



Secondary Peak Detection of PPG Signal for Continuous Cuff-less Arterial Blood Pressure Measurement

Xiaochuan He

Dept. Systems and Computer Engineering, Carleton University, Ottawa, ON, Canada

Contributors: Rafik A. Goubran, Xiaoping P. Liu

Abstract

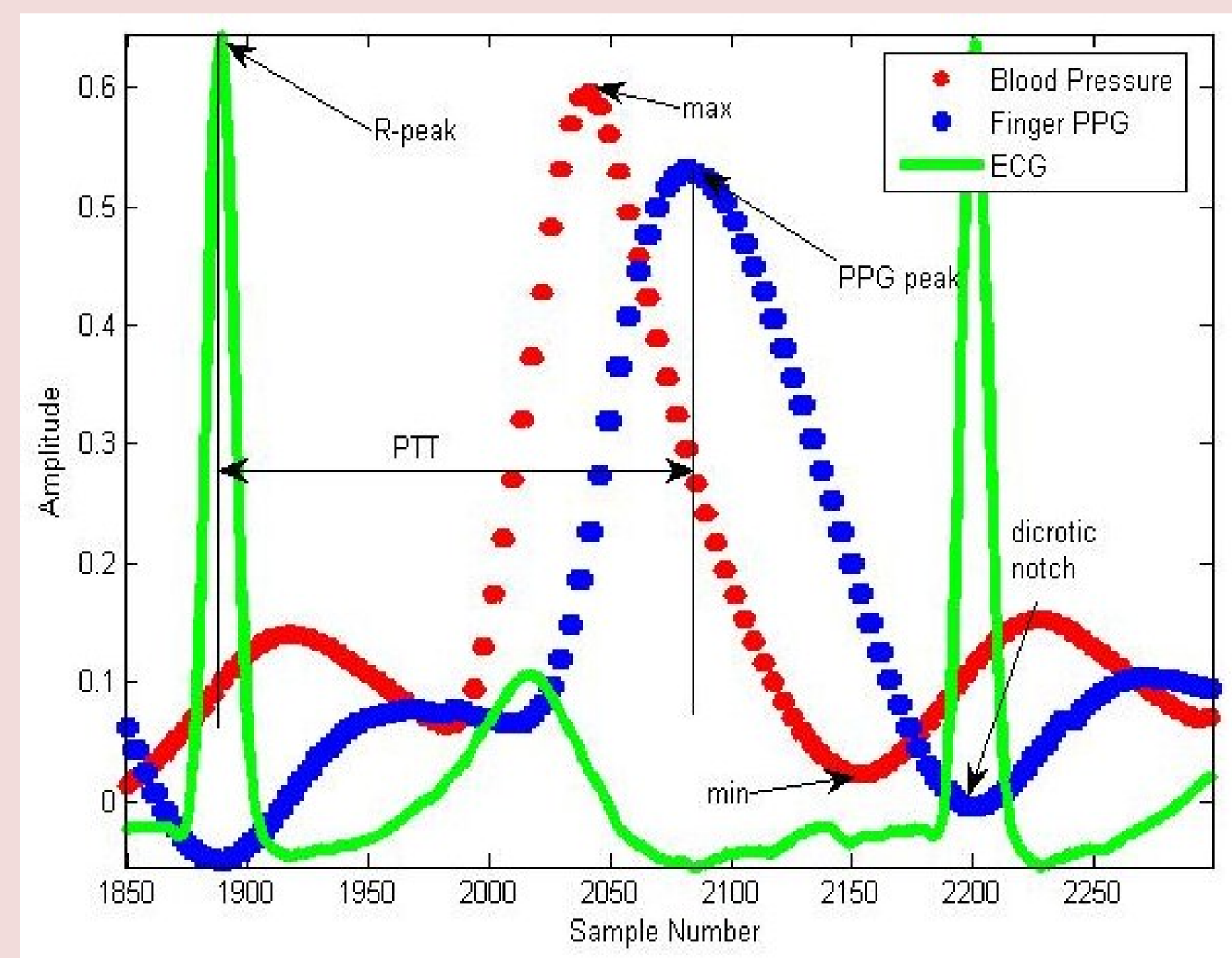
The arterial blood pressure is one of the most important physiological parameters for health monitoring. Most blood measurement devices in the market determine the arterial blood pressure through the inflation and the deflation of a cuff controlled by a bladder. This method is very uncomfortable for most of the users and may even cause anxiety, which in turn can affect the blood pressure. This study investigates a cuff-less non-intrusive approach to estimate blood pressure. The main idea is to measure the pulse transit time (PTT) that is the delay between the R-peak of the electrocardiogram (ECG) signal and the following peak of the finger photoplethysmograph (PPG) signal. The main problem of this approach is that when the dicrotic notch of the PPG signal is unobservable, the position and the amplitude of the main peak of the PPG signal will be changed. As a result, the correlation between the blood pressure and PTT can be affected. To overcome this problem, three types of secondary peak detection methods are designed to reveal the secondary peak from the original PPG signal. Actual ECG, PPG, and blood pressure measurements extracted from the MIMIC II database that contains clinical signal data reflecting real measurements are used. The results verify that the proposed detection methods improve the correlation relationship between the blood pressure and the PTT and demonstrate that the adjusted PTT can be used as an indicator of the arterial blood pressure by removing the dicrotic notch impact on the PPG signal.

