

Process of Detecting Chronic Diseases by using Photoplethysmogram- A Review

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Abstract - The aim of this paper is to detect the different types of chronic diseases with the help of the photoplethysmography (PPG). A literature review is made to detect the different types of chronic diseases such as diabetics, hypertension, heart rate (HR), arterial stiffness, etc. PPG is used to estimate the blood flow of the skin by using infrared light. Various researchers from different domains have interested only because of their advantages such as inexpensive, non-invasive and easy to set up. There are two different types of methods to calculating HR, Electrocardiogram (ECG) and PPG. The ECG signal in which a wave graph that records electrical activity of heart. By detecting peaks of waveforms of ECG or PPG we get details of heart beat.

Key Words: Photoplethysmography, Diabetics, Hypertension, Heart Rate, Arterial Stiffness, Electrocardiogram.

1. INTRODUCTION

The word plethysmograph is a combination of two different Greek words 'plethysmos' means increase and 'graph' which is the word for write and photo means light. The set up of PPG is very easy, convenient, simple and economically efficient. It uses a probe which contains a light source and detector to detect cardio-vascular pulse wave that propagates through the body. [1] The PPG signal reflects the blood movement in the arteries, which goes from heart to the fingertips through the blood vessels in a wave-like motion. [2]

The PPG Signals consists of AC and DC components. The AC components is synchronous with the heart rate and depends on the pulsatile volume changes. The DC component of the signal varies slowly and reflects variations in the blood volume of the examined tissue. There is variation in the wave due to aging of the artery which leads to stiffening.

RELATION BETWEEN DIABETES AND HEART DISEASE

The connection between diabetes and heart disease starts with the high blood sugar levels. over the long period, the high glucose in the blood stream can damages the arteries, causing them to become stiff and hard. A Fatty materials that builds up on the inside of the blood vessels, a condition is known as atherosclerosis. This can block the blood flow to the heart or brain, therefore leading to heart attack or stroke.

That's because people with diabetes, particularly type 2 diabetes, because of this conditions that contribute to their risk for developing cardiovascular disease. High blood pressure (hypertension) has long been recognized as a major risk factor for cardiovascular disease. When the patients have both i.e. hypertension and diabetes, which is a common combination, then there is a risk for cardiovascular disease is much greater.

2. LITERATURE REVIEW

D.W.Kim, S.Wookim (2007) discuss about the population of diabetes is increasing very fast due to economic development and lifestyle changes. Diabetes mellitus (DM) which is related to the defective of insulin secretion and/or function is a chronic metabolic disease. Many organs including kidney, heart, muscle, eyes and other organs are affected due to the long period of diabetes, which is associated with the tissue damage and damage of the blood vessels. They use the photoplethysmography (PPG) and Laser Doppler (LD) to measure the blood volume changes and perfusion of fingers and toes. They suggested PPG method provides good reproducibility, sensitivity. They also prove that it is simple, low cost, reliable non-invasive which could become an effective for early detection of diabetic.

K.C.Lan, P.Raknim (2018) says that the early prediction is possible when we collecting PPG-based information. They use a data mining technique to estimate Heart Rate Variability (HRV) and they predict diseases. Heart rate variability (HRV) is used to overcome the risk of cardiovascular disease and have also obtain the data via electrocardiography (ECG). collecting heart rate via Photoplethysmography (PPG) is now a lot easier. By detecting peaks in the waveforms in either ECG or PPG, we can very easily obtain the details of a person's heart beat information. The beat to beat interval is measured by peak to peak interval. In an ECG wave this is known as the RR Interval, where R is the point which corresponding to the peak of the QRS complex. They focus on the prediction of hypertension. They use six HRV parameters to predict hypertension, they are present below and they said that it is possible to predict the disease by collecting the PPG-based heart rate information.

Table -1: Descriptions of the HRV parameters.

SDNN	Standard deviation of all RR (NN) intervals
SDNN	The std deviation of average NN intervals calculated over short periods
Mean RR	Mean of all RR intervals
RMSSD	Square root of mean of the square of all NN interval differences during a time period
LF/HF	Low to high frequency power ratio.
LFmu	Normalized low frequency power of the HRV.
HFmu	Normalized high frequency power of the HRV.

S.S.Mousavi, M.Firouzmand (2109) do their work for measuring the Blood Pressure(BP) which is one of the four vital signals that provides valuable medical information about the cardiovascular. In recent years, various studies have been conducted on non-invasive and cuff-less BP estimation by using the photoplethysmography(PPG)signals. S.S.Mousavi gives a new method for estimating the mean arterial pressure (MAP), Diastolic blood pressure (DBP) and Systolic blood pressure (SBP) by using only the PPG signals. They uses raw value of the PPG signals at a given time interval for estimating BP. They used parameter based algorithms and use the features which are extracted from PPG signals in time or frequency domain. The results are also very close to the standard boundary with an average error close to zero for SBP estimation. Also, according to the British Hypertension society (BHS) standard, the proposed algorithm for DBP estimation got grade A.

