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# Preprocessing Techniques and Area Estimation of ECG from a Wireless ECG Patch

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**Abstract**— In electrocardiograms (ECGs), most of the clinically helpful information is found within the wave intervals, amplitudes, or morphology. This is principally motivated by increasing aid prices and propelled by recent technological advances in miniature bio sensing devices, electronics, and wireless communications. This paper tries to comprehensively review and experiment economical and strong strategies for machine driven ECG pre-processing and delineation for ECG information from a wearable device named WiPoint Patch HP111x developed by HMicro, Inc. ECG signal quality is the key factor in determining the diseases of the heart. The proposed methods delineate the P and T waves and helps to get the area of the wave. This information can be further used to identify the specific cardiac problems.

**Keywords**— ECG(Electrocardiogram),4-lead ECG patch, ECG signal.

## 1. INTRODUCTION

Society, the disease pattern has changed. For the detection of various cardiac anomalies Electrocardiogram (ECG) is one of the most important physiological signals that can help.

These systems can include various types of transmission modules and processing capabilities, small physiological sensors, and can thus facilitate low-cost wearable inconspicuous solutions for continuous all-day and any-place health, mental and activity status monitoring. As it is made mandatory that, wearable systems for health monitoring need to satisfy certain strict medical criteria while operating under several ergonomic constraints and significant hardware resource limitations. This will affect data streamed from such devices. To overcome these huddles, software, efficient control and processing units, interface for the user, and advanced algorithms for data extracting and decision making. This paper makes an attempt to Experiment, Pre-process and delineation from a device named WiPoint Patch HP111x developed by HMicro, Inc.

Electrocardiogram (ECG) plays a vital role in diagnosing cardiac patient's health that measures and records the electrical activity of the heart. Interpretation of those details permits the designation of a good vary of heart conditions from minor to serious. Today, cardiovascular disease is one among the outstanding reason behind death worldwide [1]. In the Republic of Indonesia, approximately 700 thousand mortalities per annum is caused by a heart attack [2]. The latest development in hardware and software technology enabled the wireless wearable devices which are capable of monitoring and recording the data in real time to diagnose cardiovascular diseases.

vital signs including the electrocardiogram (ECG), wearable health monitoring is an emerging technology for stable monitoring. To diagnose and determine major health risks and sustained diseases this signal is wide endorse. A patient will wear the device throughout the traditional daily activity, permitting medical employees to get away clearer read of the patient's condition that is offered from short periods of watching within the hospital or doctor's workplace [3]. Many countries around the world, such as Tai-wan, have entered an aging society where the share of the elderly has grown to 7% which has come to the definition of the World Health Organization (WHO) [4]. Due to the rapid growth of aging



## 2. HARDWARE AND SOFTWARE SETUP

### A. Hardware Setup

HMicro's HP111x WiPoint Biosensor Patch could be an absolutely disposable multi-parameter biosensor worn on the chest for an assortment of physiological information in clinical and remote observance settings. Physiological signals may be captured and processed inside the WiPoint Patch HP111x, and wirelessly transmitted to a destination receiver device for show or analysis. Physiological signals presently monitored embody multi-lead cardiogram and cardiogram derived vital sign. For mobile, remote observation and cloud-based applications, the WiPoint Bio-sensor Patch will communicate with Wi-Fi enabled devices (such as phones, tablets, and access points) directly via inbuilt Wi-Fi property or by employing a WiPoint chip primarily based storage and relay device like HMicro's WiPoint. Fig.1 shows HMicro's HP111x WiPoint.



**Fig.1: System of operation of HC 1100 WiPoint**

HMicro and HC1100 WiPoint Chip are designed from the bottom to achieve disposability objectives, low power consumption for multi-day operations, and wire as reliable for wearable biosensor patches for health care. By mixing into one chip a multi sensor interface system, signal processor system and a multiband frequency radio system, the HC1100 chip has achieved a high level of integration to lower the value for disposability. The HC1100 additionally permits a core of receiver systems to capture data from HC1100 primarily based biosensors. The HC1100 chip may be a high volume production that is managed by HMicro. In depth hardware and code development support tools and production ready reference designs for diverse varieties of biosensor patches and receiver devices area unit on the market from HMicro. The key innovations are enclosed with in the HC1100 chip.



**Fig .2: Modified ECG WiPoint patch**

Based on the above discussion and the key innovations and features of the Wi Point patch propels its usage in a wide variety of applications. A wearable health log observation system designed to take into account many wearability criteria, for example weight and therefore the system size issue must be tiny and therefore the system must not hamper any movements or actions of the user. Moreover, radiation issues and potential problems have to be accounted. In additionally there to, the protection and the privacy of the device and picked up personal medical knowledge should be secure the system, whereas power consumption must be reduced in order to extend the operating life of the system. Finally, such systems have to be compelled to be reasonable and guarantee wide public access to low value health-monitoring services. This makes device unique and grabs good attention from health care sectors, education and research organizations and finally to the public.

