Heart Rate Variability Extraction Using a Smartphone

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***Abstract*—The heart rate variability (HRV) derived from photoplethysmography signal using a smartphone was compared with that extracted from an electrocardiograph (ECG). The result indicates that the smartphone is a possible tool to provide valid HRV detection.**

I. Introduction

Recently, a new method was proposed to acquire the photoplethysmography (PPG) signal from the video camera of a smart phone, in which one needs to press a finger on the camera and captures a video record with the built-in LED flash on [1]. Several physiological parameters such as heart rate, heart rate variability (HRV), respiratory rate and oxygen saturation can be extracted from the image PPG signal [2]. This method is simple and easy to use, of a great potential application in the healthcare management. However, the accuracy of the measurement has not been well assessed. Gregoski et al validated that the heart rate acquired by a Motorola Droid Phone was in line with the heart rates acquired by an electrocardiograph (ECG) and a pulse oximeter [3]. On this basis, we studied on the extraction of HRV using a smart phone and compared the results with a reference ECG record.

II. Methods

Ten healthy volunteers (7 males, 25±5 years, height 166±8cm and weight 62±12kg) participated in this study. Each subject was instructed to lie on a mattress and placed their left index finger on the camera lens of a HTC S510e smartphone with the built-in flash LED turned on. A video record was captured with a resolution of 320×240 pixels at a sampling rate of 15 frames per second (FPS). A reference ECG was measured by the Finapres Medical System (standard 3-lead system, 200 Hz sampling rate). The subject was asked to keep still during the whole experiment of 5 minutes.

The recorded video was processed in Matlab 7.0. Firstly, a 64×64 pixel region in the center of the video image was selected as the region of interesting (ROI). Secondly, the average intensity of the ROI of each frame was calculated to generate a time-series waveform of PPG signal which was then resampled at 200 Hz using the spline interpolation. Lastly, peak-peak intervals were computed by a peak detection algorithm and the SDNN, one parameter of HRV which is defined as the standard deviation of the peak-peak intervals, was analyzed. Simultaneously, R-wave peak detection from the ECG signal was also performed and the SDNN was also computed. For both smartphone PPG signals and ECG signals, falsely detected beats were manually identified and adjusted.

III. Results

The SDNN computed from the smartphone PPG signals was compared with that derived from the ECG. Pearson correlation coefficient was calculated and the result is 0.78. Signal agreement of the PPG and ECG was assessed using Bland-Altman plot with 95% limits of agreement. More than 95% of data points were within the limits of agreement, as shown in Fig.1.

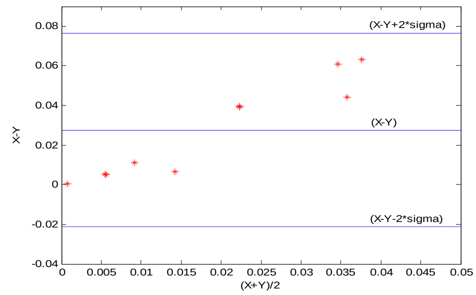

Figure 1. The Bland-Altman plot. X stands for the SDNN calculated from the smartphone PPG and Y for the SDNN obtained from ECG.

IV. Conclusion and discussion

The smartphone is possible to provide the HRV measurement. However, we only tested it with 10 subjects and assessed using only one parameter of HRV. In addition, the sampling rate is too low (15 FPS). More subjects and more parameters of HRV should be tested, and a higher frame rate camera will be used in the future work.

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