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Digital Stethoscope: A New Approach to know and Hear Heart Beat and Heart Frequency Rate

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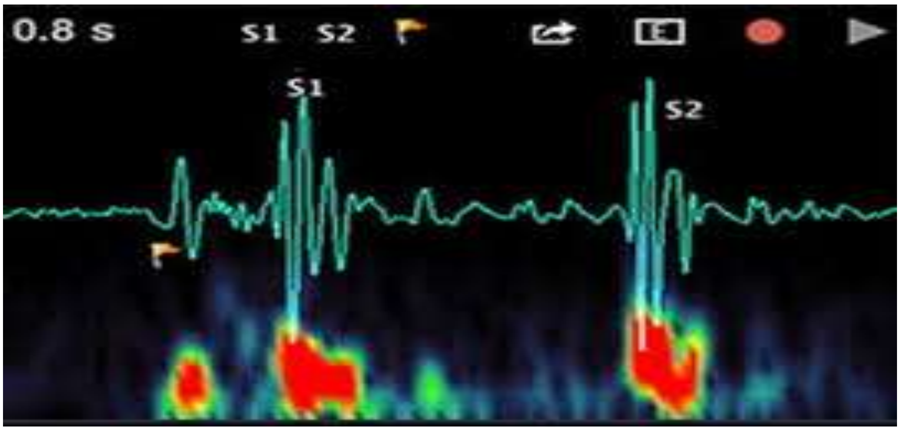
Abstract: The motive of this journal is to digitalize the stethoscope and improve and make easier and accurate measurement of heart beat and frequency rate. The part of the motive of this device is everyone can hear them heart beat and to know about them health with the help of any instruction and network and also heart beat frequency rate, heart beat sound recorded using additional devices and the recording signal (heart beat sound or frequency rate) easily transfer by using smart phone with related apps.

Keywords: Accuracy, Anyone Can use, Digitalized, Easy to Handle, Simple.

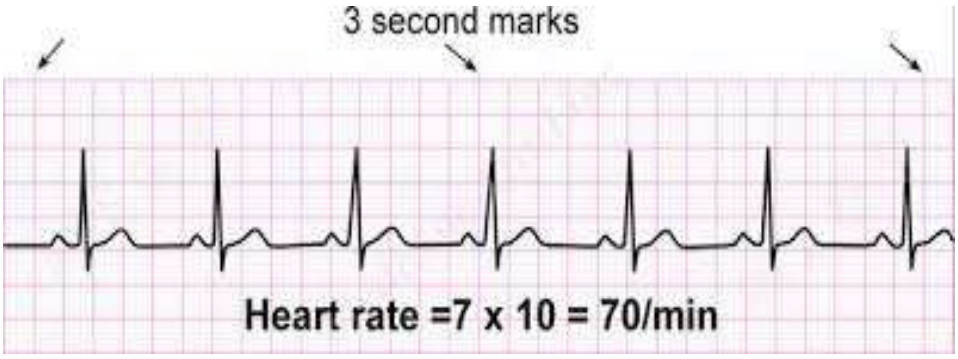
INTRODUCTION

The stethoscope was invented in France in 1816 by René Laennec at the Necker-Enfants Malades Hospital in Paris.[1][2][3] It consisted of a wooden tube and was monaural. Laennec invented the stethoscope because he was uncomfortable placing his ear on women's chests to hear heart sounds.[4][5]:186 He observed that a rolled notebook, placed between the patient's chest and his ear, could amplify heart sounds without requiring physical contact.[6] Laennec's device was similar to the common ear trumpet, a historical form of hearing aid; indeed, his invention was almost indistinguishable in structure and function from the trumpet, which was commonly called a "microphone". Laennec called his device the "stethoscope"[7] (*stetho-* + *-scope*, "chest scope"), and he called its use "mediate auscultation", because it was auscultation with a tool intermediate between the patient's body and the physician's ear. (Today the word *auscultation* denotes all such listening, mediate or not.) The first flexible stethoscope of any sort may have been a binaural instrument with articulated joints not very clearly described in 1829.[8] In 1840, Golding Bird described a stethoscope he had been using with a flexible tube. The bird was the first to publish a description of such a stethoscope but he noted in his paper the prior existence of an earlier design (which he thought was of little utility) which he described as the snake ear trumpet. Bird's stethoscope had a single earpiece.[9]