S.Usaman, M.B.Reaz done the work in the characteristics of photoplethysmogram(PPG) has been investigated non-invasively to measure the condition of arterial stiffness. They will work on a total 101 type 2 diabetic patients and aged is from 50 to 70 year were participated in their study. The patients divided into two groups which Group1 consist of patients with HbA1c<8% and those with HbA1c>10% is in Group 2.An area under curve has been investigated and chosen as PPG parameter. An independent sample t-test used to compare an auc-PPG between two levels of HbA1c which are HbA1c<8%.The results have explained that changes in arterial properties can be non-invasively detected by analyzing pulse shape characteristics. An auc-PPG promises a potential technique for analyzing shape with dicrotic notch.

3. METHODOLOGY



As shown in above flow chart, any PPG diagnostic structure consists of three stage pre-processing, features extraction, classification.

a. PRE-PROCESSING IN PPG SIGNALS.

The quality of the PPG signal depends on the various factors such as location and the properties of the subject’s skin at measurement that also include the individual skin structure, the blood oxygen saturation, blood flow rate, skin temperatures and the measuring environment. PPG sensors optically detect changes in the blood flow volume via reflection from through the tissue. The changes in the light intensity are associated with small variations in blood perfusion.

b. PPG FEATURES EXTRACTION AND ITS APPLICATIONS

PPG signals were recorded using commercial devices and they were analyzed off-line by using MATLAB. With the help of pulse we extract the important features from that PPG Signals. Here we will take the standard wave form of the PPG signals for the analysis and give information of some terminology .The PPG pulse is commonly divided into two phases: the anacrotic phase is the rising edge of the pulse, another is the catacrotic phase is the falling edge of the pulse as shown in figure below.

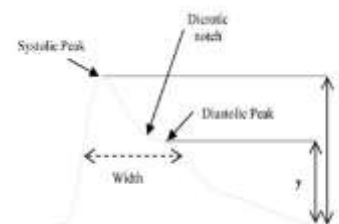


Fig 1: waveform of PPG

The first phase is primarily concerned with systole and the second phase with diastole and wave reflections from the periphery. From the PPG wave we can also understand some terminology which is as given below.

- Peak to peak intervals:-The distance between two consecutive systolic peak will be referred to as peak-peak interval.
- Pulse Interval:-The distance between the beginning and the end of the PPG waveform.

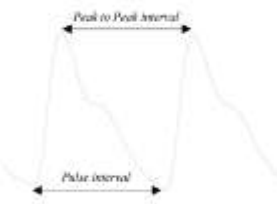


Fig 2: two consecutive PPG waves

Second derivative photoplethysmogram (SDPPG) which is one of the application of PPG for detecting the arterial condition. So, before going to SDPPG we see First derivative photoplethysmogram.

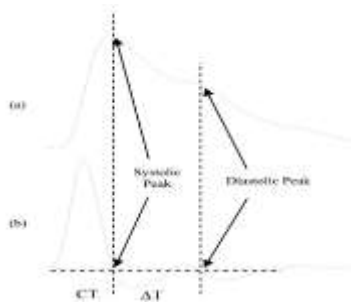


Fig 3: first derivative wave of PPG

Crest time (CT): crest time is the time from the foot of the PPG waveform to its peak which is see in figure.

ΔT :-T is the peak-to-peak time which is related to the time taken for the pressure wave to propagate from the heart to periphery and back. The time between the systolic and diastolic peaks is ΔT .

Second derivative photoplethysmogram (SDPPG)

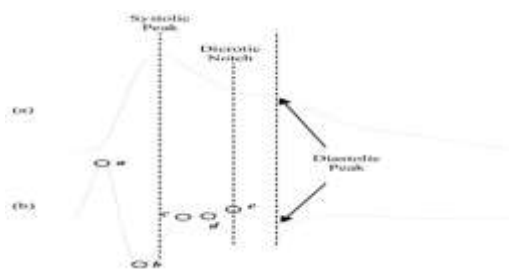


Fig 4: second derivative wave of PPG

The second derivative of the finger PPG waveform is used to stabilize the baseline and enable the individual features to be visualized and detected easily. The waveform includes four systolic waves and one diastolic wave namely a-wave(early systolic positive wave),b-wave(early systolic negative wave),c-wave(late systolic reincreasing wave),d-wave(late systolic redecresing wave) and e-wave(early diastolic positive wave).The e-wave represents the dicrotic notch as shown in figure.

4. CONCLUSION

This review discussed the photoplethysmography technology and also give the applications of PPG with the help of literature survey. A common structure of any PPG diagnostic system consists of three stages preprocessing, feature extraction, and classification. The main focus of this review was the preprocessing and feature extraction stages. In the feature extraction stage, the characteristics of the PPG waveform and its derivatives have been clarified. Photoplethysmography is a very reliable technology due to its simplicity, low cost and non-invasive. It has potential for early screening for various chronic diseases such as Heart Rate, Hypertension, Diabetics, arterial stiffness, etc. However, a full understanding of the diagnostics value of the different features is still lacking and more research is needed.

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