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Design and Implementation of Arterial Pulse Detection Sensor

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Abstract:
In this work, a non invasive technique is proposed to detect arterial pulses from tridosha analysis. This system uses ayurveda knowledge for diagnosis of tridosha based on human constitution (prakriti). This system uses three ECG electrodes mounted on human wrist for capturing vata, pitta and kapha signals respectively. These three signals are then amplified and filtered using signal condition unit. By analyzing the variations in these signals, respective dosha is identified and prakriti of a person is determined.

Keywords: Nadi parikshan, Tridosha signal, ECG electrodes, Data acquisition.

I. INTRODUCTION

Identification of any diseases before treatment is very important in medical system. Ayurveda is the ancient indian system of medicine. In the non-invasive Indian traditional system of *Ayurveda* it is believed that the function of entire human body is governed by three humors: *vata*, *pitta*, and *kapha*, called as tridosha. The standard position to obtain tridosha is through a "pulse waveform" obtained on a wrist with the index, middle and the ring fingers respectively as shown in Fig 1. Each person is born with one of the seven prakritis, vaat, pitta, kapha, vaat-pitta, vaat-kapha, pitta-kapha or sama prakriti. In ayurvedic, there are eight different methods (Asthavidhapariksha) for diagnosis of imbalance in Tridosha signals. Among the eight different methods, the Nadi pariksha plays an important role in the identification of dosha in the human body. The convenient, inexpensive, painless, and noninvasive pulse-based diagnosis extracts the imbalances of *Tridosha*, which in turn identifies the presence and location of disorders in a patient's body.

Figure.1. Standard position to obtained pulse

It describes an easy-to-use system that captures the arterial pulse as a time series data. It had been checked the important properties of collected pulse waveforms, such as reproducibility, completeness, variations with age & pressure applied, and so on. These observations were found to be consistent with the literature and believe that it can be used quantitatively for identifying different types of nadis. The identification of the diseases from ayurvedic method probably costs lowest among the other existing diagnosis procedure. This is because just by studying the pulses in the wrist any ayurvedic practitioner can identify the diseases. Therefore there is a necessity to develop a low-cost medical instrumentation based on the principle of ayurveda for more accurate diagnosis. There is no availability of standard instrument in the market for ayurvedic disease diagnosis. Some works of literature report about the instruments developed for pulse diagnosis using different types of sensors and signal conditioning units. By using various sensors and methods in the recent years many devices were designed to read the tridosha signal which helped in disease diagnosis. According to a recent development, a survey on nadi parikshan for Early Detection of Several Diseases and Computational Models Using Nadi Patterns. In this study, it has been explained about the quantitative measure of the tridosha level (for vata, pitta, and kapha) using the pressure sensors which was placed on the wrist with velcro tape. The sensors are further connected to three data acquisition channels through coaxial cables. The pulse data is observed on the computer screen to read the nadi patterns using visual studio application.

II. RELETED WORK

There were different sensors used for pulse detection. Initially, irregular pulses were detected using photoplethysmography (PPG). In 2009, Tajuki Suzuki analyzed the correlation between the ECG and PPG signals By using the correlation characteristics a detection algorithm of the arrhythmic pulse to distinguish the artifacts ascribable to body movement and evaluated its accuracy.[1] After that in another study, GMR sensor used for detection of radial and carotid arterial blood flow. The influence of magnetic field on the shape of the detected signal was utilized for detection of bio-signals. While it had been established that the GMR based sensor can be used to detect a quasi-periodic bio-rhythm, possibly related to blood flow, the exact parameter that was being detected by the sensor had not been identified. [3] C. Hlenschi used the Magnetoelastic sensor for heartbeat detection. This sensor can be designed for the detection of the blood pressure waves which is generated by the heart, which generates along the arteries. The blood vessels health and the heart function relate with the velocity and shape of the pulse wave which is traveling through arteries. magneto elastic principles can be successfully used to detect small oscillations such as the ones generated by the pulsation of the blood vessels using a simple device and extends the type of the pulse wave sensors.[5] Recently in 2016, Byung-Hyun Kim using the concept of reflection coefficient of the resonator can vary as a function of the distance between the resonator and the walls of the major arteries, and the corresponding variation were utilized to obtain heart rate information at the wrist.[6] Above all the developments, it is obvious that the ancient technique is being replaced by a device with suitable techniques and different sensors for examining the Nadi.