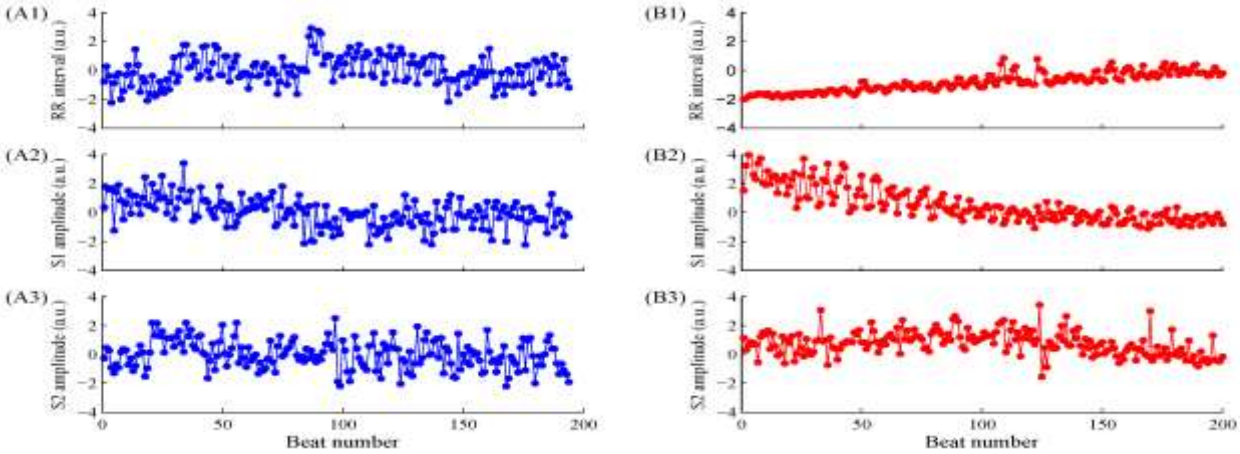
In 1851, Irish physician Arthur Leared invented a binaural stethoscope and, in 1852, George Philip Cammann perfected the design of the stethoscope instrument (that used both ears) for commercial production, which has become the standard ever since. Cammann also wrote a major treatise on diagnosis by auscultation, which the refined binaural stethoscope made possible. By 1873, there were descriptions of a differential stethoscope that could connect to slightly different locations to create a slight stereo effect, though this did not become a standard tool in clinical practice.

Somerville Scott Alison described his invention of the **stethophone** at the Royal Society in 1858; the stethophone had two separate bells, allowing the user to hear and compare sounds derived from two discrete locations. This was used to do definitive studies on binaural hearing and auditory processing that advanced knowledge of sound localization and eventually to an understanding of binaural fusion.[1]



The medical historian Jacalyn Duffin has argued that the invention of the stethoscope marked a major step in the redefinition of disease from being a bundle of symptoms, to the current sense of a disease as a problem with an anatomical system even if there are no noticeable symptoms. This re-conceptualization occurred in part, Duffin argues, because prior to stethoscopes, there were no non-lethal instruments for exploring internal anatomy.[10]

Rappaport and Sprague designed a new stethoscope in the 1940s, which became the standard by which other stethoscopes are measured, consisting of two sides, one of which is used for the respiratory system, the other for the cardiovascular system. The Rappaport-Sprague was later made by Hewlett-Packard. HP's medical products division was spun off as part of Agilent Technologies, Inc., where it became Agilent Healthcare. Agilent Healthcare was purchased by Philips which became Philips Medical Systems, before the walnut-boxed, $300, original Rappaport-Sprague stethoscope was finally abandoned ca. 2004, along with Philips' brand (manufactured by Andromed, of Montreal, Canada) electronic stethoscope model. The Rappaport-Sprague model stethoscope was heavy and short (18–24 in (46–61 cm)) with an antiquated appearance recognizable by their two large independent latex rubber tubes connecting an exposed leaf-spring-joined pair of opposing F-shaped chrome-plated brass binaural ear tubes with a dual-head chest piece.



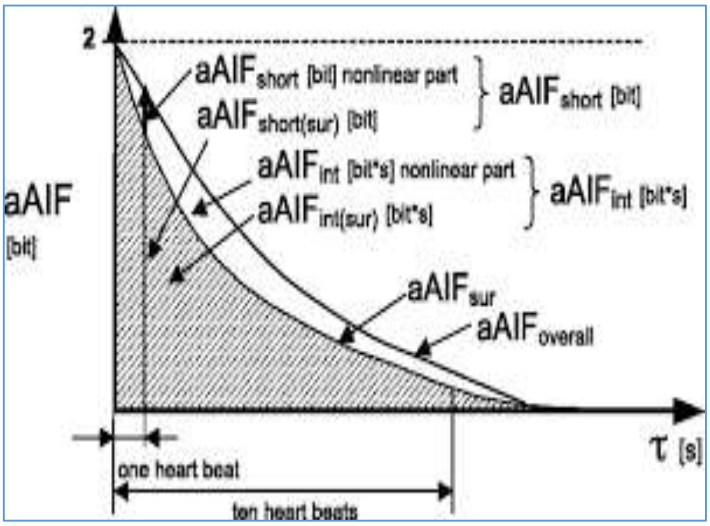
Early flexible tube stethoscopes. Golding Bird's instrument is on the left. The instrument on the right is the stethophone.[1]Several other minor refinements were made to stethoscopes until, in the early 1960s, David Littmann, a Harvard Medical School professor, created a new stethoscope that was lighter than previous models and had improved acoustics.[11] In the late 1970s, 3M-Littmann introduced the tunable diaphragm: a very hard (G-10) glass-epoxy resin diaphragm member with an overmolded silicone flexible acoustic surround which permitted increased excursion of the diaphragm member in a Z-axis with respect to the plane of the sound collecting area. The left shift to a lower resonant frequency increases the volume of some low frequency sounds due to the longer waves propagated by the increased excursion of the hard diaphragm member suspended in the concentric accountic surround. Conversely, restricting excursion of the diaphragm by pressing the stethoscope diaphragm surface firmly against the anatomical area overlying the physiological sounds of interest, the acoustic surround could also be used to dampen excursion of the diaphragm in response to "z"-axis pressure against a concentric fret. This raises the frequency bias by shortening the wavelength to auscultate a higher range of physiological sounds.

