Prospects of Cuffless Pulse Pressure Estimation from a Chest-Worn Accelerometer Contact Microphone

Arash Shokouhmand[1], Haoran Wen[2], Samiha Khan[3], Joseph A. Puma[4], Amisha Patel[4], Philip Green[4], Farrokh Ayazi[2,5], Negar Ebadi[1]

[1]Stevens Institute of Technology, Hoboken, USA
[2]StethX Microsystems Inc., [5]Georgia Institute of Technology, Atlanta, USA
[3]New York Institute of Technology, [4]Sorin Medical P.C., New York, USA

Introduction: Clinical studies have established a direct correlation between pulse pressure (PP) and stroke volume, as well as a connection between stroke volume and heart sounds. However, the relationship between PP and heart sounds produced by blood ejection remains unexplored. To address this gap, this study investigates the prospects of cuffless monitoring of PP from heart sounds induced by blood ejection onto the chest wall. This approach offers an alternative to cuff-based pulse pressure monitors currently used in home settings.

Methods: The proposed framework leverages a sensitive accelerometer contact microphone (ACM) to record chest vibrations. A discrete wavelet transform (DWT) decomposes the chest vibration recordings into a set of sub-bands, from which several time-domain features are extracted. An extreme gradient boosting (XGBoost) regressor is trained on the feature space for PP estimation, and the estimated values are compared with PP readings from a standard cuff-based blood pressure monitor.

Results: The performance of the model is evaluated on 20 patients with cardiovascular diseases (CVDs). Average root mean square error (RMSE), mean absolute error (MAE), and accuracy of 11.41 (± 6.42) mmHg, 10.49 (± 6.73) mmHg, and 77.14% (± 19.09%) are achieved, respectively, for a leave-subject-out validation. Additionally, the performance of the model is assessed through a 10-fold cross validation where an average accuracy of 95.68% is obtained, implying high consistency with ground-truth values. The most significant signal sub-bands for PP estimation are found to be high-frequency bands such as 1-2 kHz and 512-1,024 Hz, as well as medium-frequency bands of 32-64 Hz and 64-128 Hz. It is also demonstrated that the most contributive sub-band to PP estimation is 1-2 kHz.