INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: CARDIAC PARAMETERS ESTIMATION USING SEISMOCARDIOGRAPHIC AND REMOTE PHOTOPLETHYSMOGRAPHIC SIGNALS

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SHORT ABSTRACT

Cardiovascular diseases (CVDs) are major risk factors contributing to the increasing death rate. Effective and regular monitoring of cardiac activities are useful for early detection and clinical management of the CVDs. Many vital parameters, such as heart rate (HR), heart rate variability (HRV), blood pressure (BP), oxygen saturation (SpO2), and respiratory rate (BR) provide insight to cardiac health and help in diagnosing and treating life-threatening diseases. In this study, two emerging cardiac modalities, such as seismocardiography (SCG) and remote photoplethysmography (rPPG) are considered for the estimation of cardiac vital parameters. The SCG is a non-invasive technique that captures the chest wall vibrations induced by cardiac mechanical activities. The acquired SCG signal needs precise delineation and feature extraction prior to the measurement of human vital parameters. The first part of the thesis involves the detection of the prominent peaks of SCG cycles and investigates their possible clinical applications. A data-adaptive modified variational mode decomposition (MVMD) method along with simple decision rules are incorporated to extract two fiducial points, AO and post-AC (pAC) peaks. Later, these points are utilized to derive systolic blood pressure (SBP), diastolic blood pressure (DBP) and HRV parameters. Another application is explored, which utilizes these feature points along with the demographical information of the volunteers to identify ventricular depolarization events using a deep feedforward neural network (DFN). The proposed methods are evaluated on publicly available CEBS database (at PhysioNet archive) and in-house recordings created using a small electronic circuit board consisting of a 3D MEMs-based accelerometer, pre-amplifier, and a filter.

In the second part of the thesis, camera-based rPPG technology is employed to generate the cardiac waveforms and further used them as an application in vital measurements. rPPG is a non-contact camera-based method that senses the variation in reflected light intensity associated with the change in blood flow volume. Accurate estimation of cardiac parameters using this technology needs robust framework that facilitates the extraction of reliable rPPG signal embedded within the video frames. Signal extraction frameworks involve preprocessing steps, region of interest (ROI) selection, and proper filtering schemes. In this direction, both conventional and deep neural network

(DNN) based frameworks are explored. The first method is a conventional technique that is based on 2D-variational mode decomposition (VMD) scheme. Performance analysis suggests that the VMD method performs well. However, this method is based on prior assumptions that may not hold well for real time data. Therefore, in the second approach, few DNN architectures are designed and developed without any prior assumptions to fit into the real dynamic settings. The designed architectures are based on 1D, 2D, and 3D convolution neural networks (CNNs). The input variable for the 1D-CNN is a raw signal generated by averaging the pixel values within the region of interest (ROI), whereas a scalogram-based feature image is chosen as an input for the 2D-CNN. Both the networks are proposed for the extraction of a reliable rPPG waveform that is successively used for HR estimation and HRV analysis. In contrast to 1D and 2D CNN frameworks, the input to the 3D-CNN is the raw video data. This architecture is designed for multitask where remote electrocardiography (rECG) along with rPPG is generated. The generated signals are quantified by estimating HR values and comparing them with the corresponding ground-truth values. The robustness of the proposed rPPG methods is evaluated using publicly available UBFC-rPPG, COHFACE, and ECG-fitness datasets.