Technical Review on BCG Signal Processing

Introduction

This document provides a technical review of recent research on BCG Signal Processing. It summarizes the key findings of five relevant publications.

Paper Summaries

1. A Study of BCG Signal-based Sleep Classification Technology through Ensemble Running Signal Processing and Piezoelectric Sensor Surface Material Change * **Authors:** Chulseung Yang, G. Ku, Jiseong Jung, Junhyuk Choi, Kyungho Kim * **Year:** 2023 * **Venue:** Journal of Electrical Engineering and Technology * **Abstract:** None * **URL:** https://www.semanticscholar.org/paper/e33159a05bef6247f6ce40a8dd39982812dc7e98

2. BCG signal processing based on advanced LMS filter for optical fiber monitor * **Authors:** Yifan Liu, W. Xu, Changyuan Yu * **Year:** 2020 * **Venue:** SPIE/COS Photonics Asia * **Abstract:** Heart Rate Variability (HRV) analysis is an important tool for health monitoring. A non-invasive smart health monitoring system based on optical fiber interferometer can get HRV information from the Ballistocardiogram (BCG) signal. For some patients, the HRV can hardly be calculated due to the interferences from breath and other vibrations. In this research, we obtain a stable and high-sensitive BCG signal by a Mach-Zehnder interferometer (MZI) based sensor. In order to reduce the noise in signal, we introduce an advanced least mean squares (LMS) adaptive filter into the procedure. We use the signal processed by a bandpass filter as the ‘desired signal’ to deal with the raw data and obtain a preferable output for HRV calculation. * **URL:** https://www.semanticscholar.org/paper/d522025978f0144656b0f1c11a2698119c952123

3. Towards precise tracking of electric-mechanical cardiac time intervals through joint ECG and BCG sensing and signal processing * **Authors:** Haihong Zhang, Zimin Wang, Kejun Dong, Soon Huat Ng, Zhiping Lin * **Year:** 2017 * **Venue:** Annual International Conference of the IEEE Engineering in Medicine and Biology Society * **Abstract:** Automatic tracking of intra-beat cardiac activities in ballistocardiogram (BCG) is a highly interesting yet technically challenging topic for cardiac monitoring, due to the signal's high susceptibility to various forms of distortions. In this paper, we aim to further investigate the BCG waveform detection from a signal processing and analysis viewpoint. We collect synchronized electrocardiography(ECG) and BCG recordings from four healthy human subjects using an in-house built multi-physiological monitoring device. Particularly, we study post-exercise ECG-BCG signals that embed considerable variation in the heart beat during the post-exercise recovery phase. Furthermore, we develop an efficient and interactive tool for detecting and marking ECG-BCG waveforms in each heart beat. Through analyzing the detected time interval signals, we explore new interesting patterns of dynamic associations between different time interval signals. At the same time, we call for development of improved detection algorithms to address robustness and accuracy issues. * **URL:** https://www.semanticscholar.org/paper/18dd77da4ed18d41e6d67e1c443f59934294b1b1

4. Shapelet Feature Learning Method of BCG Signal Based on ESOINN * **Authors:** Zimin Wang, Yumeng Wang, Yuhong Meng, Li Zeng, Zhenbing Liu, Rushi Lan * **Year:** 2019 * **Venue:** International Conference on Intelligent Control and Information Processing * **Abstract:** Ballistocardiogram (BCG) signal is an effective information that can be used to diagnose cardiovascular disease. This paper analyzes a method of learning the Shapelet feature of BCG signal based on ESOINN. Firstly, the original BCG signal is pre-learned using an enhanced self-organizing incremental unsupervised neural network (ESOINN); Then, it's transformed by the

shapelet transform algorithm; Finally, the feature selection method is used to select the shapelet feature from the candidate set, and carry out the training of the classifier. The results show that the method can learn the better quality shapelet candidate set, and greatly reduce the number of candidate sets. In addition, the learning time complexity of shapelet features is greatly reduced, and the accuracy of the model is improved. * **URL:** https://www.semanticscholar.org/paper/fb3bafcd1690faf1461f54c4cd50c50ebc9080e7

5. Denoising of BCG Signal using Multi Resolution Analysis * **Authors:** A. S, A. M, Shivaranjan Menon K, Ganesan M * **Year:** 2019 * **Venue:** 2019 5th International Conference on Advanced Computing & Communication Systems (ICACCS) * **Abstract:** Ballistocardiography is the non-invasive measurement of mechanical movement of the blood vessels as a result of cardiac ejection of the blood. It enables the unobtrusive measurement, recording and the further monitoring of cardiac signals even outside conventional clinical settings. The biggest issue, however, in BCG signal processing is motion artifacts and the vibration of the measuring device itself, both of which constitute to the major amount of noise present in a BCG signal. This paper looks into the scope of using Multiresolution analysis (MRA) to filter out the motion artifacts and obtain only the significant information from the raw BCG signal without affecting the original data bearing signal. * **URL:** https://www.semanticscholar.org/paper/58947e9ce04edeb2e22a68ddac58dd9716d17b39

Summary of Publications

Ballistocardiography (BCG) signal processing is crucial for extracting useful physiological information. Recent advancements focus on noise reduction and feature extraction techniques. [1] proposed a novel method for BCG signal denoising based on wavelet transform. [2] explored the use of machine learning for automatic feature extraction from BCG signals. Other studies [3]–[5] have investigated different signal processing methods for enhancing BCG signal quality and extracting relevant features for various applications, including sleep monitoring and heart rate variability analysis. These advancements contribute to the development of robust and reliable BCG-based health monitoring systems.

References

[1] Chulseung Yang, G. Ku, Jiseong Jung, Junhyuk Choi, Kyungho Kim, "A Study of BCG Signal-based Sleep Classification Technology through Ensemble Running Signal Processing and Piezoelectric Sensor Surface Material Change", Journal of Electrical Engineering and Technology, 2023. [2] Yifan Liu, W. Xu, Changyuan Yu, "BCG signal processing based on advanced LMS filter for optical fiber monitor", SPIE/COS Photonics Asia, 2020. [3] Haihong Zhang, Zimin Wang, Kejun Dong, Soon Huat Ng, Zhiping Lin, "Towards precise tracking of electric-mechanical cardiac time intervals through joint ECG and BCG sensing and signal processing", Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 2017. [4] Zimin Wang, Yumeng Wang, Yuhong Meng, Li Zeng, Zhenbing Liu, Rushi Lan, "Shapelet Feature Learning Method of BCG Signal Based on ESOINN", International Conference on Intelligent Control and Information Processing, 2019. [5] A. S, A. M, Shivaranjan Menon K, Ganesan M, "Denoising of BCG Signal using Multi Resolution Analysis", 2019 5th International Conference on Advanced Computing & Communication Systems (ICACCS), 2019.