The data acquisition setup done undergoes a slight modification to the patch since original patch cannot be reused once the battery is over. To use the same patch for multiple times, we removed the adhesive side of the patch and extended the leads instead of sticking leads with standard connectors and an external power source. This helps to use the same device multiple times and for every data collection by replacing the ECG electrodes. Since we modified the lead by extending small length of wire, we considered the noise and interference due to that during algorithm development. The modified patch and related components are shown in figure 2.

### *B. Software Setup*

The communication between the patch and the Raspberry Pi is achieved with a common hot spot to which both devices are connected. The Raspberry pi records the UDP packets send by the patch and extract the sampled values then save as csv file for each patient. The data contains information's from two channels. The collected data from each patient will be given for Mat lab application for further processing. In our acquisition setup, we used an android mobile as a hotspot device and then connected both WiPoint and Raspberry-PI to the same hotspot. The WiPoint patch streams the UDP packets to the raspberry pi and in pi, the received data will be acquired by a C application and plotted with a simple python interface. Each WiPoint having a unique ID to distinguish from others if we use multiple patches in the same place. The constrained development will limit the computational resources inside such devices. The data from the device will be affected by various reasons like interference from other power sources and devices, movements in leads and patient body and the muscle movements. Signals are an appropriate and technical origin. These are two main categories, namely morphology and the occurrence of disturbances. Naturally, we have to minimize the problems like technical and should be careful by electrode preparation and their proper placement inpatient. However, even if they are avoided at the outset, the external problems discussed above will affect the signal. To perform morphological analysis and diagnosis for decision making we need to

segregate the important ECG phases. The outcome of that operation depends on how well we can pre-process the ECG to get a clean signal.

### 3. MATHEMATICAL BACKGROUND

#### A. Variational Mode Decomposition

Variational mode decomposition uses the variation calculus to decompose the signal into different modes. It is assumed that there is compact frequency support for each and every signal mode around a central frequency. VMD uses the methodology of optimization called ADMM to find these central frequencies and intrinsic mode functions centered on those frequencies simultaneously. Continuous is the original formulation of the time domain optimization issue. Worked on the wording is as follows. Minimize the bandwidth sum of the  $k$  modes as long as some of the  $k$  modes are equal to the original signal. Thus the unknowns at those frequencies are central frequencies  $k$  and centered functions  $k$ . Because some of the unknowns are functions, variation calculus is applied to derive the optimal functions. The bandwidth of an AM-FM signal depends primarily on both, with the instantaneous frequency maximum deviation  $\Delta f \sim \max(|\omega_k(t) - \omega_k|)$  and the instant frequency change rate. Dragomiretskiy and Zosso have proposed a function that can measure an Intrinsic mode function bandwidth  $U_k(t)$ . At first, they computed the Hilbert transform of the  $U_k(t)$ . Let it be  $\tilde{U}_k(t)$ . Then formed an analytic function  $(U_k(t) + j\tilde{U}_k(t))$ . The frequency spectrum is function is one-sided (there is only a positive frequency) and assumed is to be focused on  $\omega_k$ . This signal is translated to be centered at the origin by multiplying this analytical signal  $e^{-j\omega_k t}$ . The integral of this frequency translated signal's time derivative square is a measure of the bandwidth of the Intrinsic mode function  $U_k(t)$ .

$$x(n) = x_1(n) + x_2(n), n \in \mathbb{Z} \quad (1)$$

where signal  $x_1$  has a sparse  $K$ -order derivative and  $x_2$  has a low-frequency signal. We assume that the white Gaussian noise additive corrupts the signal  $x$ ,

$$y(n) = x(n) + w(n), n \in \mathbb{Z} \quad (2)$$

the noise here is  $w$ . if there was no sparse derivative component  $x_1$ , low-pass filtering would be sufficient to estimate  $x_2$  (because  $x_2$  is assumed to be low-frequency signal by assumption).

if  $x_1$  is known,  $x_2$  should be estimated by removing  $x_1$  from the noisy data  $y$  and low-pass filtering, i.e.,

$$\hat{x} = \text{LPF} \{y - \hat{x}_1\} \quad (3)$$

where LPF represents with zero-phase low-pass filter. So we can propose to estimate  $x$  as

$$\hat{x} = \hat{x}_1 + \text{LPF} \{y - \hat{x}_1\}$$

$$\langle \quad \rangle$$

$$\text{LPF} \quad (4)$$

where  $\hat{x}_1$  is estimated as  $x_1$ . Since the low-pass filter is

(1) linear, we can write

$$\begin{aligned} \hat{x} &= \hat{x}_1 + \text{LPF}\{y\} - \text{LPF}\{\hat{x}_1\} \\ &= \text{LPF}\{y\} + \text{HPF}\{ \end{aligned}$$

$$(2) \quad y - \text{LPF}\{y\} = \text{HPF}\{y\}$$

$$J(u) = \frac{\alpha^2}{2} \|A^{-1}P^T(Py - P_1u)\|_2^2 + \lambda \|u\|_1 \quad (5)$$