III. METHODOLOGY

The arterial pulses are of very low amplitude and during acquisition, the noise gets added up. In order to visualize noise-free signal pre-processing of the signal is performed. The arterial pulses are acquired from the wrist of the patient using ECG electrodes. The ECG electrodes convert pulsation into voltage wherein, gel in electrodes reduces motion artifacts. The sensors must be placed at a proper position in order to get a proper signal. This paper describes an optimized nadi parikshan system developed using simple data acquisition unit. These sensors are placed adjacent to each other on a tape touching each other at the edges.

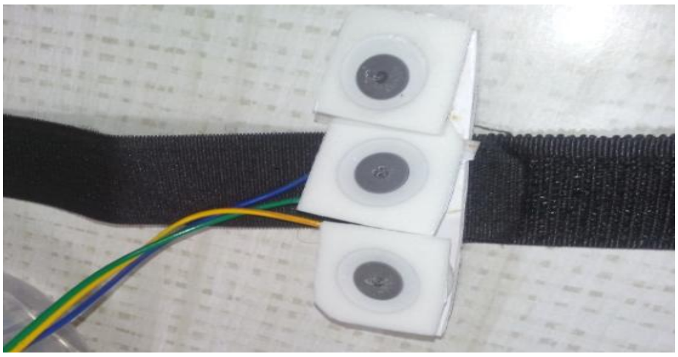

Figure.2. EGC Electrodes

The hardware set-up for the visualization of the raw signal is shown in shown in the Fig. and raw tridosha signals obtained from the set-up. The raw output signals obtained are of very low amplitude (in µv) and accompanied by random noise. For accurate diagnosis and post processing signal conditioning would be an important step.

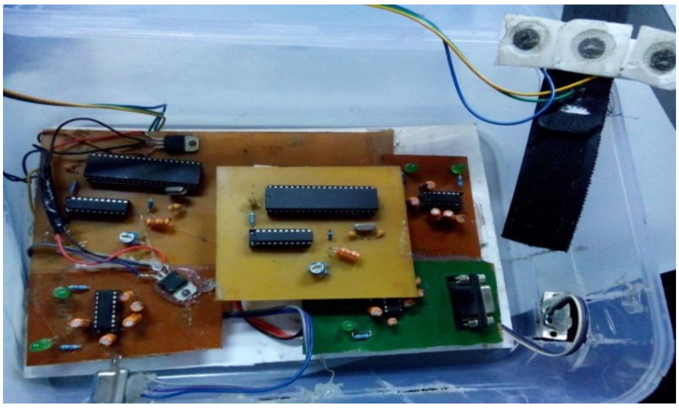

Figure.3. Hardware Setup

In the following sections, design and development of pre-processing modules using op-amp, notch filter, signal condition unit, serial communication has been discussed. The block diagram of the pre-processing module developed is shown in the Fig.4.The analog signal from the pulse sensor is amplified and filtered and visualized.

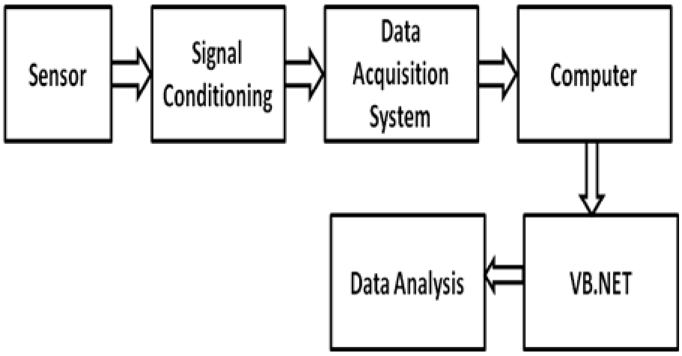

Figure. 4. Proposed System

Initially the three arterial pulse signals i.e. vata, pitta and kapha are sensed using three ECG electrodes, wherein the acquired signals are in microvolt, these signals are than pass through individual low pass filter and notch filter. The filtered outputs from notch filters are than amplified using op-amp. The output signal from the signal conditioning circuit is connected to ADC (IC ADC08084) for A to D conversion. The digitalized output signal from the ADC is visualized in the Visual studio application window using serial port communication IC MAX 232. Here the output shown on the computer window using visual basic application. With the help of Visual Basic.NET, a complete set of tools to simplify rapid application development for the experienced as well as inexperienced users.