In 1999, Richard Deslauriers patented the first external noise reducing stethoscope, the DRG Puretone. It featured two parallel lumens containing two steel coils which dissipated infiltrating noise as inaudible heat energy. The steel coil "insulation" added.30 lb to each stethoscope. In 2005, DRG's diagnostics division was acquired by TRIMLINE Medical Products.[12]

Age group	HR beats/min		R	Leukocyte Count X $10^3/mm^3$	SBP
	↑	↓			
Newborn	>180	<100	>50	>19.5 or <5	<65
Infant	>180	<90	>34	>17.5 or <5	<100
Toddler	>160	NA	>29	>16.5 or <5	<100
Preschool	>140	NA	>22	>15.5 or <6	<94
School age child	>130	NA	>18	>13.5 or<4.5	<105

1.1Current Practice

The **stethoscope** is an acoustic medical device for auscultation or listening to the internal sounds of an animal or human body. It typically has a small disc-shaped resonator that is placed against the chest, and two tubes connected to earpieces. It is often used to listen to lung and heart sounds. It is also used to listen to intestines and blood flow in arteries and veins. In combination with a sphygmomanometer, it is commonly used for measurements of blood pressure. Less commonly, "mechanic's stethoscopes", equipped with rod shaped chestpieces, are used to listen to internal sounds made by machines (for example, sounds and vibrations emitted by worn ball bearings), such as diagnosing a malfunctioning automobile engine by listening to the sounds of its internal parts. Stethoscopes can also be used to check scientific vacuum chambers for leaks, and for various other small-scale acoustic monitoring tasks. A stethoscope that intensifies auscultatory sounds is called **phonendoscope**.



A doctor using a stethoscope to listen to a patient's abdomen Stethoscopes are often considered as a symbol of healthcare professionals, as various healthcare providers are often seen or depicted with stethoscopes hanging around their necks. A 2012 research paper claimed that the stethoscope, when compared to other medical equipment, had the highest positive impact on the perceived trustworthiness of the practitioner seen with it.[13]

The advent of practical, widespread portable ultrasonography (point-of-care ultrasonography) in the late 1990s to early 2000s led some physicians to ask how soon it would be before stethoscopes would become obsolete.[14] Others answered that they thought the relationship of the various tools (stethoscopes and digital devices) would change but that it would be a long time before stethoscopes were obsolete.[15] A decade later, in 2016, the same two sides of the coin were still recognized.[16] One cardiologist said, "The stethoscope is dead", but a pediatrician said, "We are not at the place, and probably won't be for a very long time", where stethoscopes were obsolete. One consideration is that it depends on the segment of health care (emergency medical services, nursing, medicine) and the specialty. "Stethoscopes retain their value for listening to lungs and bowels for clues of disease, experts agree."[16] But for the cardiovascular system, "auscultation is superfluous", one cardiologist said.[16] Thus, it could be that cardiology in the secondary and tertiary care settings may abandon the stethoscope many years before primary care, pediatrics, and physical therapy do.

1.2 HEART SOUNDS

Acoustic heart sounds are produced when the heart muscles open valves to let blood flow from chamber to chamber. A normal heart will produce two heart sounds, S1 and S2 as shown in figure 1. S1 symbolizes the start of systole. The sound is created when the mitral and tricuspid valves close after blood has returned from the body and lungs. S1 is primarily composed of energy in the 30Hz - 45 Hz range. S2 symbolizes the end of systole and the beginning of diastole. The sound is created when the aortic and pulmonic valves close as blood exits the heart to the body and lungs which lie with maximum energy in the 50 Hz - 70 Hz range with a higher pitch. Typically, heart sounds and murmurs are of relatively low intensity and are band limited to about 100–1000 Hz. Meanwhile, the Speech signal is perceptible to the human hearing. Therefore, auscultation with an acoustic stethoscope is quite difficult [15-16]

