RESEARCH ARTICLE   OPEN ACCESS

An Efficient Method for Measurement of the RR Interval in Heart Sound

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ABSTRACT
Heart sound contains the lots of information related to the cardiovascular system. Heart sounds generated by the shrink and relaxation of the heart due to the flow of blood from body parts to heart and heart to all body parts, where it is enriched by the oxygen through the lungs. In the present work, heart sound is measured by using the capacitive transducer, placed in the simple stethoscope. The recorded signal is then filtered using the active filters, and the filtered data is then transferred to the computer memory. Finally by using the Labview software the recorded signal is de-noised again by using wavelet de-noising technique.

I.   INTRODUCTION

Since the 4000 BC, Indian medical science (Ayurved) depends upon the Nadi Prikshan which is partially related to the heart sound. Nadi parikshad gives the information about the human nervous system, cardiovascular system, digestion system and etc. The main methodology is to measure the time interval between the two difference pulses. If heart sound is measured accurately then there will the lots of information by which we can identify and cure the diseases. Also we may have sufficient time to take action.

There is drastically decrease in the measurement of heart sound since last 4 decades, due to development of the electrocardiography regardless the heart sound gives the audio and visual profile and which can give more information about the physical and mental status.

Heart sounds generated by the shrink and contraction of the heart due to the flow of blood from body parts to heart and heart to all body parts again, after enriched by the oxygen through lungs. Pattern of the sound depends upon the body structure and then acceleration or deceleration of blood occurs.[2]

There are numerous techniques for measurement of heart sound which focus to record the phonocardiogram. Traditional way of diagnosis is to hear the sound by the stethoscope which can be accurately used by the very experience physician. Few of the sensors are also spatially design for the physiological measurement.[5] Piezoelectric effect based sensors are widely used for the measurement of the low pressure signals.[3] As a matter of fact the signal the retrieve was not able to audible just used for the phonocardiogram.

In this paper this paper discuses how to use the capacitive based stethoscope in an effective manner. Stethoscope contain the diaphragm which sense the sound of pressure and then the distance between the plate of the capacitor will give the signals proportional to the input vibration. Then the signal is the amplified and transferred the computer by using the third party data acquisition card for LabView. Then rest of the all part like Data acquisition, filtering and Analysis is held in the Labview software. Wavelet de-noising technique [6] is used for extracting the sound of interest. The RR interval can be measured by the phonocardiograph.

Apart from the others we can acquire the data, save it and can also process whenever we need to, not only the visual data in-fact we can also listen the sound at any time we required.

II.   METHODS

A.   Sensor Placement

There is number of patterns of heart sound which depends upon the physical parameter of the heart. Here we use the capacitive type stethoscope (CTSTP) for the heart sound capturing. The two sounds S1 and S2 are generated in physically fit person with a uniform time difference. S1 is generated by the closing of the mitral and tricuspid valve there may be some lag between closing of these two valves. Similarly the second heart sound S2 generated due to the closing of the semilunar valve (i.e. the aortic and pulmonary valve).[2]

International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622
International Conference On Emerging Trends in Mechanical and Electrical Engineering
(ICETMEE- 13th-14th March 2014)

Amplitude of the S1 and S2 depends upon the placement of the stethoscope. If we measure the sound near the semilunar valve then there will be higher amplitude of the S2 than the S1. Likewise there will be higher aplitude of the S1 if we place the stethoscope near the Atrioventricular valve. So here we placed the Stethoscope just between the aortic and the tricuspid valve. Hence there will be almost same amplitude between the S1 and S2.

B.   Hardware Setup and Working

There are few following easy way of using the capacitive transducer.

By using the oscillator: In this method we generate a signal of known frequency and passed through the capacitive transducer and a resistance. The phase change will be in the form of the R and C. which can be measured easily. The phase difference is measured the comparing the original signal and the delayed signal. The two signals are first passed through the zero crossing detector so that they converts into the square wave. Then that signal is passed through the comparator and a pulse is generated of width equal to the phase difference and ultimately the capacitance value.

By using the DC voltage source: The equation for the current in a RC network, when the capacitance is variable and the voltage is constant is given by;

$$i = R * d(CV)/dt$$

But because the voltage is constant and the capacitance is variable then the equation will be like

$$i = R * Vd(C)/dt$$

From the above equation it can be seen that the change in capacitance is proportional to the current. The current further converted into the voltage. We use the DC voltage source for measuring the capacitance.

