INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

Phonocardiogram (PCG) is a graphical representation of a heart sound signal. It provides vital information about the myocardium, septum, and valvular events, resulting directly from hemodynamic and heart rhythm. Any heart dysfunction is reflected as an abnormal sound in the PCG signal. This thesis documents our investigation on noisy PCG signals for the segmentation and classification of heart sound signals. The contributions to this thesis work are listed below. Firstly, a hybrid dual filtering process is introduced to remove noise from the PCG signal. The method combines the band-pass filter (BPF) or wavelet transform (WT) to remove high-frequency noise and the total variation filter (TVF) to smooth the residual low-frequency noise. In the proposal, the smoothing parameter of TVF is derived from the signal complexity measures calculated as the sample entropy. Also, by analyzing the complexity of the signal to determine the prerequisite of the denoising process, it avoids over smoothing the signal waveform. The proposed dual filtering process emphasizes the S1 and S2 sounds, also known as the fundamental heart sound (FHS), in PCG signals. Secondly, the logistic function is investigated to enhance the envelope peaks of S1 and S2 sounds. The method maps the dominant amplitudes of FHS to the upper asymptote of the sigmoid-curve (logistic function) and the noise signals to the asymptotic tail by adjusting the growth rate and the shift of the sigmoid-curve mid-point. These parameters are calibrated according to the critical amplitudes that will segregate the signal amplitudes to the category of loud sound or weak noise sound. A heuristic method based on histogram analysis of signal intensities is used to decide the critical amplitudes. The PCG envelope generated using the proposal demonstrates significant improvement over the conventional methods with a large amplitude margin between the FHS and the silent intervals of the PCG signals. Thirdly, a multi-mode duration model for the hidden semi-Markov model (HSMM) is introduced for heart sound segmentation (HSS). In the proposed duration model, each mode represents a cluster of duration values defined within a restricted variance and clustered using the hierarchical agglomerative clustering method. The intuition is that each mode denotes a local reference for the HSMM to determine the actual state duration based on the maximum likelihood criterion. The modification improves the versatility of the HSMM model to accurately segment the PCG signal with large heart rate variation. Lastly, the new sub-band energy (SBE) feature and the inter-segment spectral correlations measures are presented as potential diagnostic features to classify the PCG signals into a normal, murmur, or noisy categories. It also investigates the potential of existing features such as the log-magnitude spectrogram, SBE defined over Bark scale, mel-frequency cepstral coefficients, and the rhythm pattern (RP). The proposed SBE feature is specified based on the primary frequency components of each class of the heart sound. And the inter-segment correlations are measured to investigate the changes in different intervals of the cardiac cycle. On employing the individual feature to classify PCG signals, the proposed SBE feature yields better accuracy. When different features are combined, the correlation coefficient for pair systole and diastole with either 1-4 order MFCC or the proposed SBE feature yields comparable results and performs better than the other feature combinations. From the study, it is convinced that the proposed features have the potential for improvement. The features may be extended to classify murmurs and pathology with detailed analysis.