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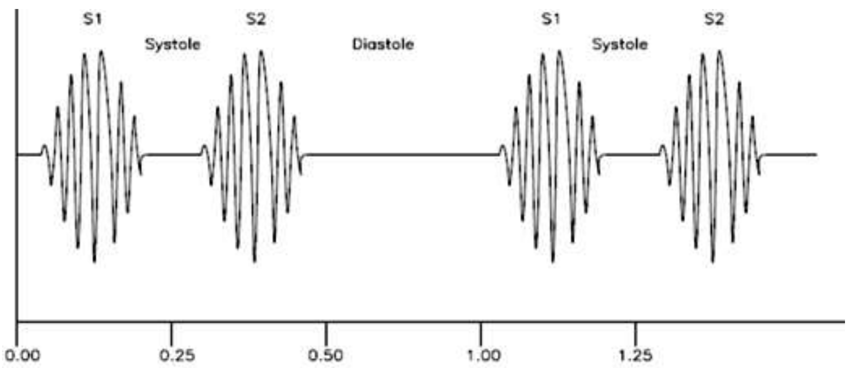
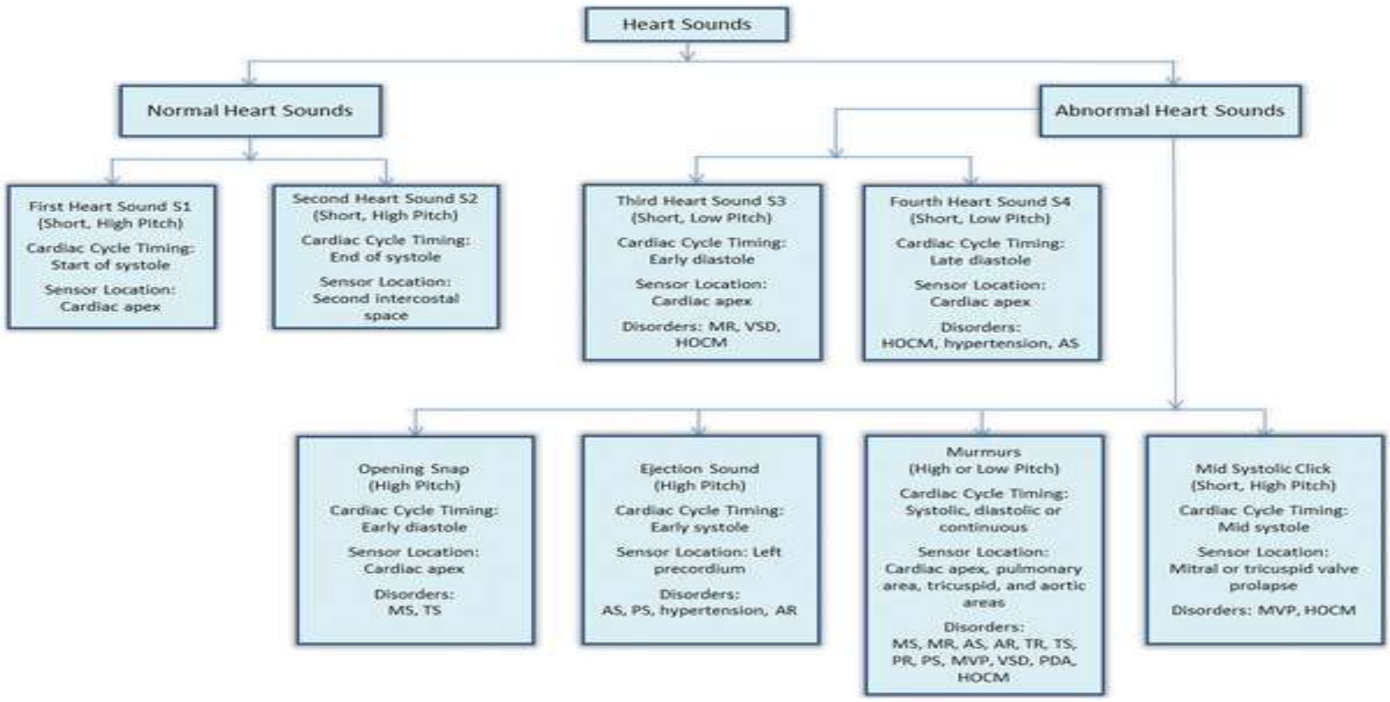


