Wireless PPG Signal For Activity Monitoring

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***Abstract*—In recent years, wireless photoplethysmography (PPG) has emerged as a pivotal technology for non-invasive monitoring of physiological parameters. This paper presents a comprehensive study on the application of wireless PPG signal acquisition for activity monitoring. The research focuses on the development and implementation of a robust, real-time monitoring system that leverages wireless PPG sensors to track vital signs such as heart rate and oxygen saturation during various physical activities. The proposed system utilizes advanced signal processing algorithms to enhance data accuracy and reliability, addressing challenges such as motion artifacts and signal noise. This study underscores the importance of wireless PPG technology in advancing the capabilities of wearable health devices, paving the way for more integrated and user-friendly health monitoring solutions.**

I. Introduction

The advent of wearable technology has revolutionized the field of health monitoring, offering unprecedented opportunities for continuous, non-invasive assessment of physiological parameters. Among the various techniques available, photoplethysmography (PPG) has gained significant attention due to its simplicity, cost-effectiveness, and versatility. PPG is an optical method that measures changes in blood volume in the microvascular bed of tissue, providing critical information about cardiovascular health, such as heart rate and oxygen saturation.

Traditionally, PPG monitoring has been confined to wired systems, limiting the mobility and comfort of users. However, the integration of wireless technology with PPG sensors has opened new horizons for ubiquitous health monitoring. Wireless PPG systems offer the advantage of real-time data transmission, increased user comfort, and the capability to monitor physiological signals in a wide range of settings, from clinical environments to everyday life.

This paper explores the development and implementation of a wireless PPG-based activity monitoring system designed to track and analyze vital signs during various physical activities. The primary goal is to create a system that can accurately and reliably capture PPG signals while mitigating common issues such as motion artifacts and signal noise, which can compromise the quality of the data.

The system's architecture includes compact, wearable PPG sensors that communicate wirelessly with a central processing unit. Advanced signal processing algorithms are employed to filter and interpret the raw data, ensuring high fidelity and real-time monitoring capabilities. By conducting extensive experimental trials, this study aims to validate the effectiveness of the wireless PPG system in different activity scenarios, demonstrating its potential applications in health monitoring, sports science, and personalized medicine.

In summary, this research highlights the potential of wireless PPG technology to enhance the functionality and user experience of wearable health devices. By addressing the challenges associated with wireless PPG signal acquisition and processing, this study contributes to the advancement of continuous health monitoring solutions that are more integrated, accurate, and user-friendly.

II. DATASET

We have collected lab recorded dataset using a wireless ppg device for our project. OpenSignals is a versatile application used for real-time biosignals visualization that is used to collect ppg data and has been stored in text format. Different activities have been recorded for efficient activity monitoring like walking, skipping and running. The blood pressure varies in each and will help classify on new unseen data.

III. METHODOLOGY

A. *Signal pre-processing*

Signal pre-processing is a crucial step in the implementation of a wireless photoplethysmography (PPG) signal activity monitoring system. The primary goal of pre-processing is to enhance the quality of the raw PPG signals, ensuring accurate and reliable extraction of physiological parameters despite the challenges posed by noise and motion artifacts. Effective pre-processing transforms the raw data into a clean and interpretable format, enabling more precise analysis and monitoring of vital signs.

Challenges in PPG Signal Acquisition PPG signals are highly susceptible to various forms of interference, including:

- Motion Artifacts: Movements such as walking, running, or even slight finger motions can introduce significant noise into the PPG signals.
- Ambient Light Interference: External light sources can affect the optical readings, leading to erroneous data.
- Baseline Wander: It comes in the category of low-frequency noise. Changes in sensor contact with the skin or other environmental factors are a major cause. The isoelectric line of PPG signal gets affected and makes estimation inaccurate . It can be removed by use of detrending (inbuilt function)

B. Our Approach

- Pre-processing of signal has been done by applying chebychev filters and moving average filters for smoothing of signal and removing moving artifacts from it.
- Savitzky-Golay filter has been used for eradicating the baseline wandering and reducing the amplitude of dicrotic notch of our ppg signal. Golay filter is also used for smoothening of signal.

