RESEARCH ARTICLE OPEN ACCESS

Heart Auscultation Detection

Mahesh Vikramsinh Bhosale[1]
*(Department of Electronics and Telecommunication, Islampur, India)

ABSTRACT
The paper describes a system for analyzing of heart auscultation so every person can get information about their own heart condition. The auscultation means the sound created by any organ due to turbulent blood flow. The murmurs are heart abnormal sounds. The murmur can be detected and analyzed by using Digital Signal Processing (DSP) stethoscope but looking cost aspect a system should have maximum accuracy level. The noise in audio files (.wave) is degraded by using Finite Impulse Response (FIR) filtering. The designed system calculates Root Mean Square (RMS) value and Low Energy Rate (LER) for sound signals directly taken from internet by using MATLAB platform. From the calculation, system classifies the signal either normal or murmur signals. Results are consulted with a physician. If signals are normal then Root Mean Square value is less than 0.3 (RMS<0.3) and Low Energy Rate is greater than 0.8 (LER>0.8).
Keywords – Auscultation, DSP, FIR, LER, Murmur, RMS

I. INTRODUCTION

Heart sound diagnosis is used as a fundamental diagnostic technique for diagnosing the state of human internal organs by listening heart sound using stethoscope. By feeling the Sound signal, a doctor determines the physiological status of the human body and estimates the imbalances present in the body of the patient. Usually doctors diagnose the disease with the help of internal sound of body but there are lots of critical sounds that cannot be differentiate by just listening. The heart sounds recording is a non-invasive test that records the electrical activity of the heart. It is important in the investigation of cardiac abnormalities. Each portion of the heart sounds signal waveform carries various types of information of patient's heart condition.

Now-a-days various techniques such as Magnetic Resonance Imaging (MRI), CT scan are used for detecting diseases and other problems of the human body. X-ray is used to determine flow of blood through the arteries of the heart. The abnormal heart sounds are cardiac murmurs. The murmurs are the pathologic heart sound that is produced because of turbulent blood flow. Cardiac murmurs are called as pathologic murmur as they are a result of problems like narrowing of valves, leaking of valves or presence of abnormal passage from which blood flow near the heart [1]. Heart murmurs can also be caused if blood is flowing through any damaged or over worked heart valve [2]. We can get suspected results from those tests but it are more costly. It requires special laboratory, skilled person and big machine setup. This creates a big problem The paper differentiates various sounds of heart by using Root Mean Square (RMS) value and Low Energy Rate (LER) techniques. The system uses MATLAB platform for easy analyzing and signal processing purpose. Hence there is a need to ameliorate the problems associated with the heart sound detection.

II. SYSTEM BLOCK DIAGRAM

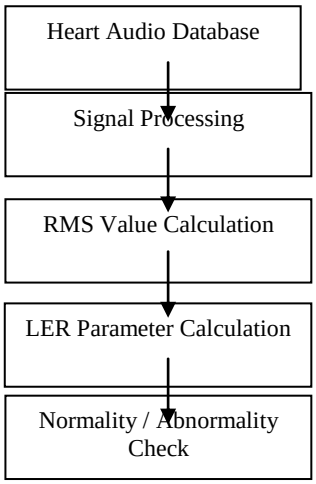

Fig.1. Block diagram of system

The working of system is divided into two phases i.e. after signal processing system calculates Root Mean Square value (RMS) and Low Energy Rate (LER). Fig.1 shows the system block diagram. In Root Mean Square (RMS) value calculation signals are sampled. After that we have to take ratio of number of samples below Root Mean Square (RMS) value and total number of samples contained by that signal.

A. Heart Audio Database

Database is the most important and primary need of any system. For implementation of this system authors have taken database from internet [6].

There are three types of database used for implementation of this system i.e. normal heart sound database, systolic heart sound database and diastolic heart sound database.

- *Normal Heart Sound Database*

The normal heart sound consist of two sound signal
that corresponds to lub and dub phase. These are termed as S1 and S2.The authors have taken seven normal heart sound database.

- *Systolic Heart Sound Database*

The activity between S1 and S2 is called as systolic murmur. The authors have taken twenty one systolic heart sound databases. Systolic murmurs are classified according to its timing and duration in to either the mid systolic ejection or pan systolic (holy systolic) category. Systolic ejection murmurs are caused by out flow obstruction. Systolic ejection murmurs can be heard in patients with aortic stenosis, mitral prolapse, mitral regurgitation, and aortic insufficiency. The authors have taken six databases for mitral prolapse, six databases for aortic stenosis, seven for mitral regurgitation and two for aortic insufficiency.

- *Diastolic Heart sound Database*

The activity between S2 and S1 is called as systolic
murmur. The authors have taken sixteen diastolic heart sounds
databases. Diastolic murmurs can be classified according to the iridology. Diastolic regurgitate murmurs result from retro grade flow across an incompetent aortic or pulmonic valve. The diastolic murmur of aortic in-sufficiency is a decrescendo murmur.