Heart Sounds

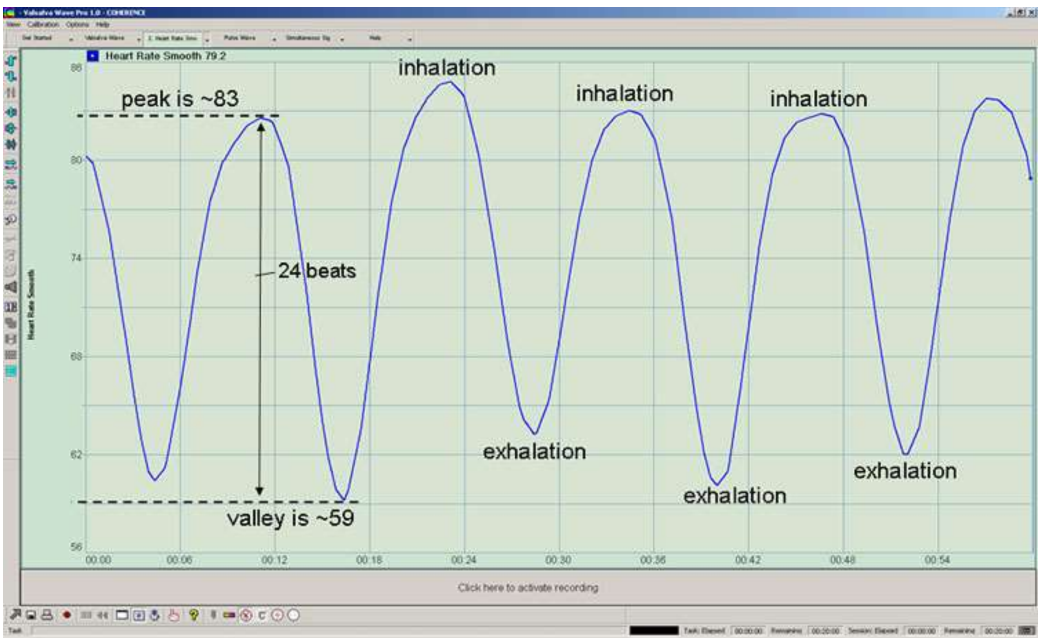


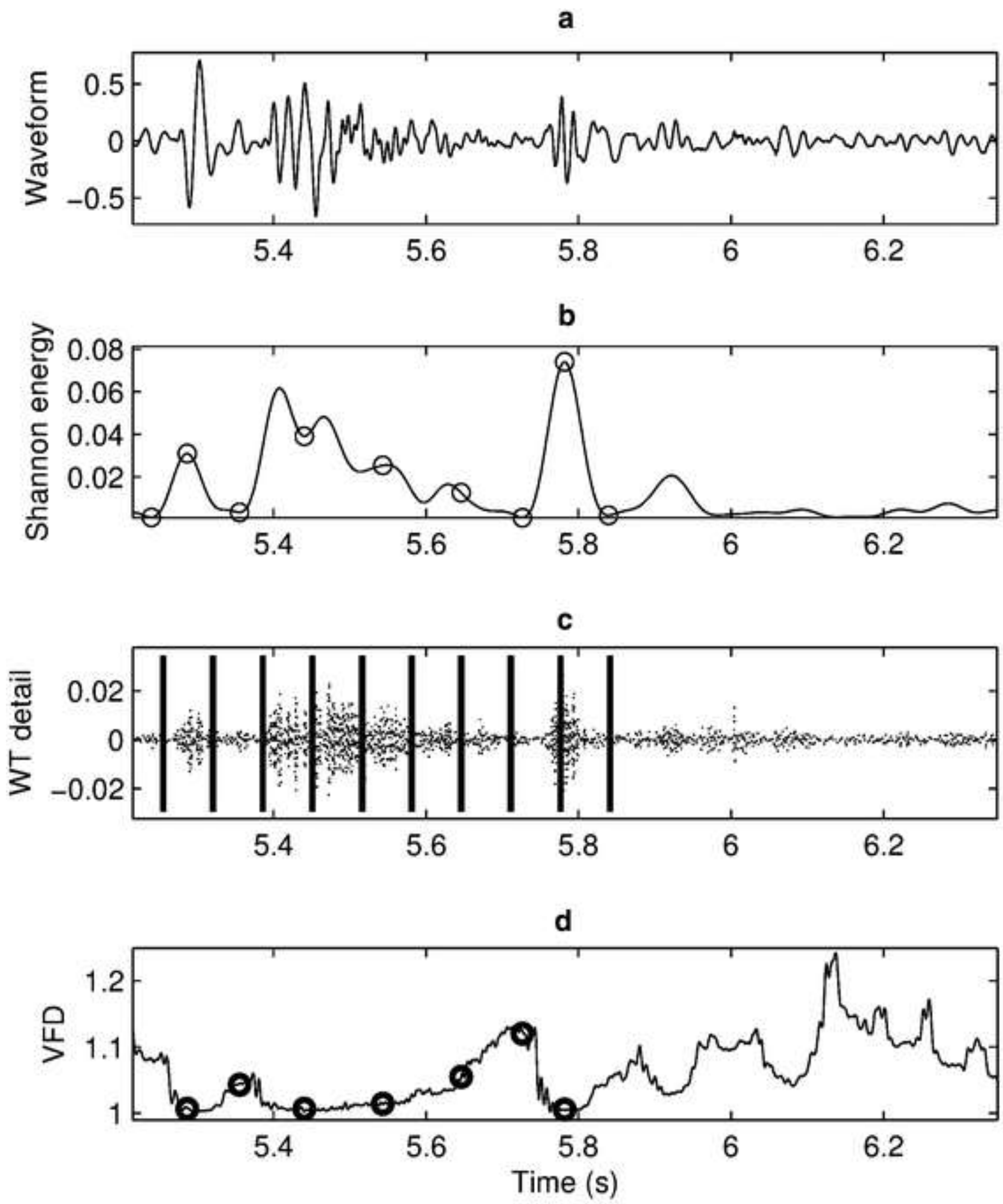
Figures and Tables

HSs are generated by the beating heart and the resultant flow of blood through it [11]. In healthy adults, there are two normal HSs (as illustrated in Figure 1): the first HS (S1), produced by the closing of the atrioventricular valves; and the second HS (S2), caused by the closure of the semilunar valves. In the case of abnormal HS, there could be other several signal activities between S1 and S2 such as S3, S4, murmur, etc. The third HS (S3) is a rare extra sound caused by a sudden deceleration of blood flow into the left ventricle from the left atrium. This sound is normal in children and adults up to age 35–40 years. After the age of 40, a third HS is usually abnormal and correlates with dysfunction or volume overload of the ventricles [12]. The fourth HS (S4) is caused by the vibration of valves, supporting structures, and the ventricular walls. S4 is proved to be a sign or symptom of heart failure during diastolic period. In general, the frequency of S1 is lower than that of S2, and the duration of S1 is longer than that of S2. The S3 occurs from 0.1 to 0.2 s after S2, while S4 occurs from 0.07 to 0.1 s before S1—both of them are low pitched. In addition to these HSs, numerous heart murmurs may arise mainly from heart problems or diseases. The murmurs are an extra or unusual sound heard during a heartbeat and broadly classified as systolic, diastolic and continuous [13, 14].