Introduction

- ❖ The conventional way to detect blood pressure is using a brachial cuff.
- ❖ Blood pressure can be easily affected by patients' statuses and emotions.



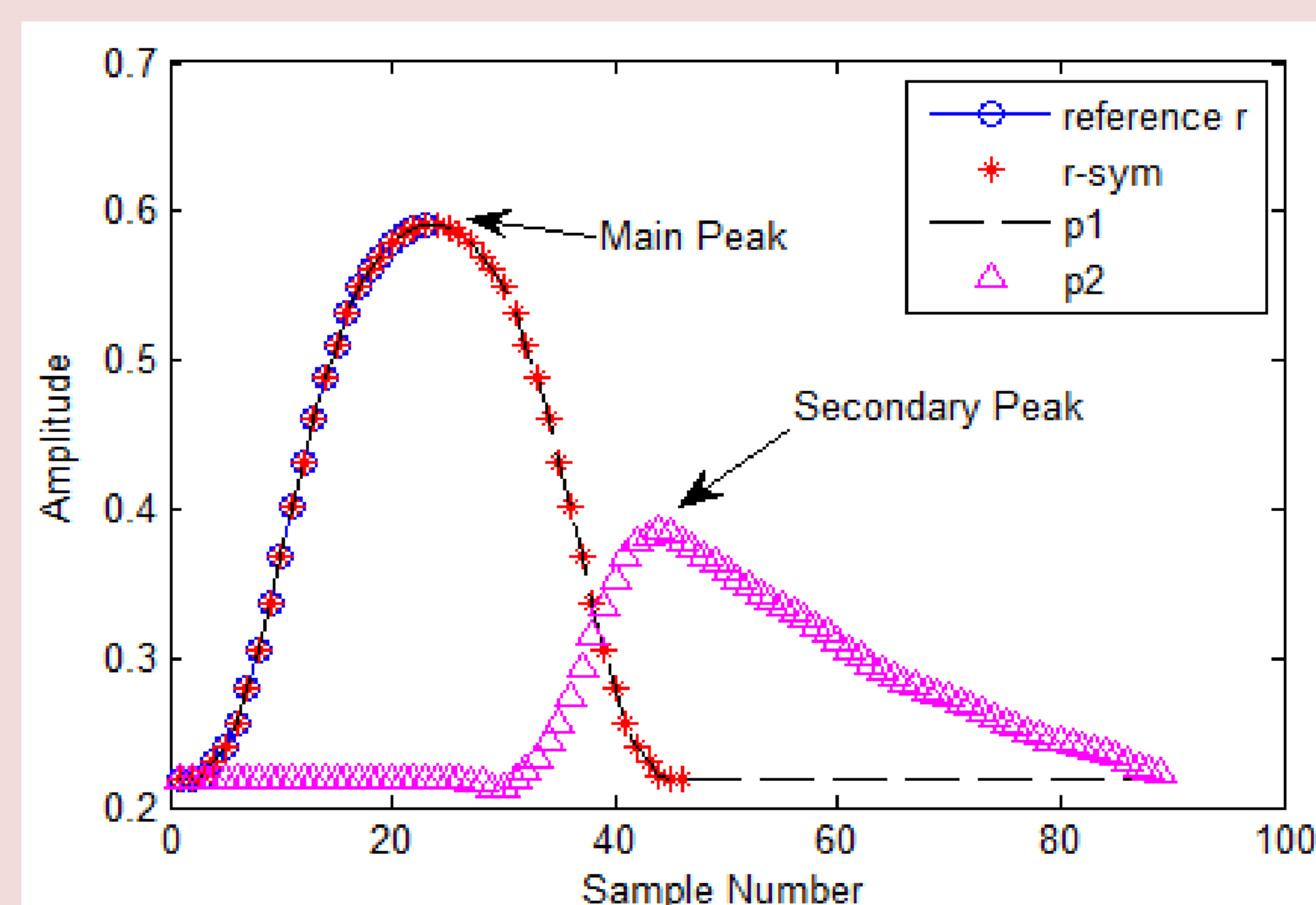
- ❖ Easy-wearing and convenient-operate.
- ❖ Cuff-less and non-intrusive
- ❖ PTT has high correlation with BP.