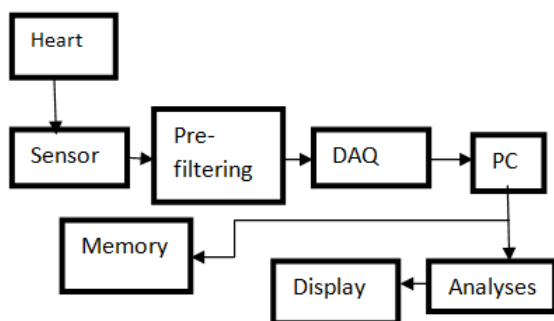The voltage is transferred to the computer via 4711a DAQ hardware. Data can be processed with the help of labview.

Fig 1: Block diagram of Device

C.   Data Analysis

Labview software is used for the data analysis and acquisition. Signals have been filtered by the third order low pass filter with inverse chebyshev topology. The cutoff frequency is of 200 Hz. Because the heart sounds frequency lies in the range of 40Hz to 60Hz (Ansourian's research [3]). After filtering the signal, that can be stored or can be processed further which is user defined. In further processing the signal passed to the Wavelet denoised block in labview.[6]
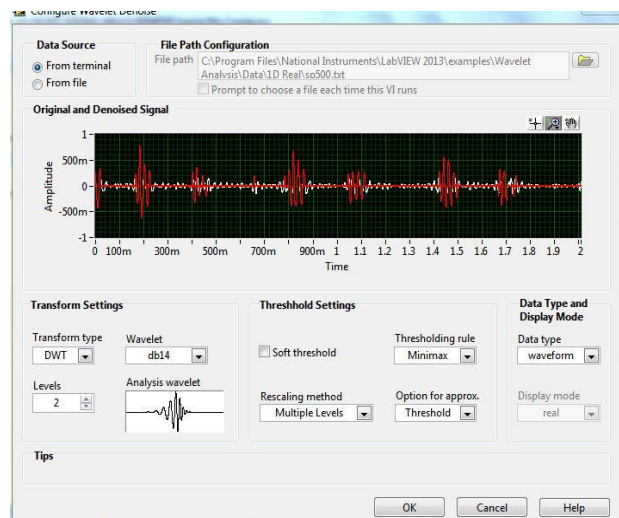

Fig 2: Wavelet de-noised Block setting

Table shows the setting which we used in the wavelet de-noising,

Table I
LabView Wavelet De-Noise Block Settings

S.No.	Setting Type	Configuration
1	Transform type	DWT
2	Level	2
3	Wavelet type	db14
4	Threshold rule	Minimax
5	Rescaling method	Multiple level
6	Option for approx.	Threshold

After the wavelet de-noising we get following signal the first signal is from the filter and the second signal is from the wavelet de-noised block;

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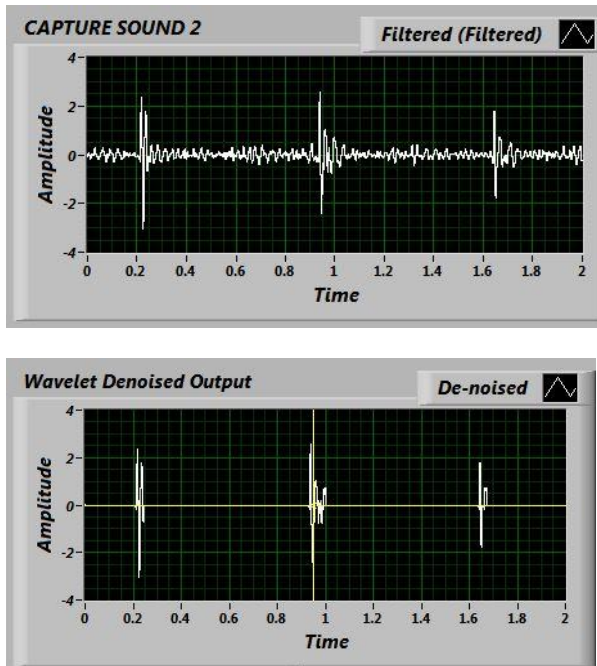*(ICETMEE- 13th-14th March 2014)*
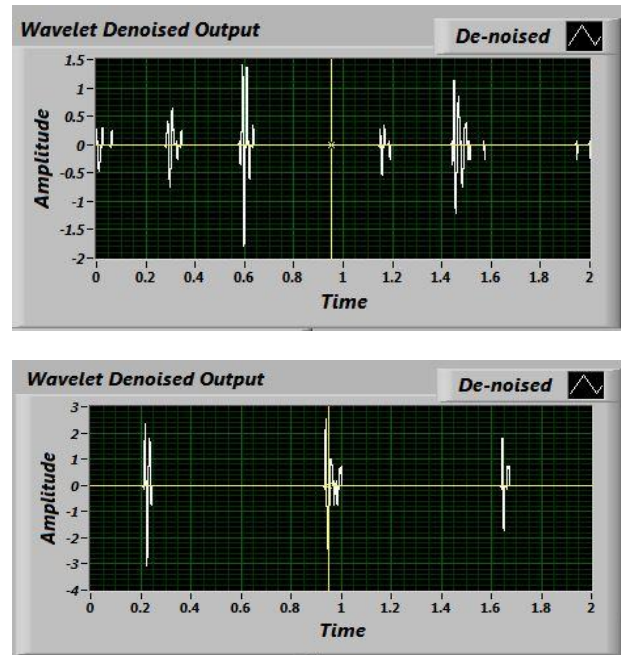
Fig 3: a) filtered signal; b) wavelet de-noised signal

