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Deriving ECG Signal from PPG Signal

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Abstract- — **Due to high cost of ECG signal, it is difficult to measure it regularly. In this paper we suggested a low cost, non invasive and easy methodology to analyze human cardio vascular system by using parameters of PPG as this signal is highly correlated with ECG. This paper deals with extraction of time domain features of PPG signal, correlate it with ECG and select most relevant features. The comparison of selected features and overall features has been done by Support Vector Machine (SVM) and Artificial Neural Network (ANN) and Linear Regression which is use as a predictors.**

Keywords **– ECG, PPG, SVM, ANN, Linear Regression**

I. INTRODUCTION

Electrocardiogram (ECG) is a way to quantify the electrical activity of heart. Electrocardiography is the process of recording the electrical activity of the heart over a period of time using electrodes placed on the skin.[1] Electrocardiogram (ECG), a noninvasive technique is used as a primary diagnostic tool for cardiovascular diseases. A cleaned ECG signal provides necessary information about the electrophysiology of the heart diseases and ischemic changes that may occur. It provides valuable information about the functional aspects of the heart and cardiovascular system. [2]Customary ECG monitoring is a good practice for patients suffering from heart diseases as well as elderly people who are prone to heart attack. But, it might not be feasible for all to have a day to day clinical ECG diagnosis. In this paper, we are using simple, non invasive and cost effective technique to diagnose heart problem. Our goal is to provide a low profile initial screening system, that is capable of engendering alert for possible un wellness and refer to a detail medical checkup.

II. LITERATURE OVERVIEW

The tissues in the human body are generally considered to be opaque, while transmission of light is seen at the skin or soft tissue levels. Wavelength of red light is comparable with color of blood; this near red is more perceptible than other wavelengths or colors. By means of this property of tissues, Photoplethysmograph acquires the information associated with pulsation by collecting the transmitted signals [3]. Moreover there have been simple, inexpensive contrivances commercially available for recording PPG signals from peripheral body components like fingertip, auditory perceiver lobe [4]. Grimaldi, D. et al proposed technique for android smart phone predicated PPG capturing technique[5]. Recently, there has been a trend to capture fingertip PPG signal utilizing high end keenly intellective phones having flash enabled camera.. [6] All these have made PPG predicated physiological sensing more appreciable and easily available. Now a days, PPG has been extensively drawing the attention of medical researchers and scientists for direct and indirect estimation and quantifications of different physiological parameters[7]. Lug et al. [8] have shown that the human cardiac cycle can be directly synchronised with PPG & ECG signals. In ECG signals, the peak to peak interval is called the RR interval, since the peak point is denoted by R. This paper deals with correlating this RR interval with the peak to peak intervals in PPG signal. The paper also involves complex study of feature extraction of PPG with the help of MATLAB to correlate it with the other parameters of ECG, namely P, Q, R, S. For this purpose, Rohan Banerjee et al.[9] have defined a methodology in which, feature corelation has been done based on mathematical tools for prediction such as Artificial Neural Network (ANN) & Support Vector Machine (SVM). For feature extraction of ECG signals (PR, QRS, QT & RR time intervals), this paper follows the methodology defined by Elgendi M. [10]. Zhao et al. [11] have also defined a useful methodology of feature selection. They have used SVM & wavelet transform for the same, which are proven methods in mathematical probabilistic networks for prediction of target set of value. Another method for ECG analysis has been defined by Saxena et al. [12]. The developers have used a combined wavelet transforms

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technique for the same, in which they used a quadratic spline wavelet (QSWT) for QRS complex detection and the Daubechies six coefficient (DU6) wavelet for P and T points detection.

To detect the intermediate peak of QRS complex, Chouhan et al. [13] have employed a modified definition of slope of ECG as the feature using an algorithm. The major contribution in feature selection is given by the mathematical tools such as Maximum Information Coefficient (MIC) & Pearson Coefficient (PCC) (ρ). Useful information is regarding MIC is amply available in the works of Reshef, D. et al [14]. The references regarding the Pearson Coefficient are limited. The wider information regarding the topic is available on the website [15]

III. METHODOLOGY

Fig 1. Shows block diagram of system. It is divided by two part, 1] find correlation between ECG and PPG using generally available mathematical tools like MIC and PCC 2] predict value of ECG through PPG using predictor SVM, ANN and linear Regression.