C. Feature Extraction

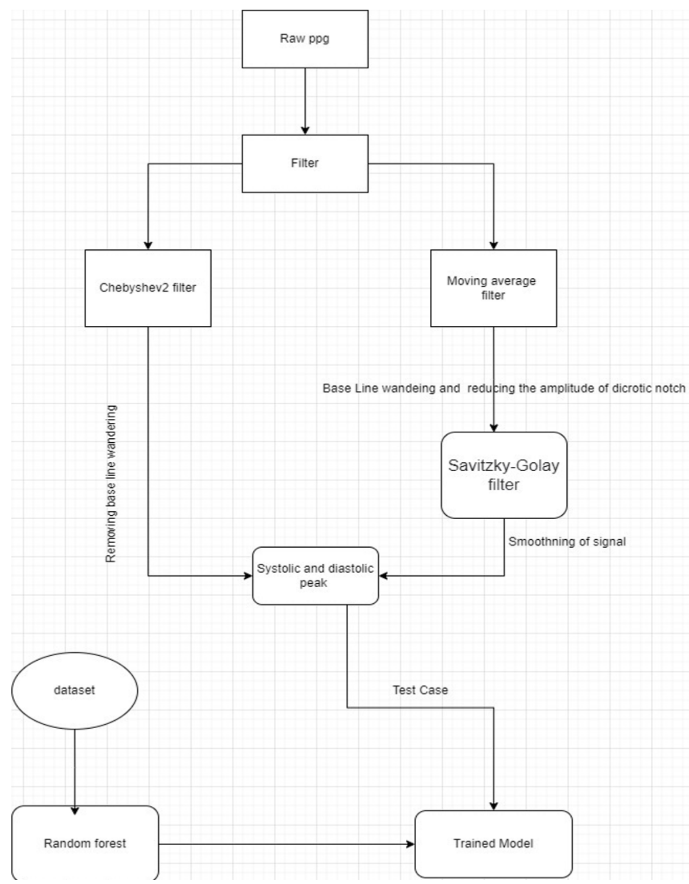
Feature extraction is a critical process in the context of wireless photoplethysmography (PPG) signal activity monitoring. Once the PPG signals have been pre-processed to remove noise and artifacts, the next step is to extract relevant features that can provide valuable insights into physiological parameters such as heart rate, oxygen saturation, and other cardiovascular metrics. Effective feature extraction transforms the cleaned PPG signals into a set of informative descriptors that can be used for further analysis, classification, and interpretation. Theprimary objectives of feature extraction in this project are:

- Accurate Heart Rate Detection: Deriving precise heart rate values from the PPG signal.
- Estimation of Oxygen Saturation (SpO2): Calculating the level of oxygen in the blood based on the characteristics of the PPG waveform.
- Activity Recognition: Identifying different physical activities by analyzing changes in the PPG signal patterns.
- Stress and Fatigue Monitoring: Assessing indicators of stress and fatigue through variations in heart rate variability (HRV) and other features.

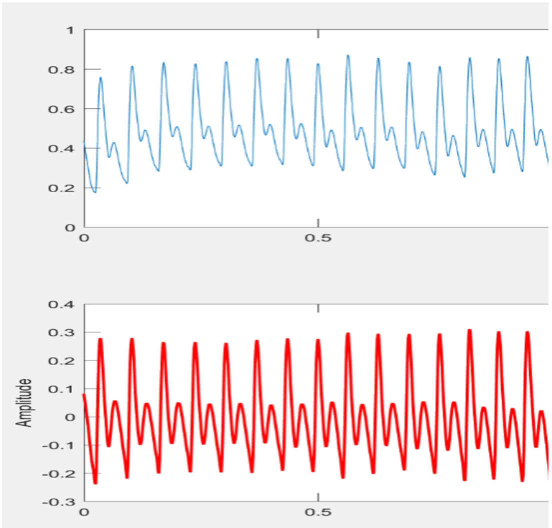
Our main objective is to use the time domain features of the acquired signal ie Peak Detection. This is done using the ”findpeaks” function of MATLAB. It operates by scanning through the signal data to locate points where the signal reaches a local maximum. A local maximum is defined as a point that has a higher amplitude than its immediate neighbors. It includes several parameters that help fine-tune the peak detection process:

