A Low-Cost Portable Heart Sounds Analysis by Using Microcontroller

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Abstract:-Generally the ratio of people against doctor is so scanty in most of the economically backward countries that cause delayed diagnosis and non-availability of on-time treatment of cardiac patients specifically in the rural areas. It forces to think about ease of utilize of low price equipment in the rural hospital center which may readily diagnose and alarm the critical cardiac condition of patient in absence of cardiologist too, so that the patient can immediately be carried to nearby city hospital for early diagnosis.

This paper presents of heart sounds analysis is done through phonocardiography, the non-invasive system monitor of the real-time heart sounds of patients. Heart has many pathological conditions of which can cause murmurs and aberrations etc., in heart sounds as much before they occur as other symptoms. This system consists of five end modules, whereas the first end module captures the heart sound signals. But in generally heart has two types of sounds. In additionally it has another two type of sounds the third sound indicates the heart attack of the patient or individual. The phonocardiogram signal can acquire signals and get subjected through some amplifier circuits and some processing techniques like (PDA, screening, feature selection method, PCG) etc., The PCG signal is traditionally analyzed and characterized by dialectology properties in the time-domain, by spectral properties in the frequency domain or by non-stationary properties in a joint time-frequency domain.

KEYWORDS: Phonocardiograph, PCG device, Human Heart, Osculation, Sound Analysis, Adaptive filter.

I Introduction

ECG is the wave form taking the record of the electrical activity of the heart via electrodes attached to skin. A simple and cheaply method, ECG is constantly used by the physicians. ECG records and their analysis that are used to detect defects in the heart are relatively a good method. On the other hand, if the likely generating system of heart is utterly acting with small heart defects, it may look very difficult to diagnose these abnormalities with the analysis of ECG records as nearly no change in the ECG will be discovered. The phonocardiogram is quite well-known device, which is used to listen to the heart sounds of a human being and the output from the machine is compared with the ideal heart sounds of human heart at the age and the deviation from the ideal response is then analyzed to detect the nature of condition. The contraction and relaxation of heart, blood flow movement can be heard through stethoscope and a device commonly used for some processing techniques like screening, PCG etc., in primary health care. Heart sounds are the noises generated by the beating heart and the resultant flow of blood through it (specifically, the turbulence created when the heart valves snap shut). In cardiac auscultation, an examiner may use a stethoscope to listen for these unique and distinct sounds that provide important auditory data regarding the condition of the heart to a trained observer. In healthy adults, there are two normal heart sounds often described as a lub and a dub (or dup), that occur in sequence with each heartbeat. These are the first heart sound (S_1) and second heart sound (S_2), produced by the closing of the AV valves and semi lunar valves respectively. In addition to these normal sounds, a variety of other sounds may be present including heart murmurs, adventitious sounds, and gallop rhythms S_3 and S_4.Heart murmurs are generated by turbulent flow of blood, which may occur inside or outside the heart. Murmurs may be physiological (benign) or pathological (abnormal). Abnormal murmurs can be caused by stenosis restricting the opening of a heart valve, resulting in turbulence as blood flows through it. Abnormal murmurs may also occur with valvular insufficiency (or regurgitation), which allows backflow of blood when the incompetent valve closes with only partial effectiveness. Different murmurs are audible in different parts of the cardiac cycle, depending on the cause of the murmur, shown in fig. 1.

Noise is a big problem in PCG signals. The sensor, the sensor contact surface, the patient's position, the auscultation area, the respiration phase and the background noise all influence the quality of the sound. In practice this means that the recordings often contain noise such as friction rubs, rumbling sounds from the stomach, and respiratory sounds from the lungs and background noise from the clinical environment. The basic aim of phonocardiography is to provide the clinicians with a complementary tool to record the heart

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sounds and murmurs heard during cardiac auscultation. Since phonocardiography is noninvasive and provides valuable information concerning the functional integrity of the heart, it has a high potential for detecting various heart diseases.