Normal Heart Beat

Smooth Heart Beat

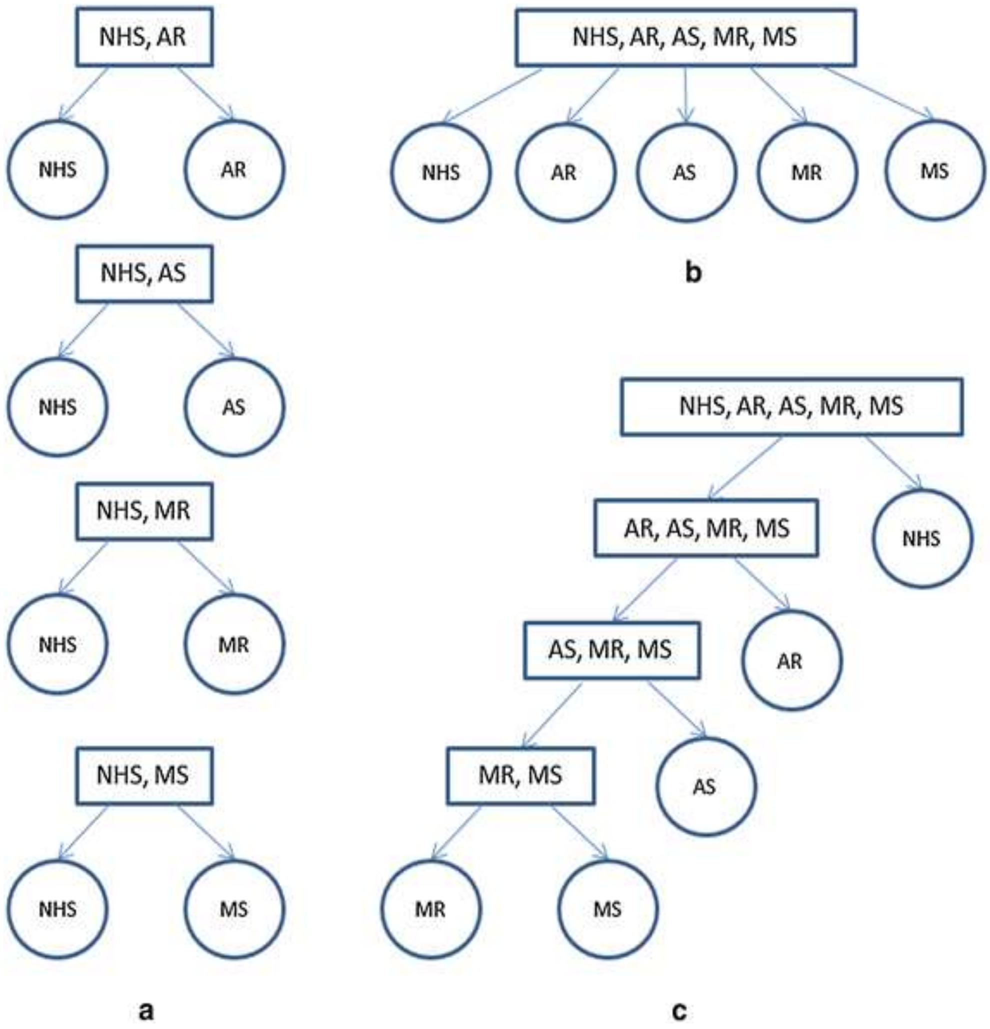




An example of feature extraction in [14]: **an** original HS waveform, **b**time domain: signals envelop extracted from Shannon energy, selected features indicated by *rings*, **c** time–frequency domain: wavelet detail, an absolute sum between time**.**

Methods for classification HS classification is a challenging task due to the nature of non-stationary property of the HS signal and large variations for the HS signals belonging to the same category. According to the review results, the artificial neural network (ANN) and support vector machine (SVM) algorithms are the classification techniques that are mostly used. The accuracy provided in [11] is 99% in classifying normal HS, MR, MS, pulmonary stenosis (PS), AR and summation gallop (SG) using ANN. The recognition rate reported in [11] was 95.56% using SVM in the classification of normal HS, MS, AS and ventricular septal defect (VSD). The ANN has the ability to adapt well to complex non-linear data (such as HS) and classify it accurately and effectively. SVM, which is a new classification technique, has been used as a classification tool with a great deal of success in various applications areas. Other methods that have been used in the classification of HSs are Gaussian mixture model (GMM), hidden Markov model (HMM), k-nearest neighbors (KNN), decision trees and Bayesian networks, etc. Interested readers can refer to [15] and the references therein, for the detailed discussions and comparisons of different classification techniques.

The structure of the classifier depends on the goal of the system which may be either to screen normally from abnormal HS or to identify a specific heart disease.[16] depicts three approaches to conduct HS classification, assuming the normal HS (NHS), AR, AS, MR, and MS are those to be classified. The objective of multiple independent binary classifications is to categorize each of the heart disorder against NHS or a different heart disorder [7,9]. The more commonly adopted approaches are multi-class classification[11] and binary hierarchical classification [6], where the former classifies the HS instances into one of more than two classes; and the latter distinguishes one class from the remaining classes at each hierarchy level.



a. Multiple binary independent classifications,

b. Multi-class classification, and

c. Binary hierarchical classification. *NHS* normal heart sound.

