

## **Algorithms for Automated Diagnosis of Heart Diseases Using an Electronic Stethoscope**

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Phonocardiography or heart sound signals acquired through an electronic stethoscope can be processed and analysed for the automatic diagnosis of heart related diseases, and thus used to provide a decision support system to assist medical professionals. Our aim is to develop an intelligent stethoscope, which is low cost and can be used in the same convenience of the normal stethoscope. This would provide an advanced device even for community level health care systems. At the core of this intelligent stethoscope is a set of algorithms. For the last two decades, a lot of work has been done to develop the automated electronic stethoscope. In addition to the investigation of heart sound signals using digital signal processing techniques, the available research has focused on segmentation of heart sound signals with or without using electrocardiography (ECG), and classification to diagnose heart diseases using the features extracted from the heart signals.

In this research, the focus is to detect heart abnormalities without ECG, as using it would make the device expensive and inconvenient, and to extract as much features as possible through signal processing and other computational methods for classification. The proposed procedure basically consists of segmentation of the heart signal to identify the first and second heart sounds, the systolic and diastolic phases, and to identify heart murmurs (due to heart valve problems), according to its phase, the temporal position and distribution (as early, late and pan). In addition, heart rate variation is also estimated to diagnose heart rate related diseases.

The segmentation algorithm is based on the Short Term Fourier Transform (STFT) or the spectrogram of the heart signal. Using the observations reported in the literature, that murmurs are of higher frequencies than heart sounds, the time-frequency spectrum is divided into two bands in the frequency domain, and the variation of energy in each of the bands with time is computed to obtain two functions: one to carry out segmentation and diastolic/ systolic phase identification; and the other to identify the temporal position and distribution of the murmurs within a phase. The algorithm was initially tested for a set of signals obtained from health-care training web sites, and has shown promising results for murmur detection. However, murmurs that overlap with the first and second heart sounds in the frequency domain posed a challenge for the proposed algorithm. As the algorithm is capable of computing the period of each heart cycle, heart rate variation can be estimated and diseases related to heart rate can also be diagnosed.

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