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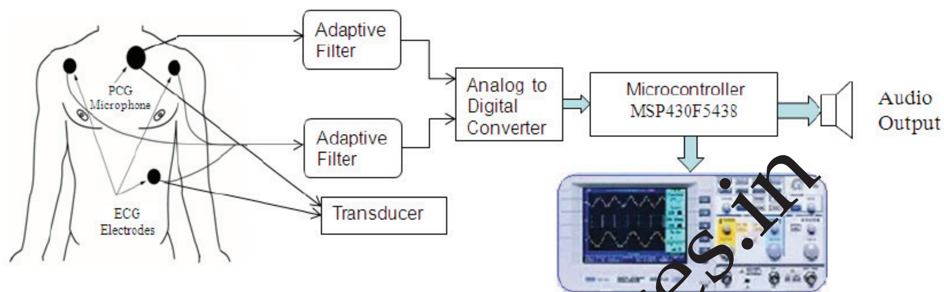

Figure 1: Block diagram of the Microprocessor based proposed PCG machine

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II. The Human Heart

The heart is a muscular organ responsible for pumping blood through the blood vessels by repeated, rhythmic contractions. The heart is composed of the cardiac muscle, an involuntary muscle tissue which is found only within this organ. The cardiac valves maintain unidirectional flow of blood by opening and closing, depending on the difference in pressure on each side. There are four valves of the heart (not counting the valve of the coronary sinus and valve of the inferior vena cava). The two atrioventricular (AV) valves ensure that blood flows from the atria to the ventricles, and not the other way. The two semilunar (SL) valves are present in the arteries leaving the heart, and they prevent the blood flowing back from the arteries into the ventricles. The sound of heart valves shutting causes the heart sounds

A. Extra Heart Sounds

The rarer extra heart sounds form gallop rhythms and heard in both normal and abnormal situations.

Heart's sounds are generated within the heart during cardiac cycle. The main cause of these sounds is acceleration and deceleration of blood flow, and closing and opening of the heart valves. Normally there are two heart sounds, and any additional sounds indicate diseased condition of cardiac. If a third heart sound is present it could be a sign of cardiac failure whereas a murmur indicates defective valves or an orifice in the septal wall. There are four sounds produced in the heart, shown in fig. 2:

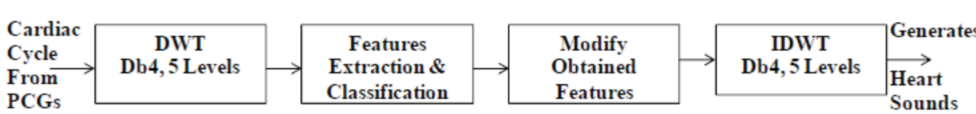

Fig.2: Block diagram of PCG feature extraction by using DWT

First Heart Sound: It is heard at the onset of the ventricular systole, during the closure of the AV valves. It is of longer duration than the other heart sounds and the frequency is around 25 to 45 Hz. It is called "Lub". The causes of the first heart sound are mainly due to three reasons: Vascular, Muscular and Valvular.

- Vascular cause is due to the turbulence created in the blood due to ventricular contraction in it.
- Muscular cause is due to the vibration of the walls of the contracting ventricles.
- Valvular cause is due to the vibration of the walls of the valve cusps during closure.

Second Heart Sound: It is heard at the end of clinical systole during closure of the semi lunar valves. It is of shorter duration and is of higher frequency (50Hz) than the first heart sound. It is called "Dub". The causes of the second heart sound are mainly also due to the three reasons: Vascular, Muscular and Valvular.

- Vascular cause is due to the oscillation/vibration of the blood column in the aorta and in the pulmonary trunk.
- Muscular cause here means vibration of the walls of the pulmonary trunk and the ascending aorta.
- Valvular cause is due to the closure of the semi lunar valves.

Third Heart Sound: It is a low pitched soft sound of 0.1 second duration, heard in the early diastole and is produced due to the first rapid filling phase, i.e., after the second sound. It occurs probably due to vibration in the ventricular wall, caused by the movement of blood. It can be heard sometimes in normal children and young individuals with thin chest and high venous return. Third sound in abnormal situation signifies heart failure.

Fourth Heart Sound*:* It is also called arterial sound and is produced during arterial contraction. It is heard just before the first sound i.e. late in the diastole. It is believed to be produced when the atria are forcefully trying to pump blood into noncompliant ventricles. It is not heard in case of a normal individual. In abnormal situations like heart failure, after myocardial infarctions, the fourth sound is often heard, shown in fig. 3.