IV. PREPROCESSING

The data for system has been referred from MIMIC database available on Physionet ATM [22] library which is use by researchers in the field of cardiology. PPG signal is prodigiously dependent to the properties of the subjects' skin temperatures, ambient light, skin structure etc. So, felicitous care should be taken for PPG

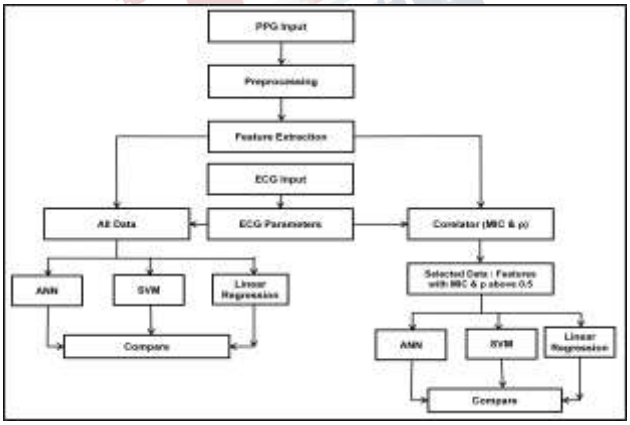

Fig 1 : Block Diagram of system.

Signal feature extraction. PPG signal generally contains an astronomically immense but gradually varying DC part along with the AC component. PPG signals are largely variable. So, PPG signal is segmented into fine-tuned length diminutive non-overlapping windows. Samples corresponding to each window are passed through a 4th order bandpass Butterworth filter (cut-off frequency 0.25 Hz and 20 Hz) to abstract the DC and high frequency noise components. The samples are further passed through moving average filter for smoothing and to abstract high frequency noise. Thus the PPG samples are ready to feature extraction.

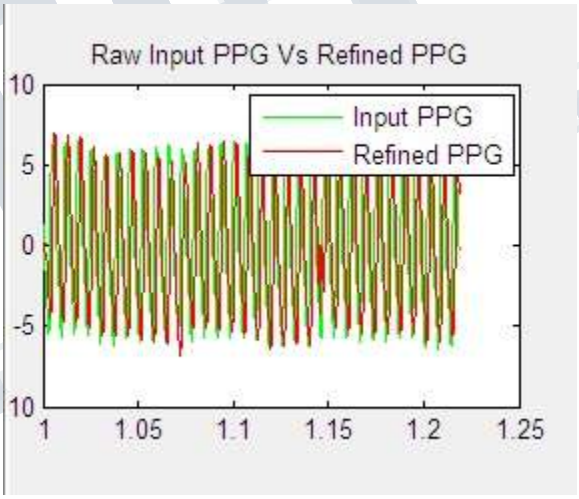

Fig 2: Input PPG and Refined PPG

V. FEATURE EXTRACTION

The methodology for extraction has been define by [9], the features of ECG are RR, QRS, PR, and QT which are the time intervals between the corresponding point on ECG wave. The data regarding this features has been referred from the online library for cardio logical research (Physionet ATM).

VI. FEATURE SELECTION

Feature selection is done by using generally available mathematical tools like MIC [15] and PCC [16].

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In this work, all features of PPG have been correlated with four feature of ECG using MIC as well as PCC. Both this methods are powerful to measure linear and non linear relationship between pair of variables. The result values given by these tools are in between 0 to 1. The criteria for selection of the data is that, the result value given by MIC and PCC should be greater than 0.5. this shows in fig 3.

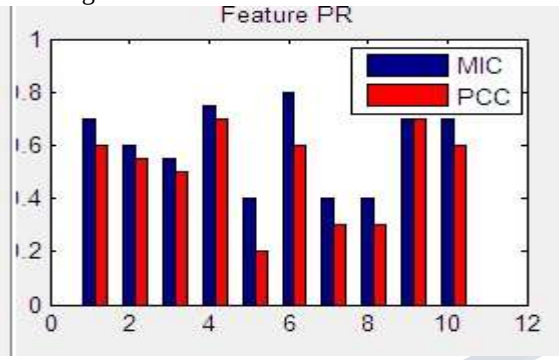

Fig 3.1: Correlation of PR with PPG parameter.

