Detection of Peak and ONSET of PPG Signal

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Abstract - **The Shape of the Pulsatile Component of PPGdiffers from subject to subject as it varies in a location and manner. With respect to a change in blood volume, similarly the peak variation takes Place. Physiological signals and this also means peak detection of PPG is relatively easy because there are few specific points. This paper is aimed at developing low complexity, low computation cost algorithm for pulse detection as well as classifying peaks and onsets in PPG waveform. The shape, frequency, and general form of cardiac pulses in PPGs can change over short periods of time. To account for these changes, specifically the frequency of the pulses, the width of the analysis window was adjusted after each identified peak to ensure that the next pulse could be better identified. Algorithm relies on the analysis of True peak and potential false peak detection. The algorithm appears promising, and future consideration of its diagnostic capabilities and limitations is warranted. The peak detection is determined by implementing an algorithm in MATLAB, and the future work involves implementing the same in real time using Lab VIEW.**

Key words - **PPG, PEAKS, ONSET POINT, REAL-TIME,MATLAB, Lab VIEW**

I.INTRODUCTION

Photoplethysmography (PPG) is a noninvasive optical Technology that detects changes in blood volume in the vascular system. PPG measurements are relatively easy to obtain in a clinical area, there are insufficient data analysis tools for efficiently processing the biomedical data. PPG measures blood volume changes at a peripheral artery such as finger, toe, ear and forehead, and measured waveform has a little difference according to where it measured. PPG is generated by blood pressure and flow; however, it is an arbitrary unit signal because PPG is easily affected by environmental conditions not only sensor fitting method, but also skin condition, skin depth, race, humidity and circumference brightness. From these char- acteristics, it is hard to analyze using PPG amplitude, and PPG analysis has mainly carried out with a timing analysis and amplitude variability. PPG has a lesser sophisticated morphology than other physiological signals and this also means peak detection of PPG relatively easy because there are few specific points. However, PPG could have an enormous baseline drift and wondering followed by physiological condition and movement, moreover it frequently happens.

II.METHODOLOGY

The following is the experimental set up for acquisition of PPG signals for identifying beat onsetsand peaks from PPG waveforms in four stages
1.PPGPre-processing,2.PPG waveform smoothening and baseline Establishment 3.Peak identification where we detected true peaks and false peaks,4.Onset detection where we identified beat onset locations.

1. PPG pre-processing

The acquisition of PPG signals is adopted with some minor noise so an exemplary pre-processed PPG waveform w0 in our database. Since there are no outlier data points in this sample, the original waveform is exactly the same as w0.

2. PPG waveform smoothing and baseline Establishment

In this stage, we estimated the frequency of the Heartbeats and computed three auxiliary waveforms with increasing smoothness: (i) a mildly smoothed waveform w1, which removed minor noise and sharp spikes; (ii) a low-pass-filtered waveform w2, which removed ectopic peaks; and (iii) a moving-average estimate of the waveform baseline b for peak detection.

We estimated the frequency of heartbeats in the input PPG waveform w_0 by power spectrum analysis. Specifically, we linearly detrended w_0 and computed its power spectrum density in the frequency domain using fast Fourier transform from MATLAB. We estimated the frequency of the heartbeats as the frequency corresponding to the maximum power spectrum in the 0.8-3.0 Hz range (corresponding to normal heart rates from 50 to 180 beats/min) and estimated the average beat-to-beat interval asits reciprocal value. In the frequency of theheartbeats is estimated to be ~1.5 Hz, with a corresponding beat-to-beat interval of 0.67 s. Based on this estimate, we computed the following three smoother waveforms.

i) Mildly smoothed waveform w_1. We firstsmoothed the waveform w_0 using a center median filter, with a window size set to one-fifth of the estimated beat-to-beat interval, followed by a center moving-average filter with the same window size. The median and moving average filters removed noise and sharp spikes whose frequencies were more than five times that of the estimated heart-beat frequency.

ii) Filtered waveform w_2. The smoothed waveformw_1 was passed through Butterworth filter with a cutoff frequency of one-and-a half times the estimated heart-beat frequency this filtered waveform is denoted as w_2.

iii) Baseline b. We estimated a baseline b of the PPG waveform by applying a center moving-average filter to waveform w_2, with a window size set to 1.5 of the estimated beat-to-beat interval detection of PPG peaks at the heart-beat frequency

