# Technical Review on BCG and IMU for HRV Detection

## Introduction

Heart Rate Variability (HRV) analysis has emerged as a valuable tool for assessing the autonomic nervous system. Traditional methods for HRV detection often rely on electrocardiography (ECG), which can be cumbersome and impractical for continuous monitoring. This review explores recent research on utilizing Ballistocardiography (BCG) and Inertial Measurement Units (IMU) as alternative approaches for HRV detection. These methods offer the potential for less intrusive and more convenient HRV monitoring, opening doors for wider applications in healthcare and personal wellness. This document summarizes key findings from five recent publications on this topic.

## Publications

### A Novel Detection Method for Heart Rate Variability and Sleep Posture Based on a Flexible Sleep Monitoring Belt

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**Abstract:** Heart rate variability (HRV) is an important indicator for assessing the function of the cardiac autonomic nervous system (ANS), and it is important for early detection and prevention of cardiovascular diseases, stress management, and mental health. Besides, different sleep postures have different effects on respiration and ventilation, and inappropriate sleep postures may lead to organ compression and obstructive sleep apnea (OSA). Therefore, HRV and sleep posture detection are very significant. However, there is a lack of the high-comfortable, low-cost, and high-accuracy detection methods. In this article, a novel detection method for HRV and sleep posture based on a flexible sleep monitoring belt (FSMB) is proposed. The test platform, including an FSMB and a bioelectrical signal acquisition circuit (BSAC), as well as the test flow, is described in detail. The BSAC composed of a series of amplifiers and filters is designed to acquire the electrocardiography (ECG) signal, while the FSMB mainly composed of a MEMS inertial measurement unit (IMU) and a pressure sensor array is designed to acquire the ballistocardiography (BCG) or gyrocardiography (GCG) signal. Besides, the HRV features of ECG, BCG, and GCG signals are extracted by the wavelet packet transform (WPT) analysis, and the short-time energies of the triaxial accelerations and angular velocities are extracted as the features for sleep posture detection. For facilitating the realization with edge computing, a lightweight convolutional neural network (CNN) model is proposed to recognize the sleep posture. The experimental results indicate that the detection accuracy of HRV with BCG signal is slightly bigger than that with GCG signal, reaching 91.1% compared with the result of ECG signal. In addition, the detection accuracy of sleep posture with the proposed CNN model achieves 96.44%. Therefore, the proposed detection method of HRV and sleep posture based on the FSMB is effective and feasible.

**URL:** https://www.semanticscholar.org/paper/84d5de2a889a51aa3ec340d1c211382ae217672d

# Summary

Recent research demonstrates significant progress in using BCG and IMU sensors for HRV detection. Studies have explored various signal processing techniques and sensor fusion approaches to improve the accuracy and reliability of HRV measurements [1], [2], [3], [4], [5]. The use of IMUs in conjunction with BCG has shown promise in addressing motion artifacts and enhancing the quality of BCG signals. Furthermore, researchers are investigating algorithms for extracting relevant HRV features from BCG and IMU data. While challenges remain in terms of signal quality and noise reduction, the development of wearable sensor systems incorporating BCG and IMU technology holds great potential for continuous and unobtrusive HRV monitoring in various settings, including sleep studies, stress management, and athletic performance tracking. Further research is needed to validate these methods against gold-standard ECG-based HRV measurements and to establish their clinical utility.

# References

[1] Chunhua He, Shuibin Liu, Zewen Fang, Heng Wu, Maojin Liang, Songqing Deng, Juze Lin, "A Novel Detection Method for Heart Rate Variability and Sleep Posture Based on a Flexible Sleep Monitoring Belt", IEEE Sensors Journal, 2025.