- ❖ The non-existence of the secondary peak will impact the position and the amplitude of the main peak of the original PPG signal, then impact PTT.

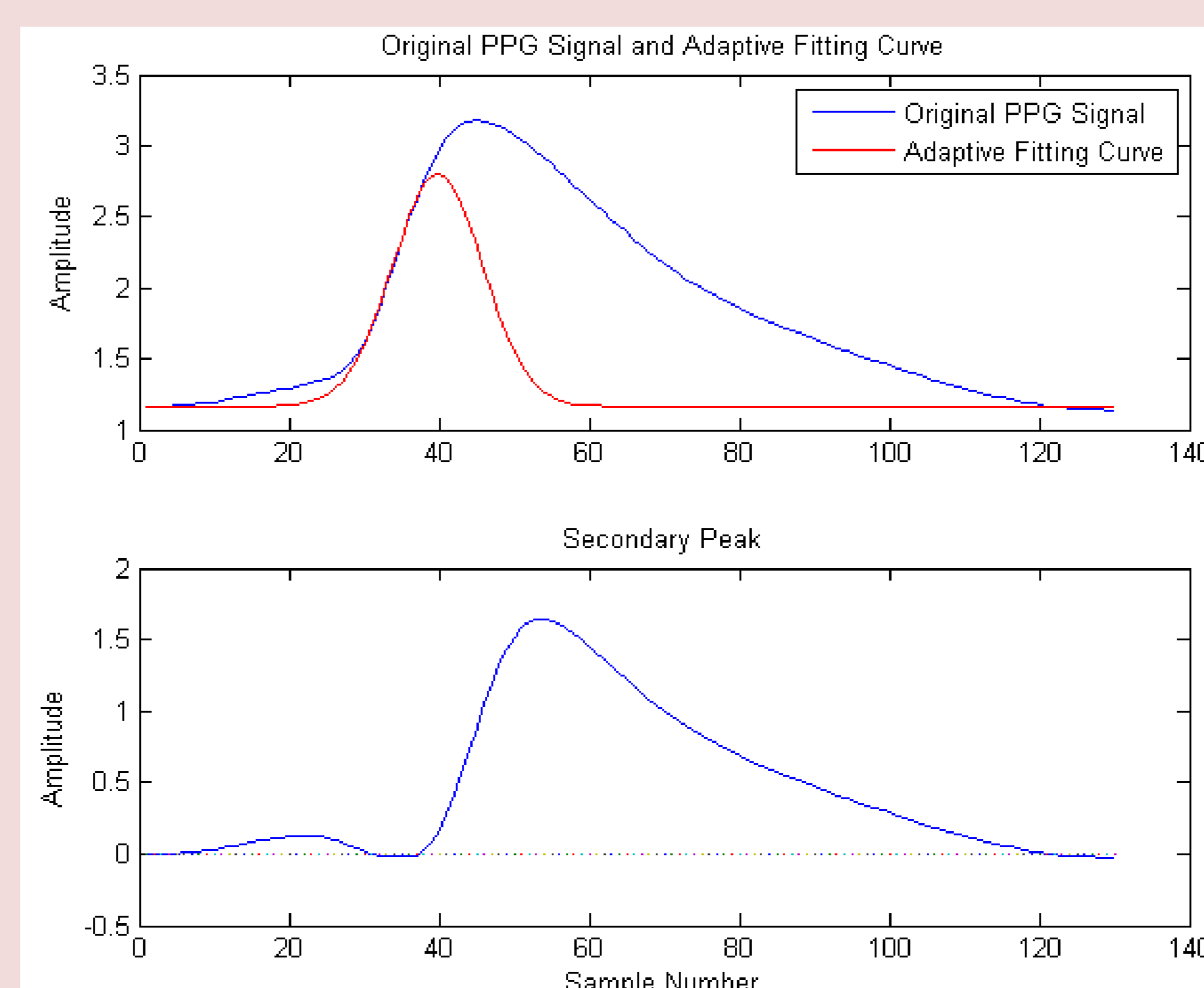
Methodology

❖ Symmetrical Curve Fitting Method (SCF)