Proper validation of a classification method is important to see its effectiveness. Usually, the available data are divided into training set and testing set, e.g., in[9], 90% of the HSs (both normal and abnormal) were applied as training samples and the remaining 10% as testing samples; in [4] 70% of the HSs were randomly selected for training while 30% were taken for testing. Two commonly selected validation techniques are "repeated k-fold cross validation" [11-13] and "leave-one-out" method [2]

Table 3 lists the summaries of classification performances in terms of sensitivity and specificity for nine selected articles, and the following observations can be made (here only AR, AS, MR and MS are considered since they are the most commonly diagnosed heart disorders):

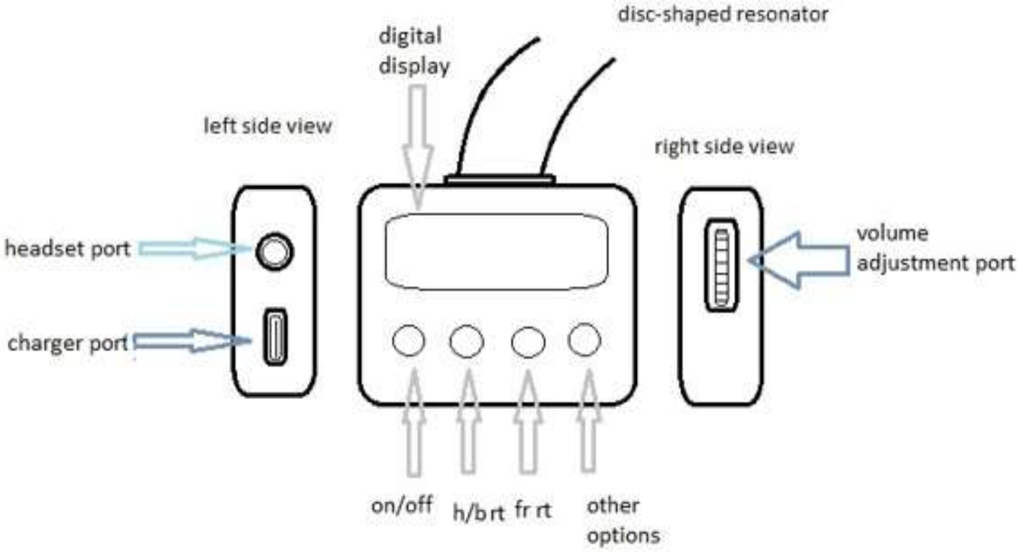
- 8, 9, 8 and 6 out of the nine selected articles considered the diagnosis of AR, AS, MR, and MS, respectively.
- The mean (sensitivities, specificities) for diagnosing AR, AS, MR and MS are (89.8, 98.0%), (88.4, 98.3%), (91.0, 97.52%) and (92.2, 99.29%).

The good classification performance obtained suggests that these techniques are potentially useful for medical application, even though it is still premature to look at their real diagnostic value as will be discussed in later sections.

Extreme learning machine (ELM), as another new machine learning method, has attracted extensive attention recently due to its remarkable advantages such as fast operation, straightforward solution and strong generalization[7-10]. However, the use of ELM in HS analysis is found to be very limited in the literature. The diagnostic potential in this domain of ELM has definitely not been sufficiently explored as yet, and so further research is required in this direction.

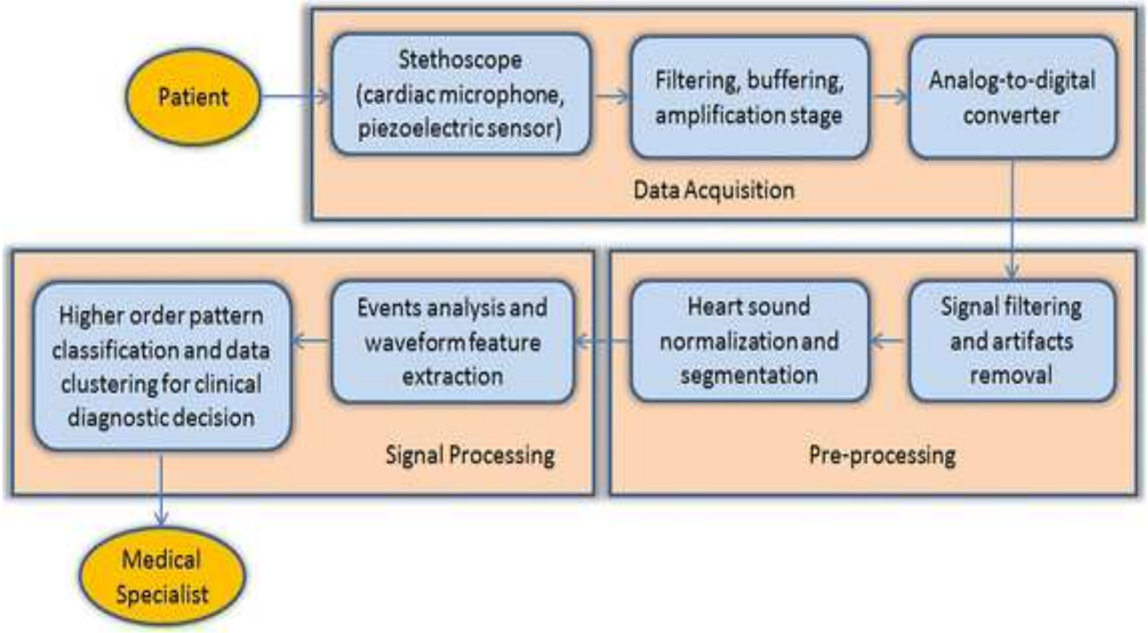
2. My innovative idea is,

Alternate the stethoscope to digitalize design. This digital device consists of the digital display by alternate of two tubes connected to earpieces. Which shows the rate of heart beat per minute within 6 seconds [that device will count the sound deflection and calculate the heart beat per minute by the output of disc-shaped resonator].and also we can hear the heart beat sound by our usual head phones. The power will get from the battery, which is located on inside the device. We can charge the battery for the charger.