B. Signal Processing

The collected signal contain high frequency noise is introduced at time of signal capture. These include power line interference, baseline drift. It is vital that the noises be suppressed prior to parameter measurement, wave identification and disease diagnosis. Analysis and recognition tasks were done using MATLAB. Fig.2. shows flow chart of Normality/Abnormality Detection of heart sound signals. Initially, the signal is filtered from high-frequency component using the Finite Impulse Response (FIR) filter. FIR filter inhibits impulsive noises while simultaneously protecting the edge features. In essence, the FIR filter operates as a window, sliding through the entire discrete sequence, and replaces the individual points with new values as defined by the window length. It is vital to note that FIR filter of sufficient length is required to filter out impulsive noise. However, filter of significant length will cause adverse effect on the details of original signal. The length of the filter is highly dependent on the signal resolution and the intended applications.

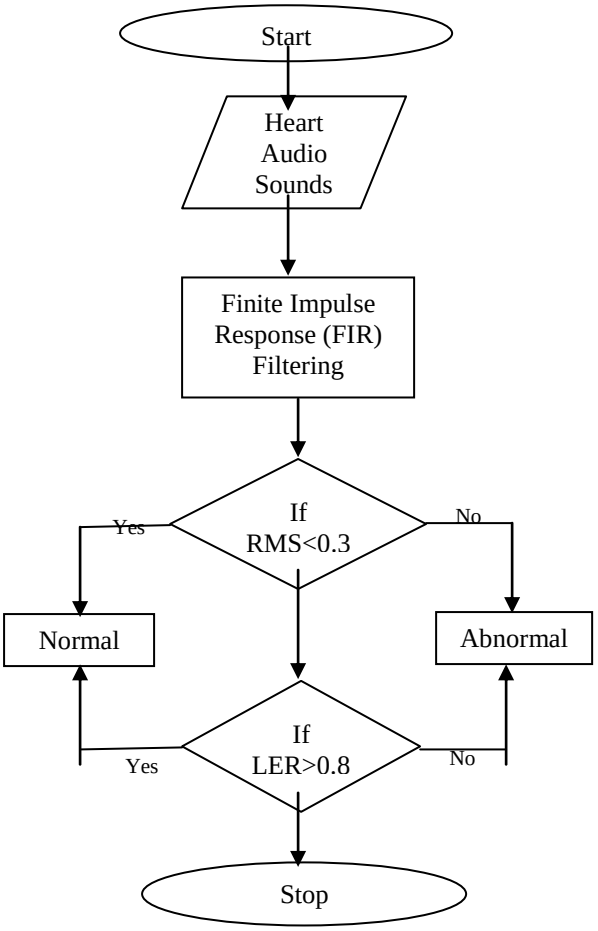

Fig.2. Flow chart of Normality/Abnormality Detection

C. RMS Value Calculation

The root of mean of square of all the values of a signal is termed as root mean square value of the signal.

$$\text{RMS} = \sqrt{\frac{1}{n}}(x1^2 + x2^2 + x3^2 + \cdots + xn^2)$$

Where the sample of signal x and n is is the total no of samples in the signal.

D. LER Parameter Calculation

If P is the no of signals below RMS and Q is the total no of signals then the fraction of these two is called the low energy rate.

$$\text{LER} = \frac{P}{Q}$$

Where P is the no. of signals which are below the root mean square value and Q is the total no. of signals. The Low Energy Rate for a signal is between 0 and 1.

E. Normality /Abnormality check

The heart sound signal is said to normal or abnormal depending on Root Mean Square (RMS) value as well as Low Energy Rate (LER) parameter. The heart sound signal is said to be normal if Root Mean Square value is less than 0.3 (RMS<0.3) and

Low Energy Rate is greater than 0.8 (LER>0.8). The heart sound signal is said to be abnormal if Root Mean Square value is greater than 0.3 (RMS>0.3) or Low Energy Rate is less than 0.8 (LER<0.8).

III. HEART DISEASES

a. Aortic regurgitation

The murmur of aortic regurgitation occurs during diastole as the aortic valve fails to close completely and blood regurgitates from the aorta back in to the left ventricle [8]. The murmur is a high-pitched decrescendo murmur heard best along the left lower sterna border. Of note, aortic regurgitation is sometimes associated with 2 other murmurs as well as systolic ejection murmur can result from the volume over load of the left ventricle resulting in increased flow across the aortic valve, and an Austin Flint murmur (diastolic murmur heard at the apex) can be generated by impingement of the regurgitate flow on the anterior leaflet of the mitral valve.