The Graphical User Interface (GUI) provided by visual basic avoids writing of numerous lines of codes to describe the appearance and location of interface elements. Here application window is designed and programming for application development is done using .NET language. After download the visual basic application. Create a new project, in that select Window Form Application. This application is windows user interface. Fig 5 shows the new application window.

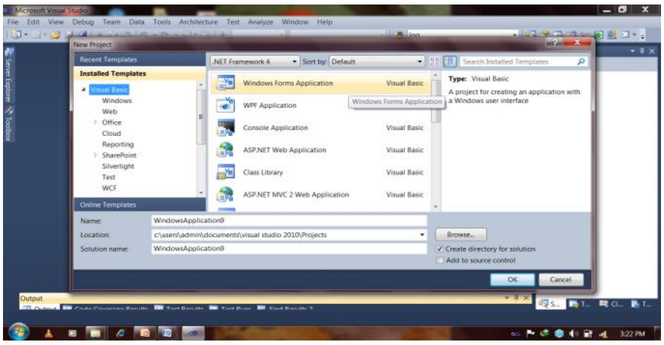

Figure. 5. New application window in vb.net

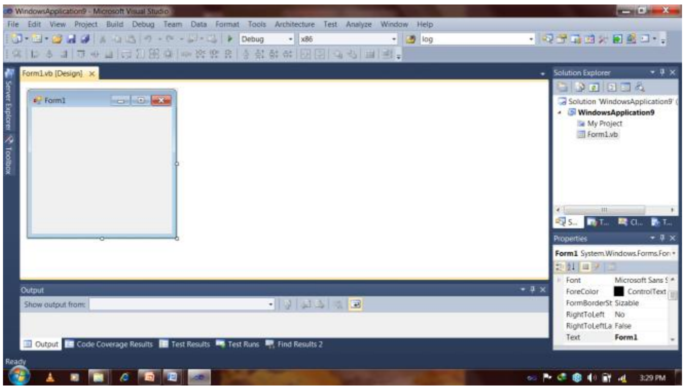

Figure. 6. Window in vb.net

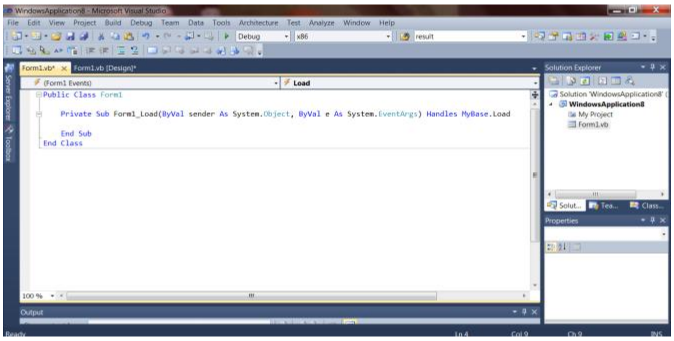

Figure.7. Programming window

IV. SIMULATION AND RESULT

For detection of pulses using sensor and find the prakriti of person and analysis of doshas are explained using the work flow of system.

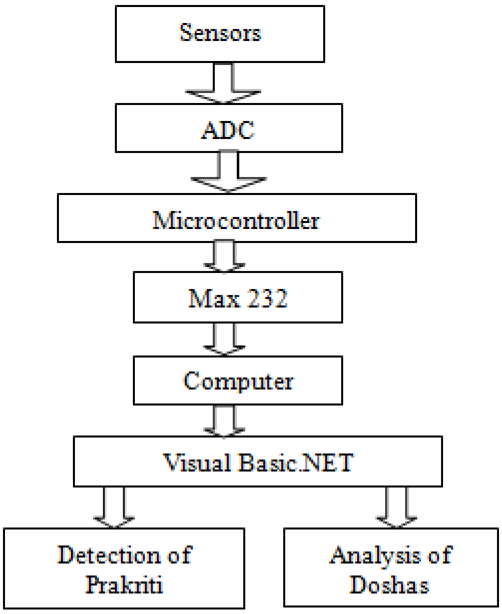

Figure.8. Work Flow Of The System

Step 1: The three ECG electrodes are placed on the wrist of the individual using velcro belt. These sensors sense the blood volume inside the arterial pulse of the wrist for V, P and K at the constant pressure and convert it into voltage value.