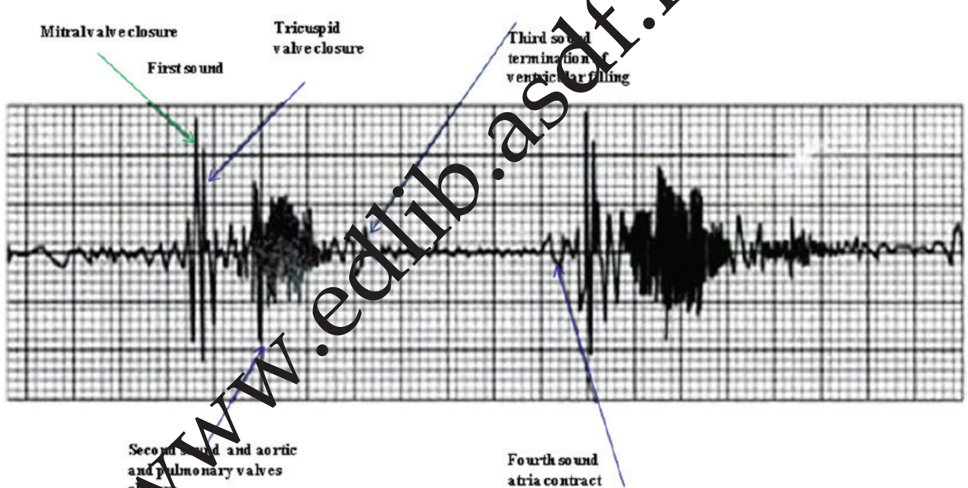

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Fig. 3: Basic heart sound in a phonocardiogram recording

III. Acquisition of PCG Signals

The audio recording chain involves a sequence of transformations of the signal: a sensor to convert sound or vibrations to electricity, a pre-amplifier to amplify the signal, a pre-filter to avoid aliasing and an analogue to digital converter to convert the signal to digital form. In addition, the chain can be complemented with an analysis step and an information presentation step. Sensors Microphones and accelerometers are the natural choice of sensor when recording Sound. These sensors have a high-frequency response that is quite adequate for Body sounds. Rather, it is the low-frequency region that might cause problems. The microphone is an air coupled sensor that measures pressure waves induced by chest-wall movements while accelerometers are contact sensors which directly measure chest-wall movements. For recording of body sounds, both kinds can be used. More precisely, condenser microphones and piezoelectric accelerometers have been recommended. Electronic stethoscopes make use of sensors specially designed for cardiac sounds. Compared to classical stethoscopes, electronic stethoscopes try to make heart and lung sounds more clearly audible by using different filters and amplifiers. Some also allow storage and the possibility to connect the stethoscope to a computer for further analysis of the recorded sounds. The leading suppliers of electronic stethoscopes are Cardionics, Thinklabs, Meditron (Welch-Allyn) and 3M (Littmann). Thinklabs uses a novel electronic diaphragm detection system to directly convert sounds into electronic signals. Welch-Allyn Meditron uses a piezo-electric sensor on a metal shaft inside the chest piece, while 3M and Cardionics use conventional microphones. More recently, ambient noise filtering has become available in electronic stethoscopes, shown in fig. 4.

IV. Adaptive Noise Canceller

In a noisy environment (e.g. inside a vehicle), speech communication is greatly affected by the presence of background acoustic noise (e.g. noise produced by man and god made).Consequently, there is an utmost requirement to ensure negligible noise components in the recorded PCG and ECG signal. One possible way to satisfy such a requirement to obtain a better recording of the desired signal is the use of a simple noise canceller. However, such a naive approach to subtract the reference noise signal directly from the primary signal is bound to fail because the noise signal at the reference sensor is not exactly the same as the delayed and/or filtered version of noise at the primary sensor. In worse cases, this may even lead to an increase in the average power of the noise output. However, when proper provisions are enforced and the subtraction operation is controlled by an adaptive process, we will be able to obtain a far more superior noise cancellation performance compared to the previous approach.

V. Result Discussion

The characteristics of the PCG and ECG signal and other features such as heart sounds S1 and S2 location; the number of components for each sound; their frequency content; their time interval; all can be measured more accurately by digital signal processing techniques.