Peak Identification: We identified PPG peaks in three steps:

i) Identification of Initial peaks: We identified an initial set of peaks on w_0 by finding a local maximum in each time interval where the filtered waveform w_2 is above the baseline b

ii) Detection of potential false peaks :We detected potential false peaks from the initial set by imposing certain requirements on the peak's height and peak-to-peak interval. First, we sorted all peaks on w_0 by height in increasing order and selected the height value at the 2/3 length position. Next, we required that each initial peak had a height greater than half of the selected height value. Then, we computed the median absolute deviation (MAD) of the peak-to-peak intervals t, with MAD = median[|t-median(t)|], and required that each interval not deviate from the median interval by more than two times MAD.

iii) Relocation of missed peaks :For intervals between true PPG peaks on w_0 where potential false peaks were detected, we attempted to relocate putative false peaks and identify the locations of true ones. Specifically, starting from the left-boundary position of each interval, we advanced median(t) seconds and marked this point as the expected position of the next peak. Next, we searched around the expected position to identify a local maximum on the smoothed waveform w_1 within a window size of length set to MAD. If the local maximum was located at either end of the window, we increased the window size by MAD seconds and repeated the process until the maximum was located inside the window. Then, we identified the equivalent maximum on w_0 and labeled it as the next peak.

4. Onset Detection: We identified the onset position corresponding to each true peak in three steps. First, we found ranges where $w_0$was below both the filtered waveform w_2 and the baseline b. This was to ensure that the identified onsets would be insensitive to different selections of baselines Finally, we identified the minimum position on the waveform

III RESULTS:

The following is the results for detection of peaks and onset for a normal signal.

