PPG Signal Processing and Systolic Peak Detection using Elgendi's Method

1 Introduction

Photoplethysmography (PPG) is a technology that measures blood volume changes in the body utilizing a light sensor. PPGs are mainly used for monitoring heart rate and blood circulation and show regular changes in blood flow caused by each heartbeat. A typical PPG waveform includes **Systolic Peak**, which occurs when blood is pumped out of the heart, showing the highest point in the signal. It also includes **Dicrotic Notch** that appears after the systolic peak, creating a small dip in the signal, and **Diastolic Peak** that occurs after the dicrotic notch, caused by the reflected blood wave from the body, creating a small second peak.

In this work, the **systolic peaks** are detected using the **Elgendi's method**. This method calculates the first derivative of the PPG signal and finds the points where the slope changes from positive to negative, indicating the location of systolic peaks. To improve detection accuracy, an amplitude threshold and a minimum distance between peaks are applied based on the expected heart rate and the sampling frequency.

Similarly, the dicrotic notch and diastolic peak can also be detected using the first or second derivative of the PPG signal. In the first derivative, the dicrotic notch appears as a local minimum after the systolic peak, and the diastolic peak appears as a local maximum after the notch.

2 Methodology

2.1 Data Acquisition

The PPG signal sampled around the frequency of 1000 Hz was read from a CSV file.

2.2 Preprocessing: Moving Average Filter

This signal does not include effective high-frequency noise. Therefore, a **moving average filter** is a suitable tool to filter baseline wander and smooth the PPG signal. This method is simple, computationally efficient, and effective in cases where the signal does not contain significant high-frequency noise. This approach preserves the full signal length and maintains better edge behavior. The padding technique was also applied at the start and end of the signal using reflection to allow the moving average window to be centered even at the edges without losing data.

2.3 Systolic Peak Detection: Elgendi Method

The systolic peaks were detected by first calculating the first derivative of the filtered PPG signal. Zero-crossings where the slope changes from positive to negative were identified, corresponding to potential systolic peaks. In this vein, an amplitude threshold was applied to exclude minor fluctuations. In addition, minimum distance between peaks was set based on the sampling frequency and the maximum expected heart rate (100 BPM), reflecting normal physiological conditions.

3 Results

3.1 Filtered PPG Signal

Figure 1 shows the original and filtered PPG signals. The moving average filter successfully removed slow baseline wander while preserving the important features of the signal.

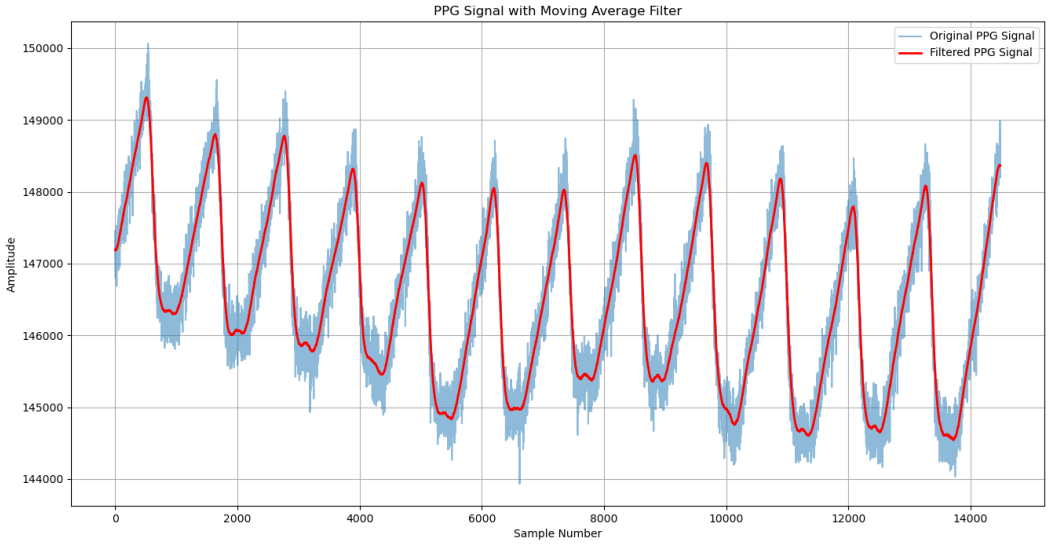

Figure 1: Original and Filtered PPG Signal using Moving Average Filter

3.2 Detected Systolic Peaks

Figure 2 displays the detected systolic peaks on the filtered PPG signal. Detected peaks are marked clearly, demonstrating successful application of the Elgendi method.

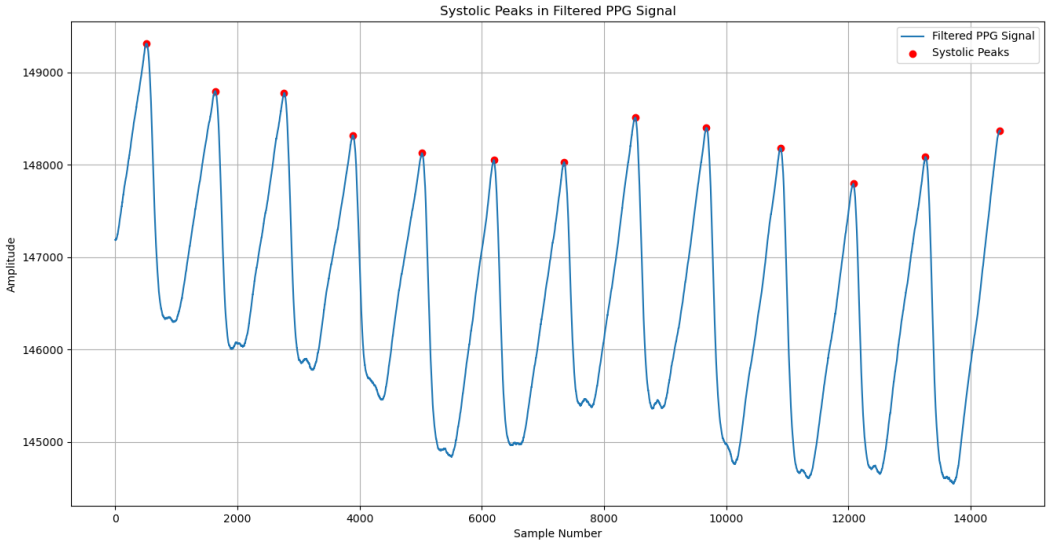

Figure 2: Detected Systolic Peaks in Filtered PPG Signal