### B. Sparsity- Assiated Signal Smoothing(SASS)

In this method we perform the denoising 1D signal which will use both sparse principles of optimization and conventional filtering of linear time-invariant (LTI). This method is called ‘Sparsity-Assisted Signal Smoothing’ (SASS) [12], with some of the low-pass component and a discrete component based on a signal modeling. The problem is formulated as a regularized linear inverse problem. To set parameters for regularization and non-convexity, we provide simple direct methods. We derive a related optimization algorithm that makes computationally efficient fast banded system solvers. This SASS approach does a denoising wavelet, but does not do so by sparsely optimizing wavelets. The approach is relatively free pseudo-Gibbs phenomena in denoising wavelet. We assume that the  $x$  signal can be estimated as

### C. Cheb Function Approximation System

The functionality of the Chebfunction and chebop systems are examined. The Chebfunction system is a set of Mat workplace codes which can be used to control functions similar to symbolic computing. However, the operations are conducted numerically using polynomial representations. Chebop is built with the help chebfun to represent linear operators and allow differential equations solutions for Chebfunction. In this article, we present examples to illustrate the simplicity and effectiveness of the software. We take into account edge provision map functions as well as linear and nonlinear differential equations

$$x_j = \cos\left(\frac{j\pi}{n}\right), \quad 0 \leq j \leq n$$

(6)

For smooth functions on  $[-1, 1]$ , the original chebfun class implemented by Battles in 2004 is now called fun. An object of chebfun is made of one or more functions. Each smooth piece is mapped to the interval  $[-1, 1]$  in Chebyshev polynomials of the shape.

$$f_N(x) = \sum_{j=0}^N \lambda_j T_j(x), \quad x \in [-1, 1]$$

(7)

## 4. LITERATURE SURVEY

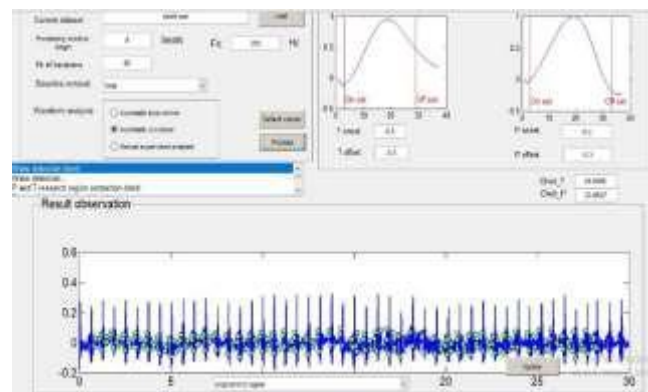
Jameela Binti Nor Mazlan et.al [5] proposed a technique that lacks ECG data alone for the current polysomnography method. A patch-type electrocardiogram sensor has been designed to monitor patients away from the hospital and features a low cost, small size, and wireless electronic device. Alexander M. Chan et.al [6] proposed a Bluetooth Low

Energy (BLE) technique consisting of two electrocardiographic electrodes, a microcontroller, a tri-axial accelerometer and a BLE transceiver. Heart rate, respiratory rate, posture, steps are measured by the sensor. Abdelbaset Khalaf et.al [7] proposed a wireless data transmission technique to an Android-based mobile phone using the Wi-Fi 802.11 standard. The smartphone application displays the information about the electrocardiogram as well as the heart rate and GPS data. Jia-Wei Jhuang et.al [8] discussed that the healthcare platform is designed to create a digital signal processing (DSP) mobile telecare environment. An electrocardiography

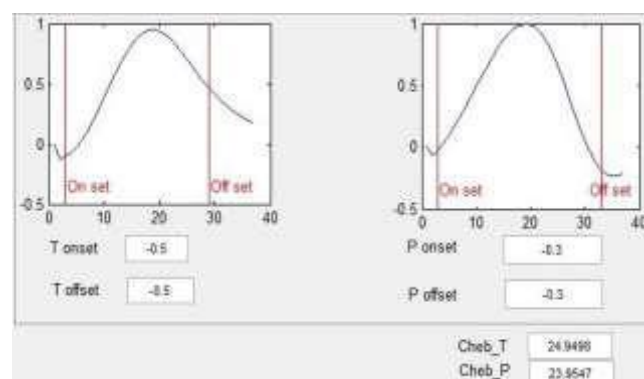
(ECG)/respiration (RESP) prototype is developed in the proposed platform to record variations in the single-lead ECG signal and thorax impedance caused by user respiration. Ali Alzaidi et.al [9] discussed ECG electrode non-contact, developed with smart materials and various textile technologies. Such electrodes with integrated nanostructure conformal antenna can use a wireless transmitter to send data to an external device for remote health, telemedicine monitoring, and health delivery. Young-jin Park et.al [10] discussed the transmission experiment using BLE with stream data, although BLE is incapable of transmitting large amounts of data. F.J. Martinez-Tabares [11] discussed about a system model of the electrode-skin interface a new long-term ECG monitoring system under the wear and forget principle. The goal of this paper is to introduce BLE wireless technology which produces results when a medical stream data was transmitted. Compared to other competitive and implantable systems, this can perform real-time measurements with minimal invasive effect.