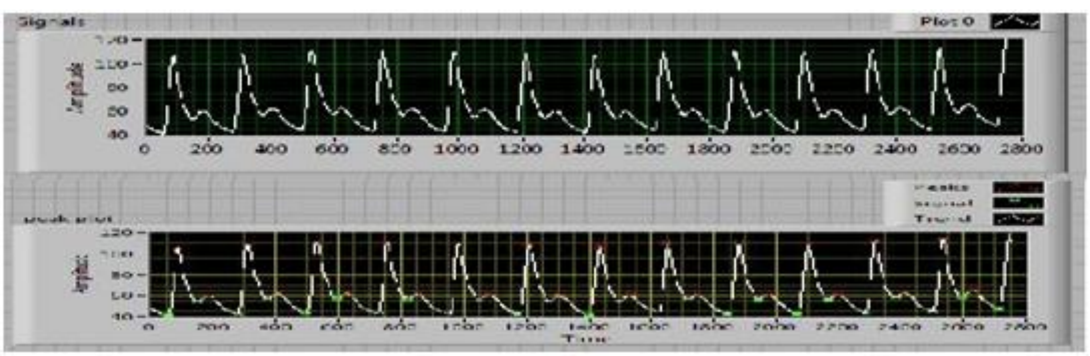


Fig 1. Peak Detection in Normal Subject

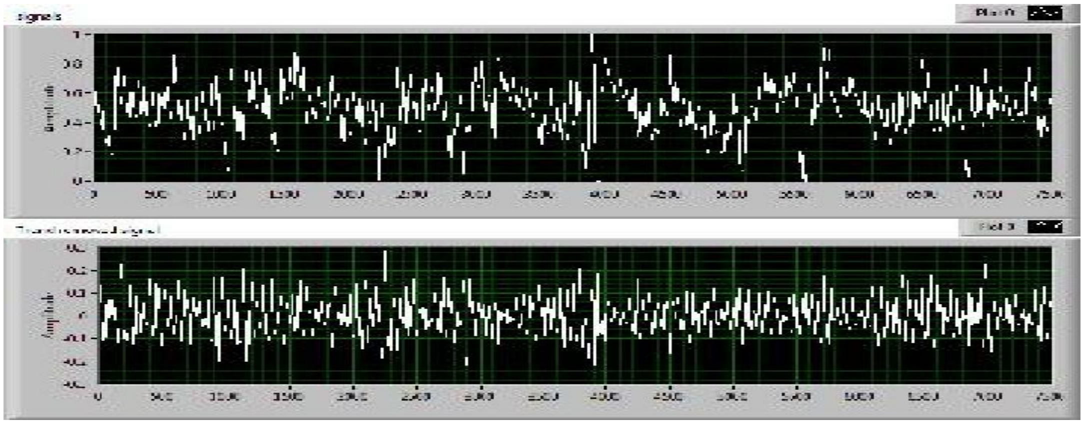


Fig2.Acquisition of Abnormal signal and its Baseline drift cancellation

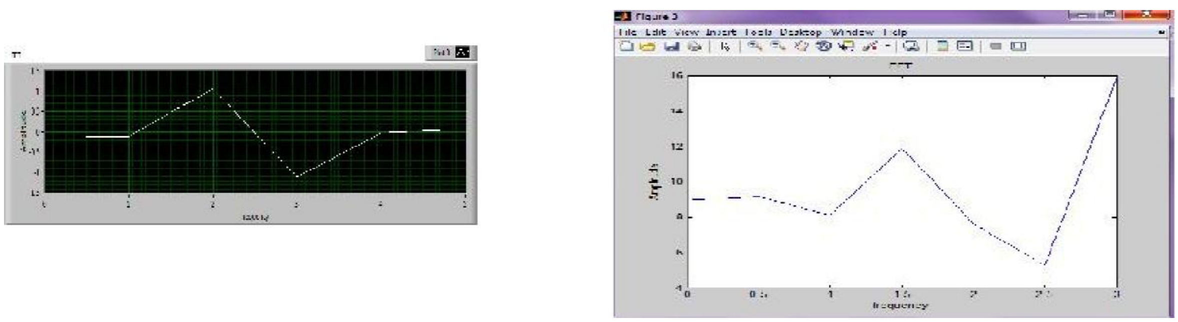
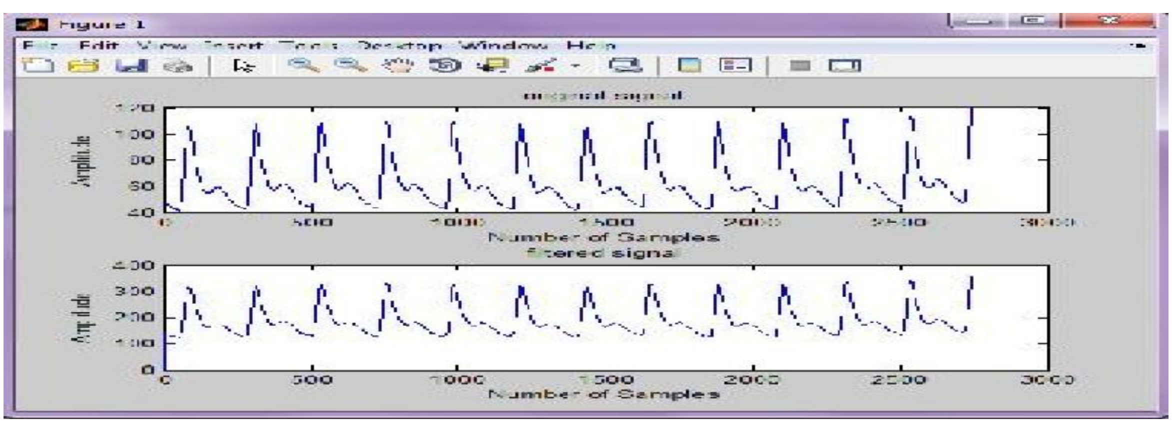


Fig 3. FFT on abnormal Subject



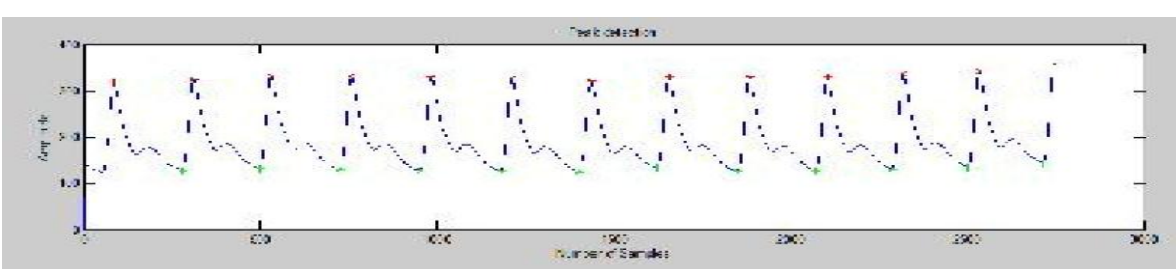


Fig.4Detecting Peaks and onset for a Normal subject.