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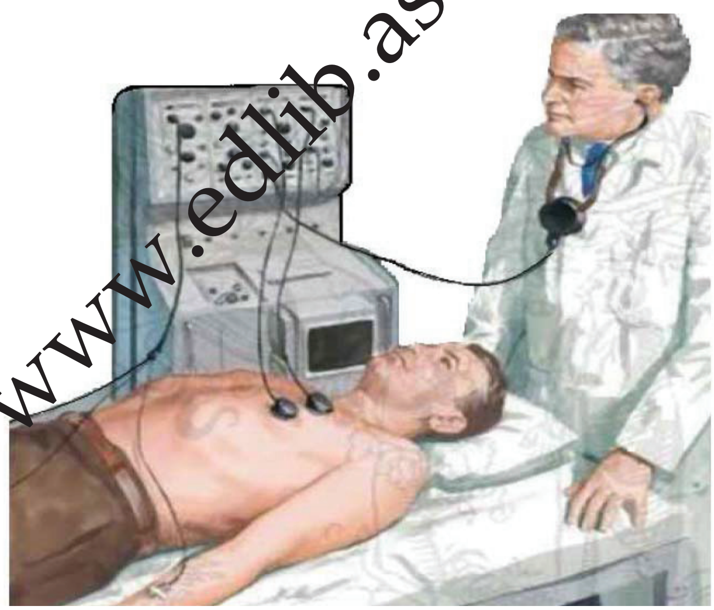

Fig. 4: Instrument used for recording sounds connected with the pumping action of heart.

The performance of the system as a whole is now being considered and a critical analysis of this project is made. The output that was observed after performing tests on a number of persons quite resembled the output of a commercial PCG and ECG machine (see figure 5 & 6). The observations carried on patients gave quiet satisfactory results sufficient to conclude the condition of the heart in a deterministic way. However, it may require a little skill to observe and analyze the waveform generated by this equipment since it seems to be a little mutilated (see figure 5) which need careful.

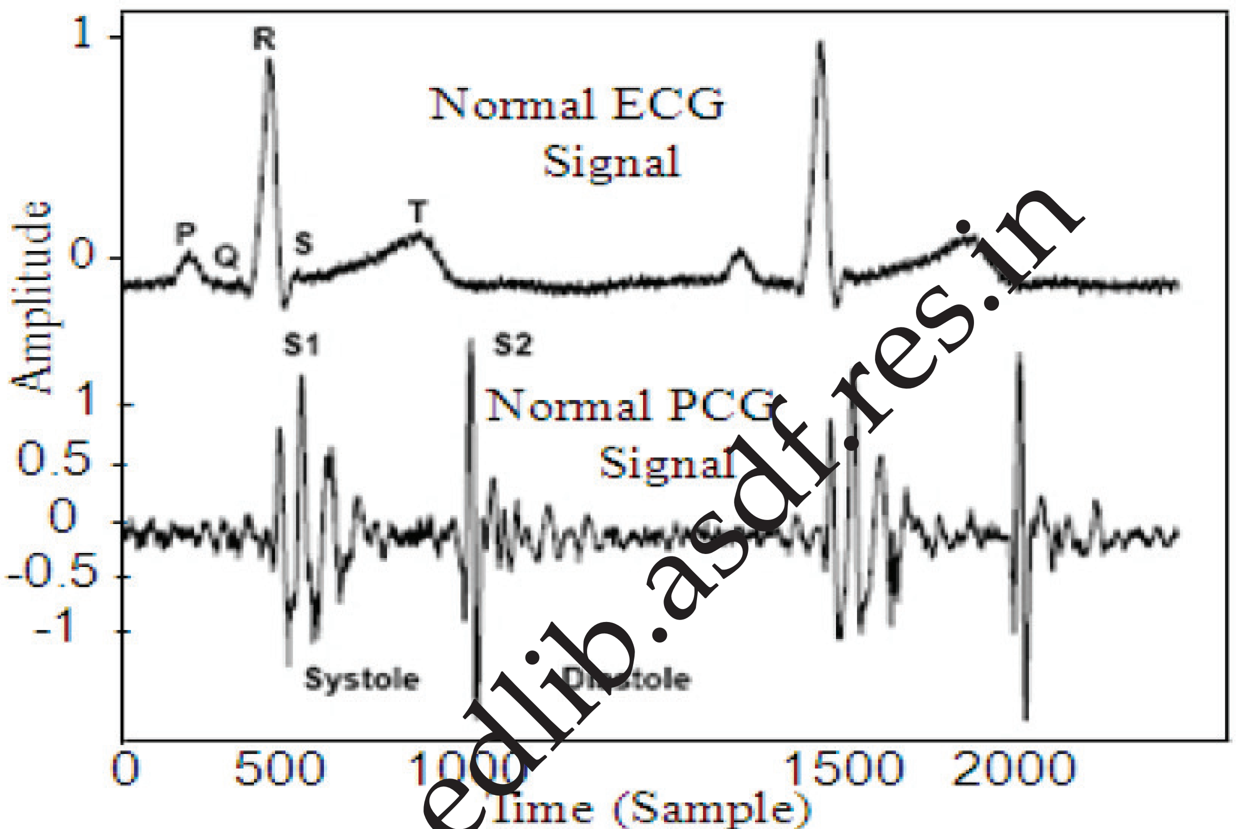

Fig. 5: Correlation between the phonocardiogram signal (PCG) and the electrocardiogram signal (ECG)