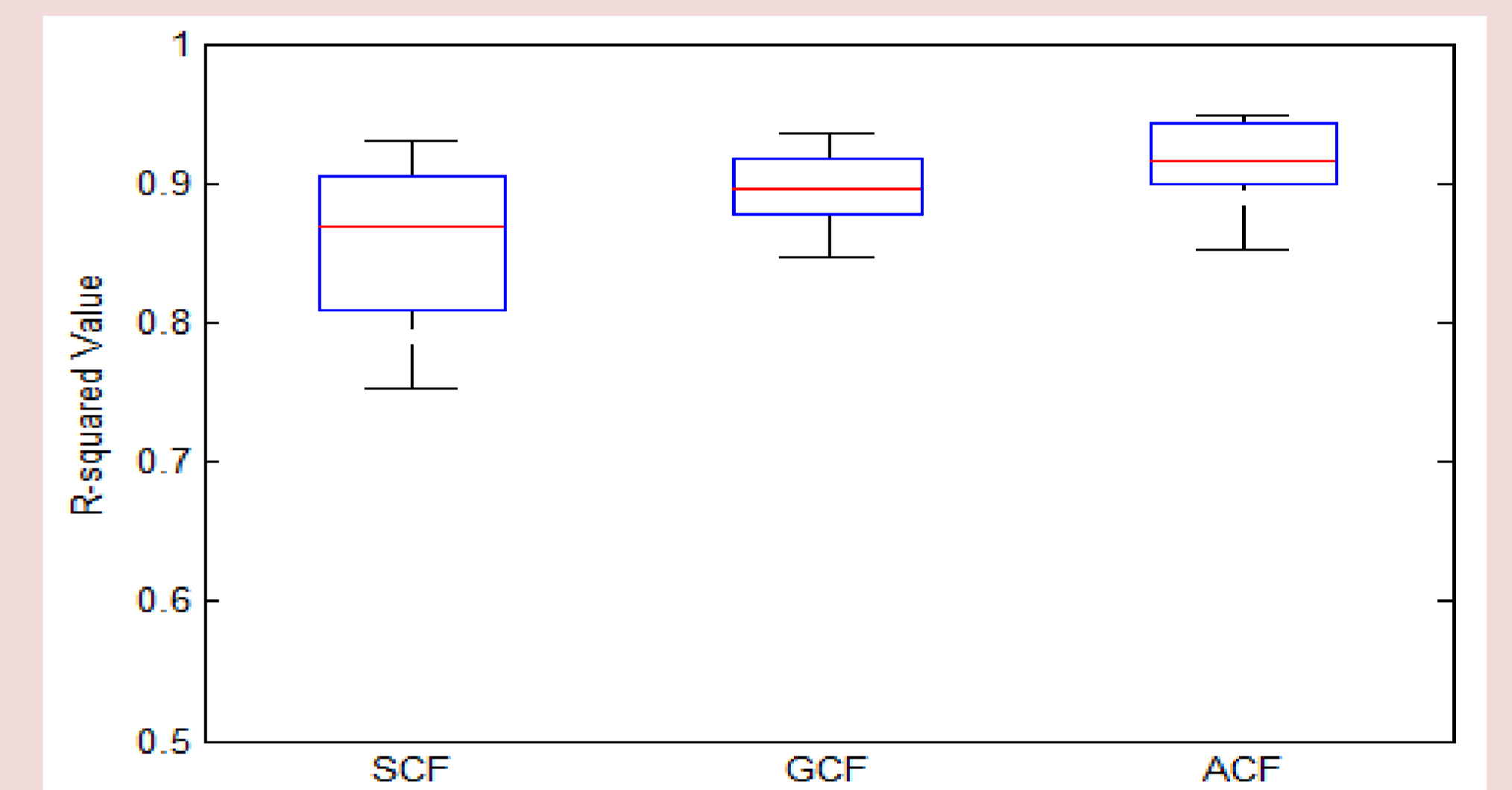
- ❖ **Gaussian Curve Fitting Method (GCF):** Finding the Gaussian curve that best fits the upstroke side of the original PPG signal.

