

Abstract

Heart sound analysis using auscultation, the noninvasive cardiac testing, continues to be the physician's primary tool for the diagnosis of heart valve diseases. Phonocardiogram (PCG), a graphical representation of the cardiac sound provides valuable information of functioning of heart valves and the hemodynamics of the heart. The aim of the thesis is to process and extract useful information from PCG signal for clinical purposes and automatic disease diagnosis using digital signal processing and pattern recognition techniques. The simple and cost-effective approach for detection of heart valve diseases has been the major motivation towards employing it in efficient ways from PCG signal. In particular, the focus is on increasing the classification accuracy for diagnosing the valvular heart disease and decreasing the computational load in the identification phase while an attempt is made simultaneously to keep the recognition accuracy reasonably high by introducing novel feature sets. First, it proposes a heart sound segmentation algorithm for detecting the location of primary heart sounds ($S1$ & $S2$) in a continuous PCG recording and boundary estimation algorithm for estimating the exact boundaries of primary heart sounds that do not require electrocardiographic (ECG) signal as a continuous auxiliary input. Subsequently, a robust feature extraction method has been proposed for automatic classification of heart sounds based on empirical mode decomposition (EMD) method for capturing different diseases specific information from PCG signal. In sequel, a straightforward and non-exhaustive search based approach has been proposed in the thesis to optimize the artificial neural network (ANN) structure for automatic classification of heart sound signals. The proposed framework attempts to design a compact form of output layer with less number of nodes than output classes, select a set of input features based on singular value decomposition (SVD), QR factorization with column pivoting (QRcp) and F -Ratio, make certain optimum selection of hidden nodes based on SVD, select and prune weights based on

the concept of local relative sensitivity index (LRSI) for empirically chosen overparameterized ANN structure for PCG classification. Finally, a PCG signal enhancement method has been proposed based on EMD framework. A combination of EMD and Savitzky-Golay (SG) least-squares polynomial filter is presented for PCG denoising. In addition, a novel denoising method has been proposed which combines the EMD and adaptive degree polynomial filter (ADPF), in order to achieve superior performance in the enhancement of PCG signal.

Keywords: Adaptive-degree polynomial filter, artificial neural network, boundary estimation, classification of heart sounds, denoising, diastole, empirical mode decomposition, F-Ratio, heart sounds, murmurs, optimization, phonocardiogram, pruning, QRcp, Savitzky-Golay filter, segmentation, SVD, systole.