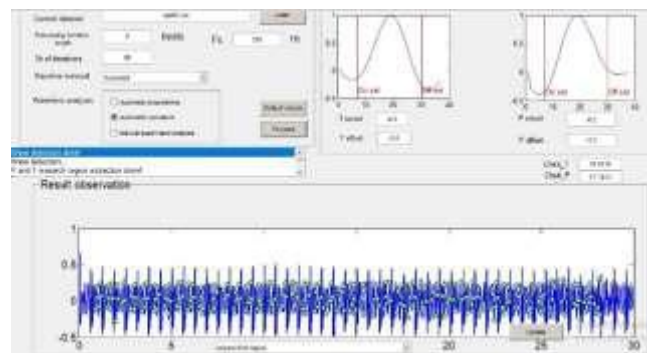
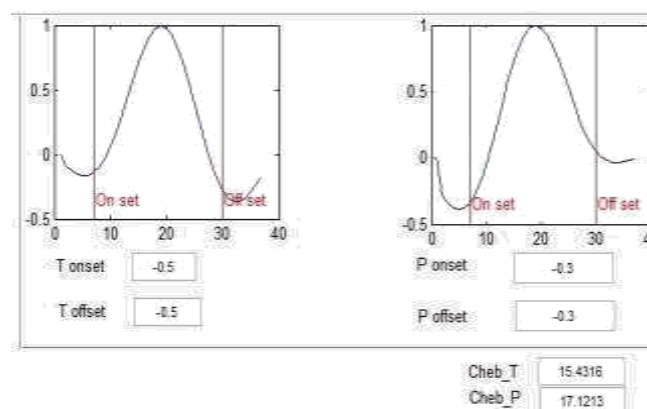
## 5. RESULTS

The delineation and estimation of the ECG is based on the work done by Choalin and team [15]. In this paper we introduce two methods of pre-processing, Variational Mode Decomposition and Sparsity-Assisted Signal Smoothing. Chebfun will determine the ECG components of specific interval and area can determine various abnormal conditions in ECG and diagnosis of the various heart diseases. Using the Chebfun we are getting the area of deflections of the P and T waves. So while using the raw data which has come from the WiPoint patch this data, we will interface to Mat lab GUI and performing the de-noising. After de-nosing some power noise which is 50Hz present in the de-noised signal, so to remove that noise we are going for the techniques like VMD and SASS. The below results will show the de-noising and the area of deflection of the P and T waves.



**Fig .3: VMD based denoised signal**



**Fig .4: Area of deflections of P and T using Cheb function****Fig .5: SASS based denoised signal****Fig .6: Area of deflections in P and T using Cheb function****TABLE 1:AREA OF DEFLECTION OF P AND T WAVES USING DIFFERENT PREPROCESSING TECHNIQUES**

| ECG Data Acquisition Mode | Preprocessing Technique | P Wave Area | T Wave Area |
|---------------------------|-------------------------|-------------|-------------|
| While Sleeping            | VMD                     | 23.0121     | 15.4545     |
|                           | SASS                    | 15.4316     | 17.1213     |
| While Sitting             | VMD                     | 30.9509     | 14.1756     |
|                           | SASS                    | 23.9547     | 24.9496     |

The above table describes the two posters of the data collection using this wireless patch that is while sleeping and sitting. So that the raw data from patch will be varied, so to find the area of deflections in P and T waves we are using a chebfunction. The values will differed according to the denosing techniques that can be shown in the table.

## 6. CONCLUSION

In this paper we modified wireless patch for ecg monitoring is used and applied for two different preprocessing techniques Variational Mode Decomposition(VMD) and Sparsity Assisted Smooth Signal Processing(SASS). The delineation of ECG components followed by the area of approximation of P and T Wave using Chebfunction. The results can be further used to diagnose and

cardiac diseases with their significance in the area P, Q,RS,S,T waves. This framework can be further extended to develop an early warning indicator for cardiac diseases.

## 7. ACKNOWLEDGMENT

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