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Heart Sound Segmentation Techniques: A Survey

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ABSTRACT : *PCG (phonocardiogram) segmentation plays very important role in heart sound analysis. PCG signal is a weak biological signal with the strong noise. The PCG segmentation of heart sound is generally used to determine the human heart condition. The biomedical signal recordings are so complex and non-stationary that they are also affected by different kinds of noise making their interpretation quite difficult. Different segmentation techniques are discussed in this paper and a survey is reported. PCG segmentation using discrete wavelet transform (DWT) in conjunction with Shannon entropy provides a useful tool for phonocardiogram segmentation. The entropy of the details coefficients is calculated at each level and threshold to detect heart sound signal. This paper presents an analysis of various PCG segmentation techniques and suggested performance measures.*

Keywords: *PCG signal, Wavelet, Entropy, Segmentation, Recurrence time statistics etc..*

I. INTRODUCTION

Heart sound signals carry the physiological and pathological characteristics of the heart. Each heart beat is very complex and short and the main frequency of heart sound signal is found between 10Hz and 250Hz. Phonocardiogram records the heart sounds and noise also and hence heart auscultation examination becomes essential. Usually, heart sounds are weak acoustic signals [1].The PCG signals are heart sound signals produced by the vibration of the heart sound and thoraxic systems which contain information related to the heart condition. The OCG signals are used in diagnosing various pathological conditions of the heart valves. The signal of normal case includes two distinct activities, the first heart sound s1 and the second heart sound s2; whereas for an abnormal heart, many signal activities between the first and the second heart sound can be seen. These extraneous activities occurring between s1 and s2 are referred as two abnormal sound signals s3 and s4. There are numerous algorithms reported in existing literatures performing PCG segmentation. Some of them are studied and analyzed for extracting the heart sound [2-4].

1.1 PHONOCARDIOGRAPHY – TECHNIQUE

The auscultation of the heart gives the clinician significant information about the functional integrity of the heart. Extended information can be collected if the temporal relationships between the heart sounds and the electrical and mechanical events of the cardiac cycle are compared [5-7]. This analysis of heart sounds using a study of the frequency spectra is known as phonocardiography [8]. The phonocardiogram is a device capable of obtaining heart sounds and displaying the obtained signals in the form of a graph drawn with the signal amplitude versus time. Different components of heart cycle are required to be separated [9]. This relationship is obscure but it can help the physicians to examine the PCG signal and further analysis.

1.2 CARDIAC SOUNDS

Heart sounds are basically short-lived bursts of vibration energy having transient characteristics which are primarily associated with valvular and ventricular vibrations. The site of origin and their original intensity determine the radiation of the heart sounds to the surface of the chest. There are four basic sounds during the sequence of one complete cardiac cycle [7]. Figure 1 shows the normal heart sound wave form.

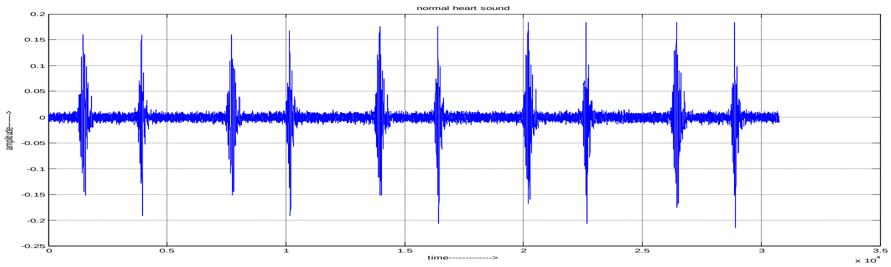

Fig: 1 Normal heart sound signal.

II. METHODS

Quiceno et al. [2008] proposed a nonlinear Dynamic analysis and high-frequency decomposition for segmentation of PCG signal. In this technique inter-beat segmentation is carried out using the DII lead of the ECG recording for locating the occurrence of the first heart sound (S1). Next, the intra-beat segmentation is achieved by using recurrence time statistics (RTS), which is sensitive to changes of the reconstructed attractor in a state space derived from nonlinear dynamic analysis. If the segmentation using RTS fails, an alternative segmentation is proposed using thresholding over the Shannon envelogram extracted from the high-frequency decomposition. The performance results for each segmentation event are shown in Table 1 illustrating Mean Squared Error (MSE) with respect to the points marked by specialists and the number of points whose difference with the label is more than 30ms. The total MSE in all intra-beat segmentation points (360 for the end of s1 (s1-e), 360 for the beginning of s2 (s2-b), and 360 for the end of s2 (s2-e)) is 18.25ms, and the total accuracy of the algorithm is 97.7% [2].