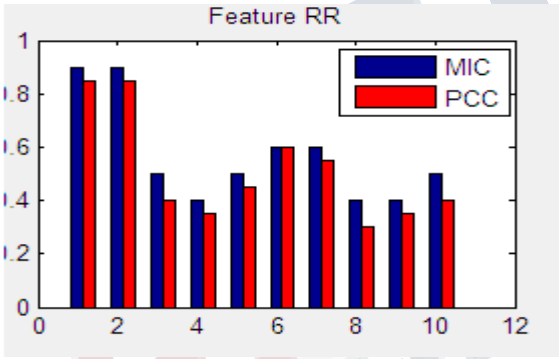

Fig 3.2: Correlation of RR with PPG parameter.

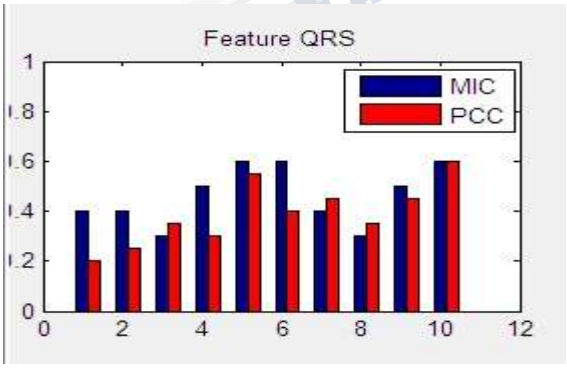

Fig 3.3: Correlation of QRS with PPG parameter

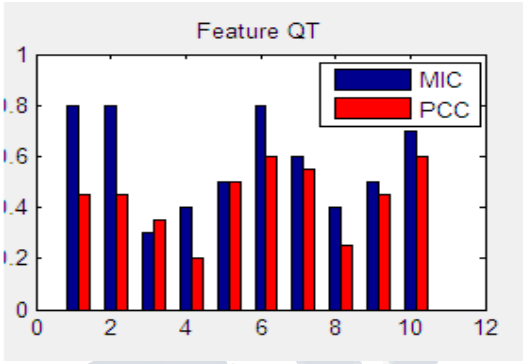

Fig 3.4: Correlation of QT with PPG parameter

Table 1: Datapair dependency from MIC and PCC

MIC	PCC	Datapair dependency
high	high	Strong and linear
high	low	Strong but non linear
low	low	weak
low	high	NA

Refer table no 1, for more details on the significance of MIC and PCC values. We eliminate weak and NA features using this predefine table [9].

Table 2: Selected Features

Features	Parameter
PR	1,2,3,4,6,9,10
RR	1,2,6,7
QRS	4,5,6,7
QT	1,2,5,6,7,10

VII. PREDICTORS

With the help of MIC and PCC, the correlation between ECG and PPG signal becomes clearer as shown

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in fig 3.1 to fig 3.4. The selected parameters and All parameters are then tested with the help of ANN, SVM and Linear Regression. The selection criteria for the parameter are that the data pair relationship should not be weak or NA as shown in table no 1.

VIII. RESULT

Table 3: Using All Parameter

Parameter	ANN %	SVM %	Linear Regression%
PR	67	73	68
RR	64	76	72
QRS	86	69	66
QT	80	68	78

Table 4: Using Selected Parameter

Parameter	ANN %	SVM %	Linear Regression%
PR	94	88	73
RR	86	83	78
QRS	91	88	76
QT	83	81	83

Table no 3 and 4 shows predicted Accuracy results given by ANN, SVM and Linear Regression Predictors. The results given by selected parameters are more inclined towards accuracy and thus it proves that the parameters selected with the help of MIC and PCC are accurate. Accuracy given by ANN is more as compared to SVM and Linear Regression.

IX. CONCLUSION

This paper correlates ECG parameters with the help of PPG signal analysis. ECG and PPG signals are highly correlated with each other. Overall performance of system improves due to selection tools such as MIC and PCC and we can predict value of ECG with the help of PPG signal.

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