The following is the detection of heart beat frequency in an abnormal signal

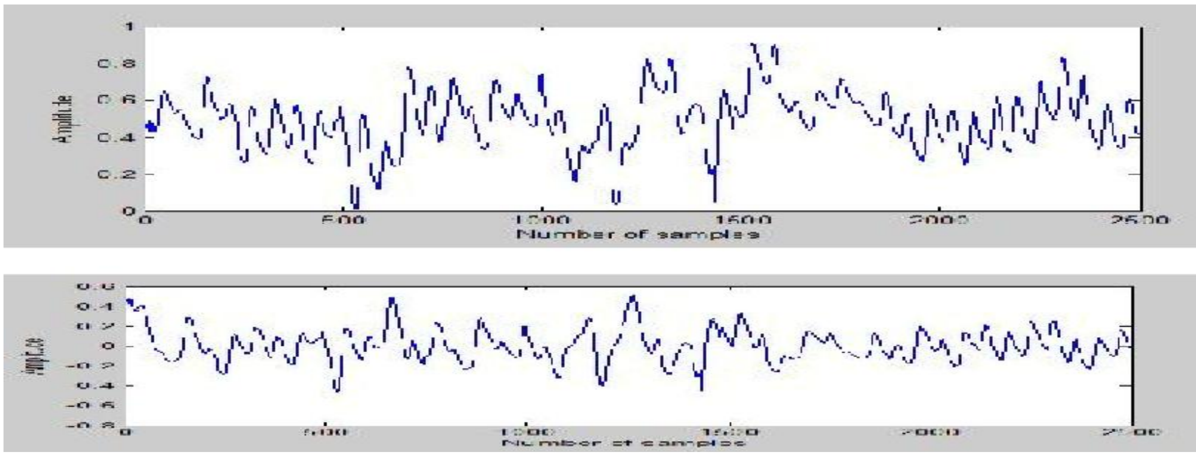


Fig 6.FFT Applied to the Abnormal Subject

The signals are acquired using LabVIEW software and analysis is done by implementing the algorithm in MATLAB.

IV.CONCLUSION AND FUTURE SCOPE:

The signals were thus analysed and its peak identification such as initial peaks, detection of potential false peaks and relocation of missed peak detection have to be identified. This peak detection is determined by implementing an algorithm in MATLAB, and then implementing the same in real time using Labview. The future work includes the validation of the result with a stronger data base.

REFERENCES:

[1]. “Pulse oximetryplethysmographic waveform during changes in blood volume,” Br J Anaesth, vol. 82, (no. 2), pp. 178-81, Feb 1999.

[2]. W. Zhong, T. Heldt, G.B. Moody, and R.G. Mark, “An open-source algorithm to detect onset of arterial blood pressure pulses,” Computers in Cardiology, pp. 259- 262, Sep. 21-24 2003.

[3]. Stephen,P.Linder,Suzanne,M.Wendelken, Edward, vWei “Using the morphology of PPG peaks to detect changes in posture-2004”,Journal of Applied Physiology

[4]. Stephen Paul linder,SuzanneWendelken “Using the Morphology of the photoplethysmogram Envelope to Automatically detect hypovolemia”-2005,Journal of clinical monitoring.

[5]. BistraNenova, Ivo Iliev- “An automated algorithm for the fast pulse wave detection”.November-2010-international Journal of Bio-Automation.

[6]. Hang Sik Shin, Chungkeun Lee, Myoungho Lee- “Adaptive threshold method for the peak detection of photoplethysmographicwaveform”,October 8,2009-Journal Homepage

[7]. Paul Cox, Chris Madsen, Kathy L. Ryan, Victor A. Convertino,EmilJovanov “Investigation of photoplethysmogram morphology for the detection of hypovolemiastates”,August 24,2008-IEEE EMBS

[8. Liangyou Chen, Andrew T. Reisner, and JaquesReifman-“Automation of Beat onset and peak detection algorithm algorithm for the field collected photoplethymogram”,september 2-6,2009-IEEE EMBS

[9]. Umar Farooq, Dae-Geun Jang, Jang-Ho Park, Seung-Hun Park-“PPG Delineator for Real-time Ubiquitous Applications”september 4,2010-IEEE EMBS.