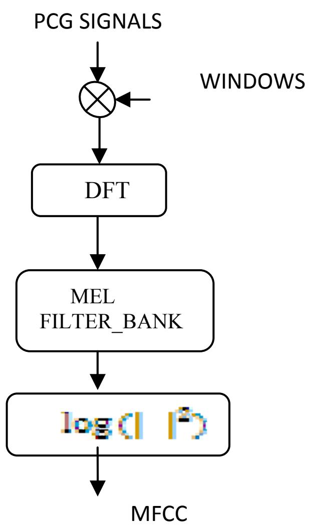

Figure 2.

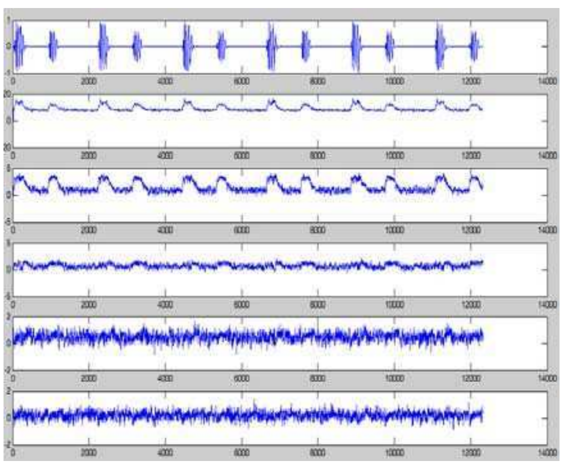

Figure 3. Shows the 1st to 5th capstral coefficient of PCG capstral of a healthy individual.

The first state is related to Sounds' Phase and the 2nd state is related to the Systole and Diastole Phase, the primary HMM model was made in the form of $\lambda 0=(A,B,\pi)$ where A= states transmission matrix, B=Distortions matrix, and π= primary probability matrix.

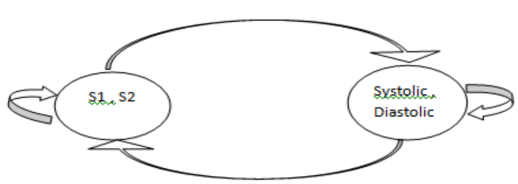

Figure 4. Shows the 1st model presented in this research.

As a result of the continuity of the observance vector which is the same capstral coefficients, estimation function of Single Gaussian was used. Using Baum-Welsh algorithm, new λ model was made and the use of Viterbi algorithm the maximum sequence of probability was extracted [2]

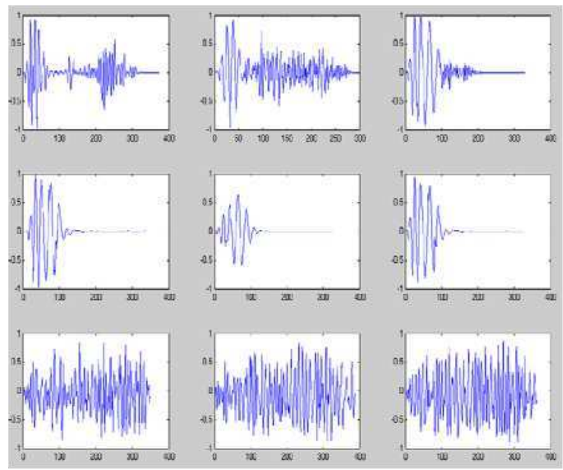

Figure 5. Shows the segregated sounds through HMM method.

4. Feature extraction

In order to extracting feature, the two wavelets of db7 and sym18 were used. Because of high volume of sym18 calculations, the db7wavelet with 5 levels were used in this research.

4.1. Detail-Means

In this state, we considered a 5-dimentional feature space for each signal of which each dimension included the 2nd to 5th detail mean and 5th approximation mean.

4.2. Multiscale-PCA

In order to reduce the dimension of features space, the wavelet-based PCA method was used. Firstly, with a sym18-type wavelet, the signal was decomposed to 5 level and based on Kaiser (which is on the basis of selecting larger directions from the mean of all directions), the feature space reduced from 1001 spots to 98 spots.

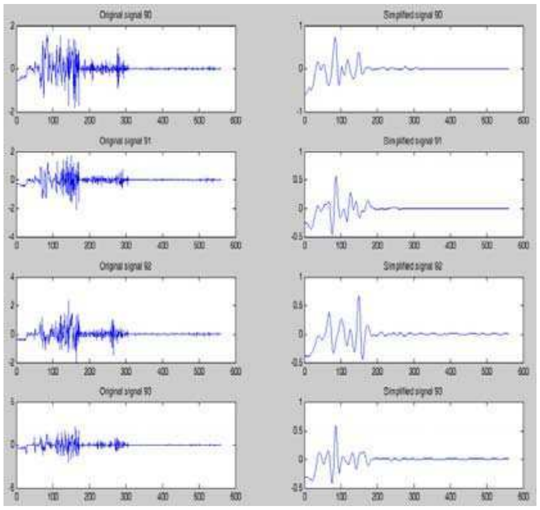

Figure 6. Shows the results of the reduced signals.

5. Results

According to the nature of data distribution, involvement of fuzzy in formulating, classification, and data clustering will be useful. That is, the boundaries between the clusters can be fuzzy instead of definite. In this research, we used C-Mean algorithm. “AA” variable, works as the first-type data counter, “AB” counter as the second-type data counter, and “AC” variable as the third-type variable; A, B, and, C respectively represents the number of classified samples of the above-said groups.

Acc_AS=A/AA
Acc_Normal=B/AB
Acc_VSD=c/AC

According to the following relations, we evaluated the classification accuracy of each group.
Table.1 shows the fuzzy classification results for the sounds using the above-said methods.

Ultimately, it was specified that using multiscale-pca will make more useful results than those from detail-main method.

Table 1.

Accuracy Of Cluster	Acc_ AS	Acc_NORMAL	Acc_VSD
Methods			
Detail_Means	0.68	0.73	0.63
Multiscale_PCA	0.71	0.83	0.78

References

[1] Messe SR, Agzarian J, Abbott D. Optimal Wavelet Denoising for Phonocardiogerams. Microelectronic Journal 2001.

[2] Romero Vivas E, White P. Heart sound segmentation by hidden markov models. IEEE2002.

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