In this paper, Recurrence time statistics (RTS) is used to detect abrupt changes in the signal dynamics, corresponding to s1 and s2. An arbitrary state is selected on the trajectory whereupon all recurrences within a hypersphere of radious r are selected. A sliding window helps in partitioning the recorded PCG signal into overlapping segments for each segment. The radius is a very important parameter in the detection process and for very small value of radius hypersphere would be low on data; and for higher values, hypersphere will contain misleading information from erroneous parts of the reconstructed state space [10]. Wavelet decomposition and Shannon energy are used in the detection of s2 and RTS does not give a good estimation of the boundaries.

Table 1: MSE for different signals.

	R-peak	s1-e	s2-b	s2-e
MSE (ms)	-	13.4	8.7	8.8
Wrong detections	0/360	10/360	9/360	6/360

Gupta et al. (2005) presented a segmentation algorithm for detecting a single cardiac cycle (s1-Systole-s2-Diastole) of PCG signals using homomorphic filtering and k-means clustering. The signal is classified as Normal (N), Systolic murmur (S) and Diastolic murmur (D) using Grow and Learn (GAL) neural network. Homomorphic filtering converts non-linear signals into a linear signal by applying logarithmic transform. The k-means clustering is a method for nonhierarchical partitioning that is sued to indicate single cardiac cycle in the PCG signal. Segmentation performance of 90.45% was achieved [3]. Homomorphic filtering produces smooth envelope helping easier peak detection. K-means clustering of the time intervals between peaks was used to indicate the occurrence of single cardiac cycles and also to point missed cycles [12]. Following are the observations:

a. Normal heart sound had both slow varying and fast varying part. s1 has dominant frequency being between 100-200 Hz [11].
b. The fast varying parts were due to the higher frequency component of s1 (M1) or s2 (A2).
c. Noise is present in the systolic and diastolic regions with reduced amplitude.

d. In heart sounds with murmur, the fast varying parts in the systolic region (Systolic murmur) and diastolic region (Diastolic murmur) are reported. PCG results are summarized in Table 2.

Table 2: PCG segmentation results

	Correct	Incorrect	Total	%
Normal	109	1	110	99.09
Systolic murmur	106	18	124	85.48
Diastolic murmur	92	14	106	86.79
Total cycles			340	90.45

Bunluechokchai et al. (2009) introduced Heart sound analysis for assessment of heart diseases. In this research, two groups of patients: patients with normal heart sounds and those with mitral regurgitation were studied. The application of wavelet transform analysis to the heart sound signals is investigated for both groups. High frequency components of heart sounds with mitral regurgitation can be observed at the smaller scales of the Continuous Wavelet Trans-form (CWT). It can be viewed as a de-composition of a signal into a set of basic functions called wavelets. The CWT was applied to the band pass filtered heart sounds. The high frequency contents of heart sounds with mitral regurgitation can be clearly observed at the smaller scales. In addition, the abnormal heart sounds display more non-uniformity of the CWT energy distribution, in particular at the smaller scale [12-14].

Kouras et al. (2012) suggested that the biomedical signal recordings are complex and non-stationary and the signal is affected by different kinds of noise that make their interpretation difficult. The major goal of the paper consists of two ideas. In the segmentation technique, we calculate the entropy of the details coefficients at each level and threshold it in order to detect the murmur of heart sound signals. Several real-life signals were used such as Early Aortic Stenosis (EAS), Late Aortic stenosis (LAS), Mitral Regurgitation (MR), Aortic Regurgitation (AR). The results of the method are presented in Table 3 [5].

Table 3: Frequency Ranges of the Coefficients

Sampling Frequency	Level decomposition					
	d1	d2	d3	d4	d5	d6
8000 Hz	2000-4000	1000-2000	500-1000	250-500	125-250	62,5-125
11000Hz	2750-5500	1375-2750	687,5-1375	344-687,5	172-344	86-172

Wang et al. (2005) proposed an algorithm that integrated s1/s2 selection step and step for identification. An adaptive algorithm for sub-level tracking based on wavelet transform is used to separate s1 and s2 from other components like murmurs and noises. Criteria of time interval, energy and phonocardiogram (PCG) collecting position are used to identify S1 with respect to the beginning of each cardiac cycle [6]. To detect the first heart sound in noisy environment, the fundamental components are separated from background signals by using an adaptive sublevel tracking module. Shannon energy tracking is generally applied to detect peaks of s1/s2 from noisy interference based on knowledge of s1identification procedure [15].