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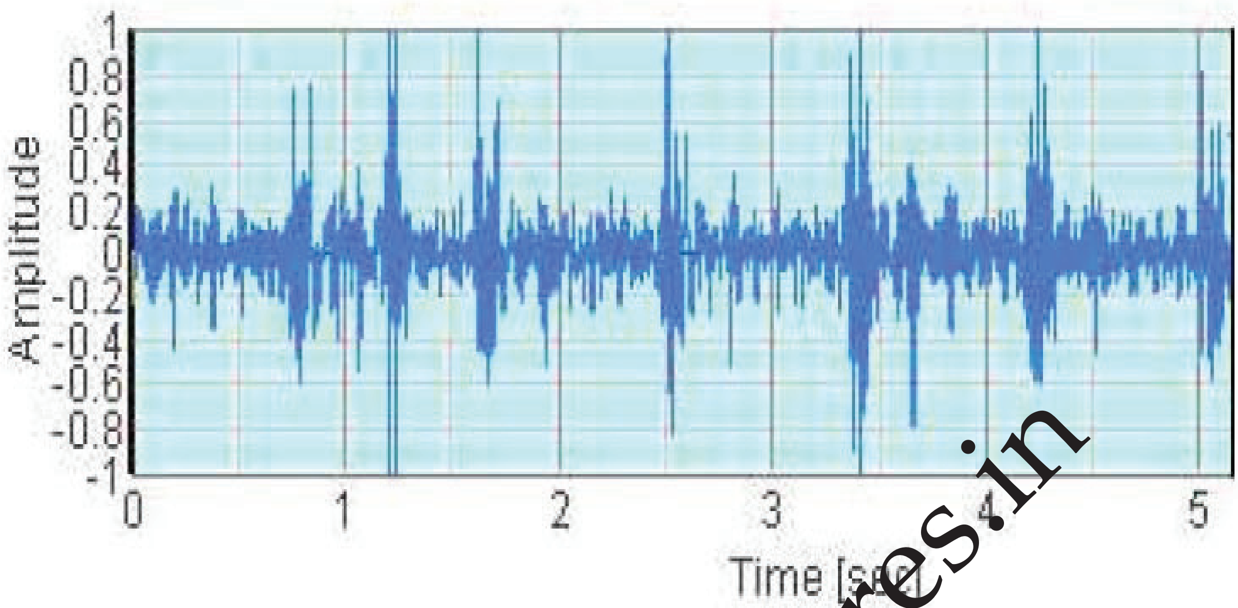