- Height: This parameter sets a threshold for the minimum height that a peak must have to be considered significant. Only peaks above this threshold are detected. Example: findpeaks(signal, height=0.5) will only detect peaks with amplitudes greater than 0.5.
- Prominence: This parameter measures how much a peak stands out due to its intrinsic height and its relative height compared to surrounding peaks. Prominence is a robust way to ensure that significant peaks are detected even if they are surrounded by smaller fluctuations. Example: findpeaks(signal, prominence=0.2) ensures that detected peaks are prominent relative to their surroundings.
- Width: This parameter specifies the minimum width of the peaks. It helps to ignore narrow peaks that may be due to noise. Example: findpeaks(signal, width=5) will only detect peaks that are at least 5 samples wide.
- Distance: This parameter sets the minimum horizontal distance (in terms of sample points) between adjacent peaks. This is useful for avoiding the detection of multiple peaks that are very close to each other and may represent the same physiological event. Example: findpeaks(signal, distance=50) ensures that detected peaks are at least 50 samples apart.
- Threshold: This parameter sets a relative threshold for peak detection. Peaks are identified based on their relative height compared to neighboring points.

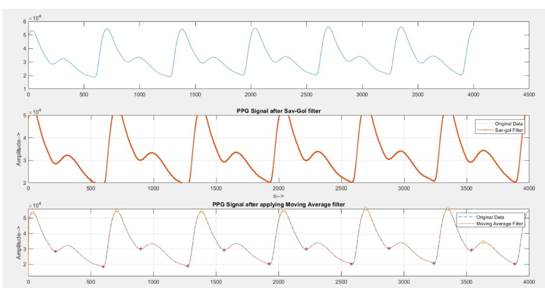
D. Work-FLow



The Savitzky-Golay filter is a digital filter used to smooth and differentiate data by fitting successive sub-sets of adjacent data points with a low-degree polynomial using the method of linear least squares. This filter is particularly useful in signal processing applications where it is necessary to preserve the original shape and features of the signal while reducing noise. It is widely employed in contexts such as spectral data processing, ECG and PPG signal processing, and other areas where accurate signal smoothing is crucial.



Chebyshev filters are a class of analog and digital filters that are designed to achieve a steeper roll-off and better passband or stopband characteristics compared to other filter types like Butterworth filters. Named after the Russian mathematician Pafnuty Chebyshev, these filters come in two main types: Type I (Chebyshev) and Type II (Inverse Chebyshev). Each type offers distinct advantages and trade-offs in terms of passband ripple, stopband attenuation, and transition band sharpness.



IV. Conclusion

In this project, we explored the implementation of a wireless photoplethysmography (PPG) signal activity monitoring system, focusing on the crucial processes of signal pre-processing, feature extraction, and the application of advanced filtering techniques. The integration of wireless PPG technology offers a non-invasive, real-time method for monitoring vital physiological parameters such as heart rate and oxygen saturation, which are essential for health monitoring, sports science, and personalized medicine.

V. FUTURE DIRECTIONS

The findings from this project demonstrate the potential of wireless PPG technology to revolutionize continuous health monitoring. By ensuring high data accuracy and reliability, our system can be deployed in a variety of settings, from clinical environments to everyday use, enabling continuous and unobtrusive health tracking.

Future research could explore the integration of machine learning algorithms to enhance the system's capabilities in activity recognition and anomaly detection. Additionally, expanding the system to include multi-modal sensors, such as accelerometers and electrocardiograms (ECGs), could provide a more comprehensive overview of a user's health status.

Acknowledgment

We would like to extend our sincere gratitude to all those who have contributed to the successful completion of this project on wireless PPG signal activity monitoring. Special thanks to the faculty and teacher assistans for providing the necessary resources and a conducive environment for research. The access to advanced laboratory facilities and computing resources has significantly enhanced the quality of our work.

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