Fig 4: a) pattern 1 ,b) pattern 2

It can be seen in above figure that the wavelet de-noised output is much easier for the analysis as it do not contain the noise.

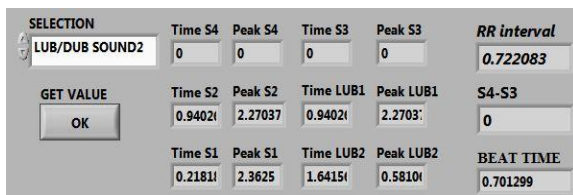Now the RR interval can be measured by the software much more easily as shown bellow,

Fig 3: information acquire from sample

III.   RESULTS & DISCUSSION

In Fig. 2(a), a Filtered data signal measured from stethoscope shown. Signal contains a little bit noise due to respiration and other external noises. After the wavelet De-noising technique waveform can be easily identified.

There is 300k sample taken from the 4117a, which give signal for the two second. The Peak time of first heart sound (S1) and second heart sound(S2) will give the RR interval information. The information can be capture manually or automatically.

We take 30 persons samples and surprisingly we found two type of sound patter, defiantly that totally depends on the physical structure of body. But the interesting thing is that that pattern is correlated to the ayurvedic 'Nadi Parikshan'. There are following to pattern.

We can see in above patterns that in pattern one there is successive S1 and S2 then a pause then again the second S1 and S2. But in the second pattern there is a uniform time difference between the S1, S2 and again S1. We conduct a SWAT analysis on these two types of person and we found that pattern1 person has extrovert personality while the second one have the introvert personality. And according to the ayurvedic 'Nadi parikshan' the pattern one in of the 'Vata dosha' and the second pattern is of the 'Kapha dosha'.

Heart sound gives the information about the heart, as a matter of fact, it may also give the relation between the nervous system and digestion system as well, If we'll able to set a correlation between the 'Nadi parikshad' and the Heart Sound.

IV.   CONCLUSION

In this paper we use the stethoscope which contains capacitive type transducer and the hardware signal conditioning circuit and the Labview signal processing and data accusation tools. By placing the stethoscope at suitable position so we can get the S1 and S2 almost of the same peak. Signals are then transferred to the Labview via 4711a Data acquisition card. By using the Labview signal processing and data acquisition tools we further modifies the signal and store that for future analysis. We filtered the signal with the cutoff frequency of 200 Hz. Then we de-noised and threshold the signal with the help of labview wavelet de-noising block. Since the RR interval is the time difference between the S1 and S2 sound that can be measure automatically or manually. If there is S3 or S4 sound is present that also can be measured and seen on the graph. Those sound can be distinguished by listening the sound captured which is the one of the advantage of using the Labview data acquisition tools.

International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622
International Conference On Emerging Trends in Mechanical and Electrical Engineering
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This paper is especially useful in heart sound measurement (S1 S2 S3 and S4) which is more accurate that previous methods. Our device not only measures the sound but also store the waveform for future references. Stored sound can also be listen which is more helpful in the identifying the sound which one is S1 and which one is S2. We use all generic components for the hardware which can be modified by the SMD component which can helps to reduce the size of the device up to 90%.

Also we found some relation between the 'Ayurvedic Nadi Parikshad' and the heart sound. Relation between these two method may start a new era in the Ayurvedic and allopathic medical fields. The accuracy can also increased by using the PVDF sensor along with our device.

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