Fig. 5: Input PCG signal

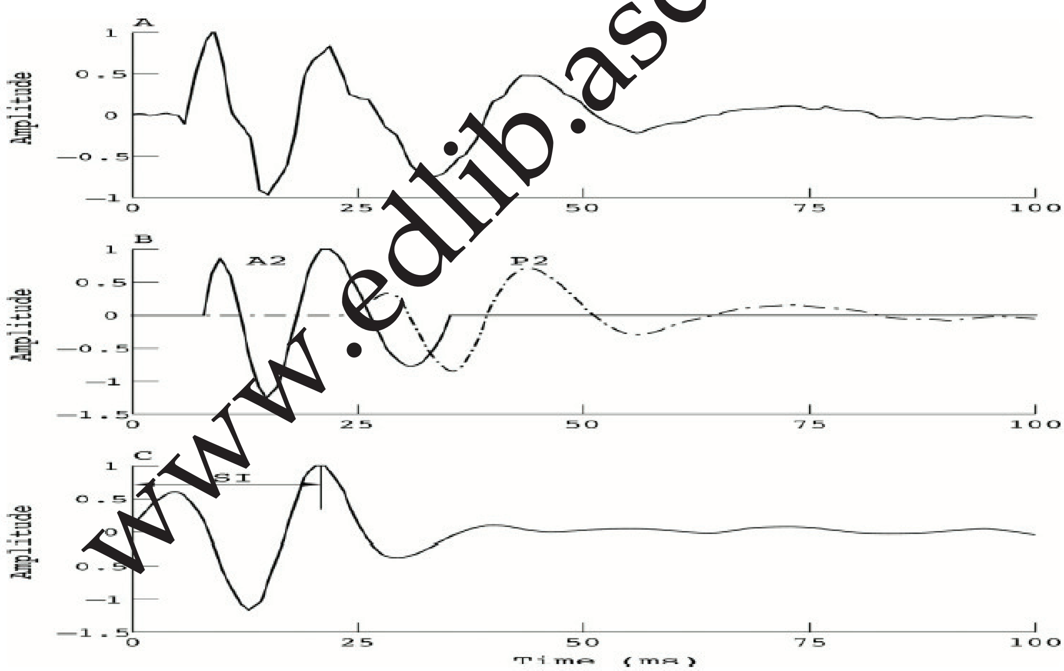

Fig. 6: Method for the estimation of the splitting interval (SI) between the aortic (A2) and pulmonary (P2) components of the second heart sound (S2).

VI. Conclusion

The main advantages of this device are – this is an innovative, versatile, cost effective device. The only shortcoming is that certain amount of noise is present in the system that can be seen reflecting in the

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output. However, this does not interfere with the diagnosis procedures or the inference. The display of signals is a little mutilated that need a careful examination.

Since biomedical signals are very noisy and varies considerably from patient to patient, and also depends upon environmental conditions, it is pertinent to consider a time sequence of patient data (i.e., historical data) rather than relying on data captured at a particular instant of time (i.e., instantaneous data). For more sophisticated analysis a self-inferential software can be created that carries sampling, quantification, and encoding of data, and works in conjunction with a linked cardiac database.

VII. References

1. A. Mahabuba, J. Vijay Ramnath and G. Anil, Analysis of heart sounds and cardiac murmurs for detecting cardiac disorders using phonocardiography, Journal of Instrumentation Society of India, Vol. 39 No.1, March 2009.
2. Shivajirao M. Jadhav, Sanjay L. Nalbalwar & Ashok A. Ghatol, Modula Neural Network based Arrhythmia Classification System using ECG Signal Data., International Journal of Information Technology and Knowledge Management, January – June 2011, Vol. 4, pp. 205 – 209.
3. Gokhan Bilgin and Oguz Altun, Cardiac Problem Diagnosis with Statistical Neural Networks and Performancee Evaluation by ROC (Receiver Operation Characteristics), Yildiz Technical University, Istanbul.
4. Curt G. DeGroff, Sanjay Bhatikar, Jean Hertzberg, Robin Shandas, Lilliam Valdes-Crutz, and Roop L. Mahajan, Artificial Neural Network-Based Method of Screening Heart Murmurs in Children, Circulation, Jounal of American Heart Association, Circulation 2001;103;2711-2716.
5. Shaikh Abdul Hannan, R. R. Manza, and R. J. Ramteke, Generalized Regression Neural Network and Radial Basis Function for Heart Disease Diagnosis, International Journal of Computer Applications (0975-8887), Volume 7 – No. 13, October 2010.
6. Sepideh Babei and Amir Garanmayeh, Heart Sound Reproduction based on Neural Network classification of Cardiac Valve disorders using wavelet Transformation of PCG Signals, Computers in Biology and Medicine 39 (2009) 8-15, Elsevier.
7. Ganmin Ning, Jie Su, yingqi Li, Xiaoying Wang, Chenghong Li, Weimin Yan, amd Xioxinang Zheng, Artificial Neural Network based Model for Cardiovascular Risk Stratification in Hypertension, Medical Biological Engineering Computation (2006) 44; 202-208, DIO 10, 1007/s11517-006-0028-2.
8. Christer Ahlstorm, Processing of the Phonocardiographic signal – method for the intelligent stethoscope. Linkoping University, Institute of Technology, Thesis No: 1253, LIU-TEK-LIC: 2006: 34.
9. Durand, L.G., de Guise, J., and Guardo, R.A.L.: A microcomputer-based spectrum analyser for phnocardiography. Proceedings of the 32nd Ani.ual Conference on Engineering in Medicine and Biology, vol. 21, p. 2, October 1979.
10. Kingsley, B.: Acoustic Evaluation of Prosthetic Cardiac Valve in the Audio Spectrum. Journal of Audio Engineering Society Vol. 20, No. 9, pp. 750-755, November 1972.

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