- ❖ **Adaptive Curve Fitting Method (ACF):** Adapt the mean and the standard deviation positions based on the position of the main peak and the shape of the upstroke of the main peak.

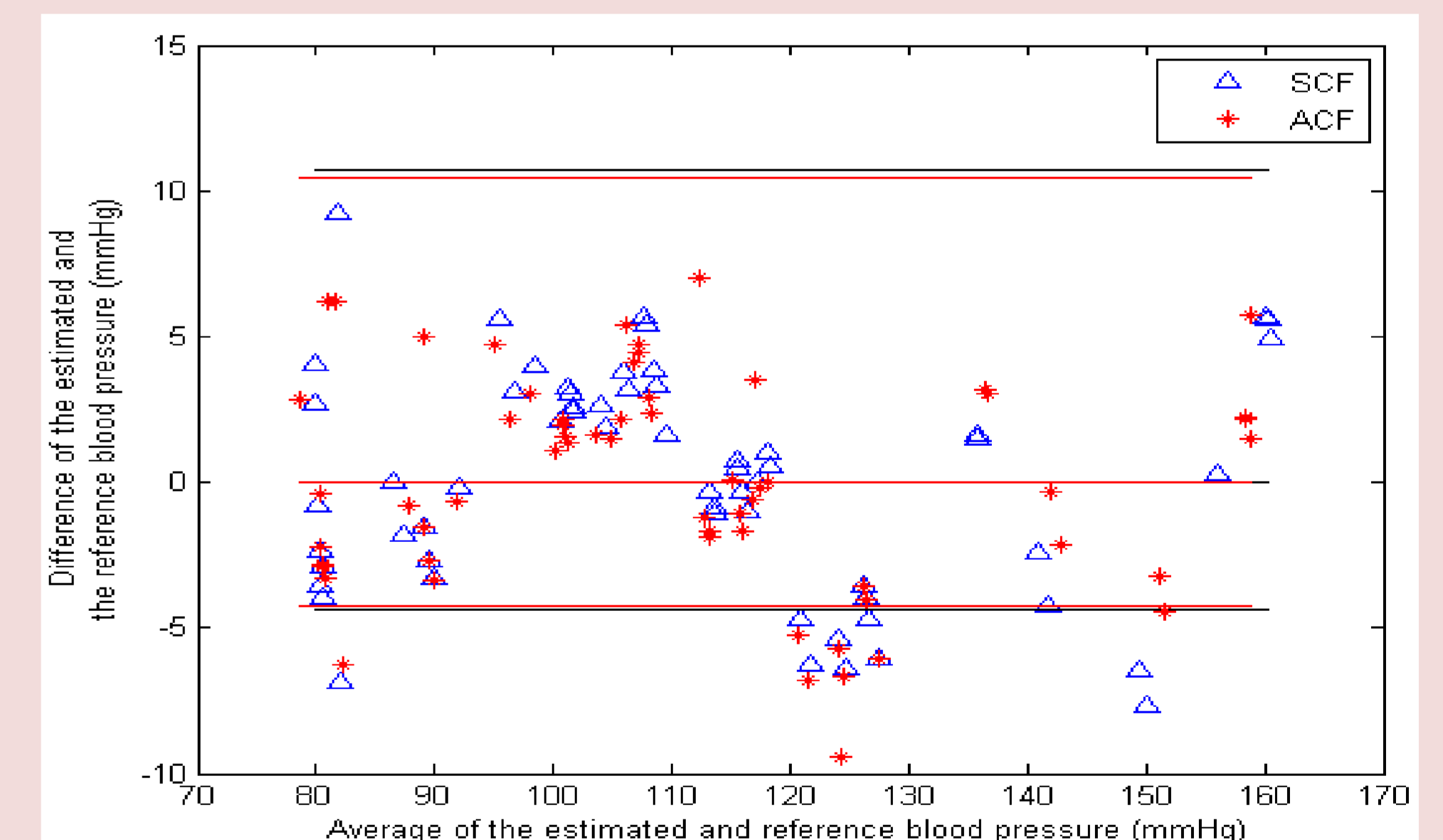


Simulation Results

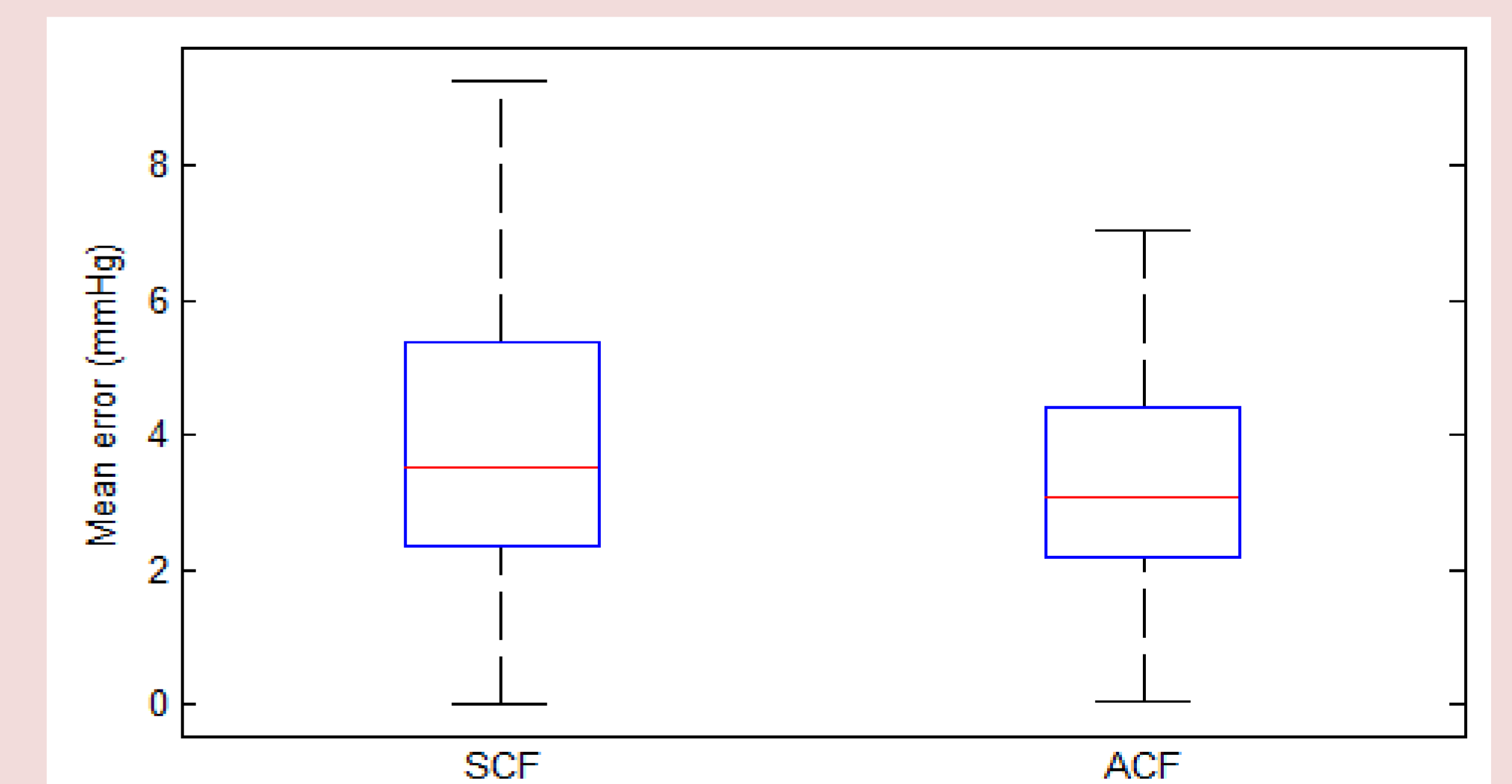
- ❖ The arterial blood pressure, ECG, and PPG signals are extracted from the MIMIC II database, where the synchronization of all types of signals can be guaranteed.
- ❖ R-squared values between the adjusted PTT and the blood pressure by using SCF, GCF, and ACF detection methods.



- ❖ The Bland-Altman plot for the estimated and the reference blood pressure by SCF and ACF methods.



- ❖ Boxplot of the ME for the systolic blood pressure estimation by SCF and ACF methods.



Conclusions

- ❖ This investigation verified that the absence of the secondary peak of the PPG signal could impact the correlation between PTT and blood pressure.
- ❖ ACF was demonstrated that could resolve the peak shifting problem and the adjusted PTT had higher correlation with the blood pressure than the original PTT without observable dicrotic notch.