b. Aortic stenosis

The murmur of aortic stenosis is a systolic ejection murmur that peaks early in systole. The murmur is harsh in quality and medium pitched. It is heard best at the second right inter space (parasternally) and often radiates to the carotid arteries. As the severity of the stenosis worsens, the murmur peaks later in systole, and the closure of the aortic valve component of S2 decreases in intensity and is delayed [4]. This delay results in a paradoxical splitting of S2, with the closure of the aortic valve and the closure of the pulmonic valve merging on inspiration. Conditions associated with aortic stenosis include the presence of a congenital bicuspid aortic valve, rheumatic fever and aortic sclerosis.

c. Mitral regurgitation

The murmur of mitral regurgitation is a pan systolic murmur generated as blood regurgitates from the left ventricle to the left atrium. The murmur is a blowing, medium-pitched sound heard best at the apex that radiates to the axilla. S1 is very soft. This murmur is heard in patients with infective endocarditic, degenerative valvular diseases (e.g. mitral valve prolapse) and rheumatic heart disease [5]. If mitral value prolapse is present then mid systolic click may be heard followed by late systolic murmur.

d. Mitral valve prolapse

In these disease, mitral valve closes completely when left ventricle of the heart contracts, preventing blood from flowing back to left atrium [3]. If any part of valve bulges out so that it does not close properly the mitral valve prolapse. This situation is not so serious but it can result into regurgitation (backward flow of blood).

IV. RESULTS

The normality of heart sound is checked by RMS value and LER parameter calculation. The input sound files (.wav) are listed in Table. I. And their RMS value and LER parameter are observed.

TABLE.I .Normal Heart Sounds

Normal Sounds	RMS	LER	Status
Normal Split S1	0.2644	0.8551	True
Normal Split S2	0.1889	0.8521	True
NL	0.2644	0.8551	True
Opening Snap	0.2212	0.8755	True
S3	0.1987	0.8493	True
S4	0.2579	0.8475	True
Normal	0.2347	0.8784	True

The various abnormal input sound files are listed in Table.II. The RMS value and LER parameter are calculated. For abnormal heart sounds RMS value should be greater than 0.3 and LER parameter is less than 0.8.

TABLE.II .Abnormal Heart Sounds

Diseases Names	Abnormal Sounds	RMS	LER	Status
Mitral Prolapse	MP	0.1230	0.8648	False
	MP2	0.5739	0.8097	True
	MP3	0.4274	0.7531	True
	MP4	0.4274	0.7531	True
	MP5	5.1469	0.7697	True
	MP6	10.7753	0.7357	True
Aortic Stenosis	AS	0.7961	0.7961	True
	AS2	0.8187	0.8187	False
	AS3	0.8069	0.8067	False
	LAS	0.7962	0.7962	True
	CAS	0.8199	0.8199	True
	EAS	0.8689	0.8689	False
Mitral Regurgitation	MR	0.5223	0.7962	True
	MR1	08755	0.7601	True
	MR2	1.3328	0.8481	True
	MR3	0.7639	0.8879	True
	MR4	1.0706	0.9405	True
	MR5	1.8049	0.6873	True
	MR6	3.3142	0.6927	True
Aortic Insufficiency	Ai1	0.3103	0.7863	True
	AI	0.1812	0.8521	False
	SFB	0.4133	0.7990	True
	SFC	0.1698	0.9018	False

Physiologic Split	SPA	0.9004	0.7568	True
	SPB	0.4133	0.7990	True
	SW	0.3130	0.7305	True
	SW2	0.3674	0.7733	True
	SW3	0.3731	0.6999	True
Gallop	AG	0.3326	0.7999	True
	QG	7.5260	0.9018	True
	QG2	0.1949	0.7156	False
	SG	0.6043	0.8069	True
	SG2	0.4058	0.8590	True
	S3G	1.6949	0.7621	True
	S4G	0.5497	0.7751	True
Aortic Regurgitation	AR	0.4387	0.7583	True
	ARS	0.1676	0.8823	False

$$Accuracy = \frac{PT+NT}{PT+NT+PF+NF}$$

$$Sensitivity = \frac{PT}{PT+NF}$$

'T' refers to true and 'F' refers to false classified signal. A positive (P) identification indicates a murmur and a negative (N) identification indicates a normal signal [3]. We have (P=37, N=7, T=36, F=8) accuracy of paper up to 99%. The paper are having 95% sensitivity.

V. CONCLUSION

This paper presents Heart Auscultation Detection system. The system is developed using MATLAB programming language. System is trained for 7 heart normal sound signals, 37 heart abnormal sound signals. Table.I and Table.II shows result of normal heart sound signal and abnormal sound signals with their Root Mean square (RMS) value and Low Energy Rate (LER) parameter respectively. Hence it should be confirm that heart normality and abnormality can be decided on basis of heart sound signals.

VI. FUTURE WORK

The development of computer based software or android application can be useful for doctors so that they can handle it easily. Hardware development can be done. For increase in accuracy of result further large database can be used.

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