Step 2: ADC is used to convert the analog voltage signals from sensor into digital value. Before these conversion ADC amplify the signals because the signals getting from sensors are in microvolt to milivolt.

Step 3: Microcontroller is used for processing the signals to the computer by using interfacing implementation with MAX232.

Step 4: IC MAX232 is used to convert the RX, TX, CTS and RTS signals. It is used to make communication between microcontrollers with RS232 cable.

Step 5: After interfacing the hardware to the computer all the data is collected in computer through RS232.

Step 6: In the computer VB.NET software is used for better analysis of doshas.

Step 7: By using the application window in VB.NET, vata, pitta and kapha signals from the sensors are observed and waveforms, pulse rate and shape of the respective signals are determined.

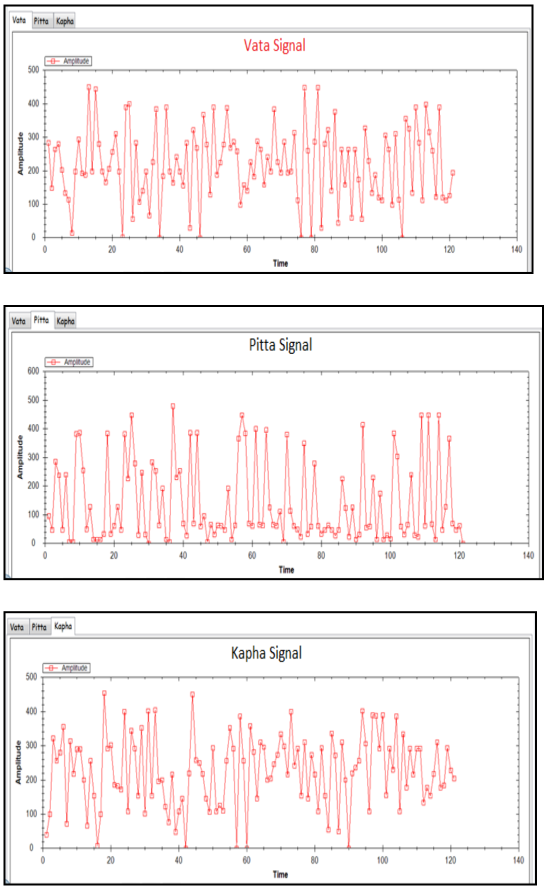

Figure.9. Output Signals Of Each Sensor

Figure 9 shows the waveform of vata, pitta and kapha signals amplitude on y-axis and time on x-axis respectively. Even though the pulse rate and waveform of the tridosha signal were agreeably, circuit was still bigger. Hence attempt has been performed to make the circuit even smaller which could be used as wearable device.

The ECG electrodes are placed on the wrist with respect to accurate position of vata, pitta and kapha. Left hand of female and right hand of male is used for pulse diagnosis.

Position- Vata: Index finger
Pitta: Middle finger
Kapha: Ring Finger

Overall Time- 60 Sec.
Number of samples- 120
Normal pulse rate - Vata: 80-100
Pitta: 60-90
Kapha: 50-70

Pulse is measured for 1 minute for diagnosis of vata, pitta and kapha readings. The data is collected based on amplitude range of vata, pitta and kapha. The amplitude and shape of the arterial pulse is considered for determining pulse patterns and detection of diseases. According to the ayurvedic medical system, when vata, pitta and kapha are in normal pulse range as mentioned above then the person is in normal state. And if the vata, pitta and kapha range is more or less than mentioned range then the person having prakriti problem which is shown on output window using visual basic application.

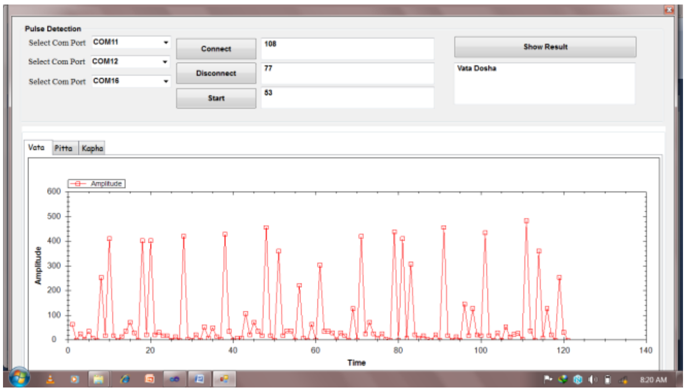

Figure .10. Shows a vata signal of a person having vata dosha.