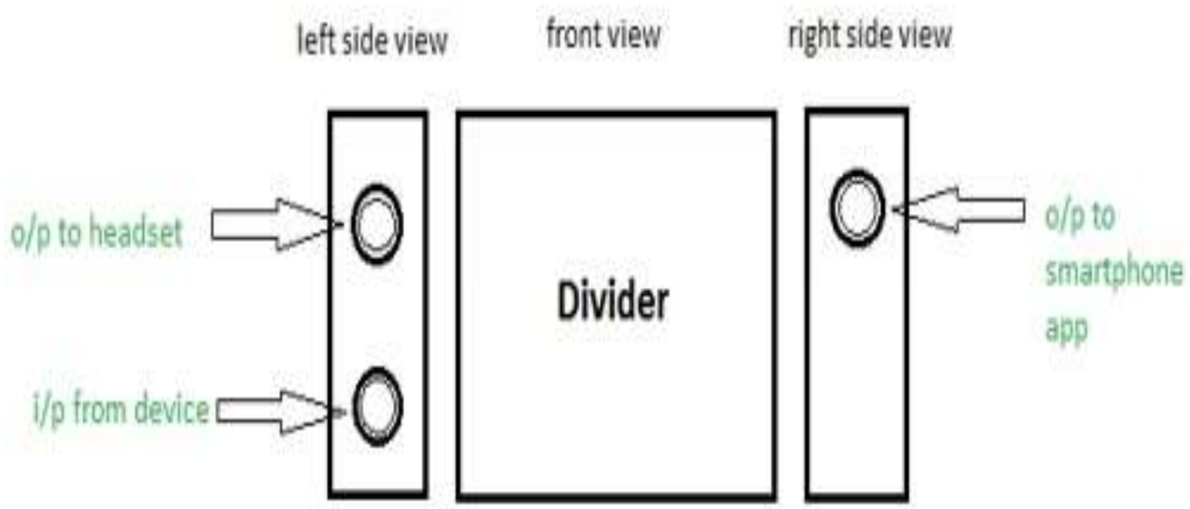


Model Diagram

2.1 BLOCK DIAGRAM



2.2Divider



Divider

And also I introduce a divider for smart phone app for recording and frequency rate and headphone connectivity. Part of the motive of this device is everyone can hear them heart beat and to know about them health with the help of any instruction and network by themselves. The motive of the device is to digitalize and make easier to use a stethoscope, etc.

2.3 Abbreviations:

ALE	adaptive line enhancer
ANC	the adaptive noise canceller
ANN	artificial neural network
AR	aortic regurgitation
AS	aortic stenosis
CMOS	complementary metal-oxide-semiconductor
CSA	the cardiac sonospectrographic analyzer
CT	computed tomography
DWT	the discrete wavelet transform
ECG	Electrocardiogram
Echo	Echocardiogram
EEMD	ensemble empirical mode decomposition
ELM	extreme learning machine
EMD	empirical mode decomposition
ES	ejection sound
FDA	food and drug administration
FFT	fast Fourier transform
FT	Fourier transform
GMM	Gaussian mixture model
HF	High frequency

HMM	Hidden Markov model
HOCM	hypertrophic cardiomyopathy
HS	Heart sound
ICA	Independent component analysis
ICS	intercostal space
IIR	the infinite impulse response
IMF	intrinsic mode function
KNN	k-nearest neighbors
LF	low frequency
LMS	least mean square
LS	lung sound
MEMS	micro-Electro-Mechanical System
MFCC	mel frequency cepstral coefficients
mHealth	mobile health
MMSE	Minimum mean square error
MP	Matching pursuit
MR	mitral regurgitation
MRI	magnetic resonance imaging
MS	mitral stenosis
MSC	mid-systolic click
MVP	mitral valve prolapse
NHS	normal heart sound
NLMS	normalized least mean square
PCG	Phonocardiogram
PDA	patent ductus arteriosus
PR	pulmonary regurgitation
PS	pulmonary stenosis
PSD	power spectral density
RLS	recursive least square
S1	the first heart sound
S2	the second heart sound
S3	the third heart sound
S4	the fourth heart sound
SG	summation gallop
SIANC	single input adaptive noise canceller
S-LMS	subband least mean square
S-NLMS	Subband normalized least mean square
SNR	the signal-to-noise ratio
SS	spectral subtraction
STFT	short time Fourier transform
STSA	the short-time spectral amplitude
SURE	Stein's unbiased risk estimate

SVM	support vector machine
TR	tricuspid regurgitation
TS	tricuspid stenosis
VHD	valvular heart disease
VSD	ventricular septal defect
WT	the wavelet transform

CONCLUSION

Now a days doctors are using usual stethoscope is only can handle by trained doctors and it is somewhat difficult and takes some amount of time to calculate heart beat rate. But this digitalized stethoscope is reducing the required time and easy to handling and accurate. Everyone can handle this digitalized stethoscope. Some advanced features also available here which is mentioned on above.

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EXTERNAL LINKS

- The Auscultation Assistant, provides heart sounds, heart murmurs, and breath sounds in order to help medical students and others improve their physical diagnosis skills
- Demonstrations: Heart Sounds & Murmurs University of Washington School of Medicine
- VCU Libraries Medical Artifacts Collection: Stethoscopes
- "The invention of the stethoscope: A milestone in cardiology", analysis of Laennec's text (1819) on *BibNum*[click 'à télécharger' for English version].