III. CONCLUSION

The paper reports a survey on several segmentation techniques of PCG signals that uses prepossessing and Wavelet transform. An improved method for heart sound detection based on wavelet-adaptive separation and Shannon energy rejection were found well performing and the segmentation method overcomes the interference of background noise and also helps to detect the primary heart sound components s1 and s2. Discrete Wavelet transform is best method according based on segmentation result using db wavelet for feature extraction for segmentation. However, it is difficult to achieve optimum performance.

IV. REFERENCES

[1] Abhishek Misal and Sinha G.R. Denoising of PCG signal by using wavelet transforms *Advances in Computational Research* 4(1) 2012 46-49.

[2] AF Quiceno, E Delgado , M Vallverd, AM Matijasevic and G Castellanos-Domnguez, Effective Phonocardiogram Segmentation Using Nonlinear Dynamic Analysis and High-Frequency Decomposition *Computers in Cardiology* 35 2008 161-164.

[3] Cota Navin Gupta, Ramaswamy Palaniappan and Sundaram Swaminathan, Classification of Homomorphic Segmented honocardiogram Signals Using Grow and Learn Network *IEEE Engineering in Medicine and Biology 27th Annual Conference Shanghai, China,* 2005 4251-4254.

[4] Chissanuthat Bunluechokchai and Weerasak Ussawawongaraya, A Wavelet-based Factor for Classification of Heart Sounds with Mitral Regurgitation *International Journal Of Applied Biomedical Engineering* 2(1) 2009 44-48.

[5] Nayad Kouras, Daoud Boutana and Messaoud Benidir Wavelet based segmentation and time-frequency characterization of some abnormal heart sound signals *24th International Conference on Microelectronics (ICM)* 2012.

[6] P. Wang, Y. Kim, L. H. Ling and C. B. Soh, First Heart Sound Detection For Phonocardiogram Segmentation *Proceedings of the 2005 IEEE Engineering in Medicine and Biology 27th Annual Conference Shanghai, China, September 1-4,* 2005 pp. 5519-5523.

[7] Abhishek Misal , G.R.Sinha , R. M. Potdar And M. K. Kowar, Comparison of wavelet transforms for denoising and analysis of PCG signal *i-manager's Journal on Communication Engineering and Systems,* Vol. 1 l No. 1 l November 2011 - January 2012 pp 49-53

[8] Sabarimalai Manikandan M., & Dandapat S. ,Wavelet-Based ECG and PCG Signals Compression Technique for Mobile Telemedicine. *International Conference Advance computing and communications* 2007 pp 164-169.

[9] El. Segaier M, Lilja O, Lukkarinen S, Srnmo L, Sepponen R, Pesonen E. Computer-based detection and analysis of heart sound and murmur. *Ann Biomed Eng,* 33(7), 2005, pp 937–942.

[10] Ahlstrom C, Liljefeldt O, Hult P, Ask P. Heart sound cancellation from lung sound recordings using recurrence time statistics and nonlinear prediction. *IEEEJSPL*, 12(12), 2005, 812–815.

[11] Liang H, Lukkarinen S, Hartimo I. A heart sound segmentation algorithm using wavelet decomposition and reconstruction, *In Proc. 19th IEEE-EMBS.* 1997; 1630–1633.

[12] A. P. Yoganathan, R. Gupta, F. E. Udwalia, J. W. Miller, W. H. Corcoran, R. Sarma, J. L. Johnson, and R. J. Bing, Use of Fast Fourier Transform in the Frequency Analysis of the First Heart Sound in Normal Man, *Medical and Biological Engineering and Computing*, vol.14, 1976, pp.69-73.

[13] B. Tovar-Corona, and J.N. Torry, Time- frequency representation of systolic murmurs using wavelets, *IEEE Computers in Cardiology,* 1998, pp. 601-604.

[14] Z.M. Zin, S.H. Salleh, S. Daliman, and M.D. Sulaiman, Analysis of Heart Sounds Based on Continuous Wavelet Transform, *IEEE Conference on Research and Development*, 2003, pp. 19-22.

[15] L. G. Durand and P. Pibarot, Digital signal processing of the phonocardiogram Review of the most recent advancements, *Critical Reviews in Biomedical Engineering*, vol. 23, 1995, pp. 163-219.