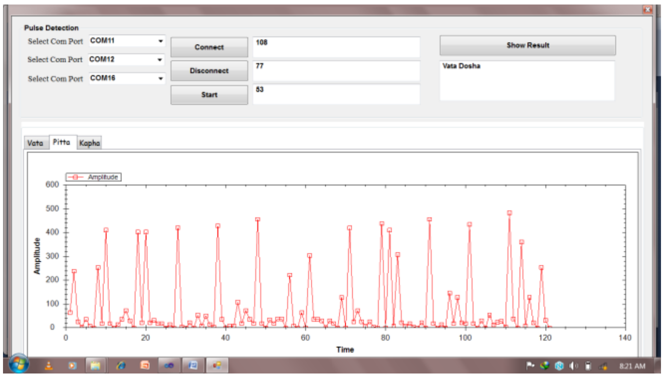

Figure. 11. Shows a pitta signal of a same person.

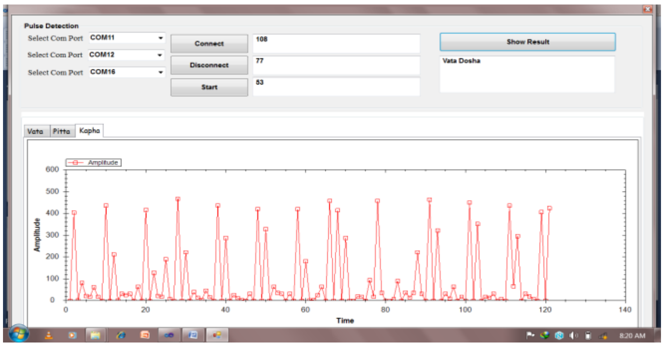

Figure .12. Shows A Kapha Signal Of A Same Person

Here, the three output windows shown in the figure 10, figure 11, figure 12, is of same person having vata dosha.
As shown in the output window, the pulse rate for vata, pitta and kapha is 108, 77, and 53 respectively. So the pulse rate for pitta and kapha is in normal range but for vata, it is higher than the mentioned range. Therefore the person is having vata dosha.

The output signal obtained is periodic and noises in the signal are also reduced. Based on the Pulse rate and the visualized signal preliminary diagnostic tests are performed.

As shown below in the table 1, Person1 is having normal prakriti because the vata, pitta and kapha pulse rate of that person is normal, between 80-100, 60-90 and 50-70 respectively. Consider person2 having vata dosha because the vata pulse rate is 107, which is higher than normal range and pitta-kapha pulse rate normal.

Now in case of person 3 having pitta dosha because the vata-kapha pulse rate is normal and pitta pulse rate is slightly higher than mentioned range. Kapha pulse rate of person 4 is higher, therefore the person is having kapha dosha.

Table .1. database of person having different prakriti

Person	Age	Pulse Rate			Prakriti of Person
		Vata	Pitta	Kapha	
Person1(M)	32	95	71	51	Normal
Person2(M)	44	105	75	52	Vata Dosha
Person3(F)	38	91	91	61	Pitta Dosha
Person4(M)	22	90	72	72	Kapha Dosha
Person5(F)	45	106	69	55	Vata Dosha

V. CONCLUSION

This research work represents design and development of optimized pre-processing module for pulse detection sensor for pulse signal analysis. The system has been designed with three ECG electrodes which are positioned on radial artery. In order to remove the noise induced due to the signal interaction with the skin and muscles, nonpolarized ECG electrodes (Adhesive gel Ag/AgCl electrodes) are used. The output obtained after signal conditioning has reduced interference of the noise. The signals are well amplified as a result tridosha pulses obtained is more precise. Further, these results are suitable for post processing, feature extraction and classification purpose; which is the next step in this research work. The developed system will be an aid to Ayurveda practitioners as a preliminary diagnostic tool. The ayurvedic practitioners can predict the prakriti to which the subject belongs to by comparing the pulse rate of the tridosha signals and through visualization of the signals.

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