NON- INVASIVE BLOOD FLOW MEASUREMENT USING PPG

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Abstract: Blood flow is the volume of blood that passes through a particular point in the circulatory system. Blood flow measurement can help in the diagnosis of heart and at the same time it is interlinked with other body parameters. Blood flow measurement can be done by various methods. Here we are proposing a non-invasive method for blood measurement which is painless and at the same time gives accurate results. This method of blood flow measurement is based upon the acquisition of the photo plethysmography (PPG) signal from the body by means of optical sensors .The obtained signal can be further analyzed for calculating the various cardiac parameters. We use a microcontroller for the transmission of signal to the computer. Analyzing and processing of the signal is done by using .This method can be also used to collect the data for further analysis from large number of peoples.

Index Terms- non- invasive, PPG, sensor, microcontroller

I.INTRODUCTION

Technology is being used everywhere in our daily life to fulfil our requirements. We are employing different sensors for different applications sometimes we may even use same sensors differently for different applications. One of the ideal ways of using technology is to employ it to sense serious health problems so that efficient medical services can be provided to the patient in correct time. This idea to provide efficient health service to patients has given birth to the project blood flow monitoring system with interfacing to PC using RS 232 Cable through MATLAB.

Blood flow monitoring and display system is a portable and a best replacement for the old model techniques which are less efficient. The blood flow rate is calculated manually using traditional techniques where the probability of error is high, so this device can be considered as a very good alternative instead of traditional techniques[2].

The project consists of a Heart beat sensor, Microcontroller and PC with MATLAB. The Heart beat rate is fed to microcontroller by heart beat sensor. The processed information is sent to PC through a USB connection. The logged heart rate is displayed on PC using MATLAB software. Then appropriate calculations are made to obtain blood flow rate from the heart beat obtained. The Microcontroller is loaded with an intelligent program written using embedded 'C' language

II.EXISTING METHODS OF BLOOD FLOW MEASUREMENTS

The different existing blood flow measurement techniques are discussed below

1) Indicator-dilution Method

Indicator-dilution method measures the averaged flow of blood in a vessel over a number of heart beats invasively. This method applies the concept of indicator, such as colored dyes and radioisotope, insertion into the blood stream and allowing it to flow in the blood circulatory system. Typically, the rate at which blood carries the indicator downstream is measured and two types of indicator dilution methods that are clinically practice are: continuous infusion and rapid injection.

2) Thermo-dilution Method

The invasive measurement method for cardiac output using temperature changes is thermo-dilution. A bolus of cold saline is rapidly injected into the right or left atrium. The blood and saline mix in the right ventricle and the temperature difference is recorded in the pulmonary artery using a Thermistor. The Swan-Ganz Catheter is a four-lumen catheter clinically used for this procedure. It can stay within the patient's body for up to 24 hours; this allows a series of cardiac output measurements to be recorded based on that Cardiac Output $\propto$ (blood temp-injectate temp)

3) Electromagnetic flow meters

The electromagnetic blood flow meter is an important tool with both medical research and clinical applications. It is based on the fact that blood is a conductor of electricity, so that the imposition of a magnetic field produces a difference of voltage across its diameter.

Measuring this voltage using electrodes on the walls of the blood vessel will allow the measurement of the mean blood velocity or the instantaneous pulsatile flow of blood. The pulsation can be averaged with respect to time indicating average blood flow over a number of heart beats.

Typical electromagnetic flow meters provide measurement output for both the instantaneous pulsatile flow of blood and the average flow. For the instantaneous pulsatile flow of blood, the flow meter measures the induced electromagnetic field, e, depending on the fact that blood is flowing with velocity, u, through a magnetic field, B. This is given by Equation:=$\int_0^{t1}(u \times B)dl$,where L is the length between the recording electrodes. For a uniform magnetic field and uniform velocity profile, the induced electromagnetic field is e = B x L x u.

4) Ultrasonic flow meters

The ultrasonic flow meter measures the blood flow in the ascending aorta by the application of Doppler principle (Huntsman et. al, 1983). It measures the instantaneous pulsatile flow in vessels non-invasively where advanced version of these devices, using Pulsed Doppler, can also measure flow profiles. The Pulsed Doppler flow meter applies an ultrasonic transmitter, which exerts a pulse travelling in a single packet to the source, i.e. red blood cell (RBC). The wave reflects off of RBCs in the blood stream and is received by the transmitter with a time delay proportional to the distance travelled. Analyzing the Doppler shift at various delays creates the velocity profile of blood across the vessel.

Pulses are usually transmitted at 4 or 8 MHz and last about 1us. The intensity of the packet is convolved with the velocity profile to create the reflected signal. Thus, the received signal must be mathematically de-convolved before it adequately represents the velocity profile across the vessel.

III. PROPOSED METHODOLOGY FOR BLOOD FLOW

1) Principle of PPG

The principle of PPG is explained briefly here[3]. Light travelling though biological tissue can be absorbed by different substances, including pigments in the skin, bone, and arterial and venous blood. Most changes in blood flow occur mainly in the arteries and arterioles (but not in the veins). For example, arteries contain more blood volume during the systolic phase of the cardiac cycle than during the diastolic phase. PPG sensors optically detect changes in the blood flow volume (*i.e.*, changes in the detected light intensity) in the microvascular bed of tissue via reflection from or transmission through the tissue. The interaction of light with biological tissue can be quite complex and may involve scattering, absorption and/or reflection. Blood absorbs more light than the surrounding tissue. Therefore, a reduction in the amount of blood is detected as an increase in the intensity of the detected light. The wavelength and distance between the light source and photodetector (PD) determine the penetration depth of the light. We are using a green led sensor made by Omron (HR-500U, OMRON, Muko, Japan) which has much greater absorptivity for both oxyhaemoglobin and deoxyhaemoglobin compared to infrared light. Therefore, the change in reflected green light is greater than that in reflected infrared light when blood pulses through the skin, resulting in a better signal-to-noise ratio for the green light source.

2) Optical sensors

An optical sensor is a device that converts light rays into electronic signals. Similar to a photo resistor, it measures the physical quantity of light and translates it into a form read by the instrument. One of the features of an optical sensor is its ability to measure the changes from one or more light beams. This change is most often based around alterations to the intensity of the light.

The wearable PPG has two modes—transmission and reflectance—as shown in Figure 1. In transmission mode, the light transmitted through the medium is detected by a PD opposite the LED source, while in reflectance mode, the PD detects light that is back-scattered or reflected from tissue, bone and/or blood vessels.

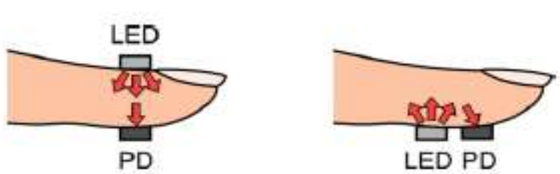

Fig.1 Light-emitting diode (LED) and photodetector (PD) placement for transmission- and reflectance-mode photoplethysmography (PPG).

The transmission mode is capable of obtaining a relatively good signal, but the measurement site may be limited. To be effective, the sensor must be located on the body at a site where transmitted light can be readily detected, such as the fingertip, nasal septum, cheek, tongue, or earlobe. Sensor placement on the nasal septum, cheek or tongue is only effective under anesthesia. The fingertip and earlobe are the preferred monitoring positions; however, these sites have limited blood perfusion. In addition, the fingertip and earlobe are more susceptible to environmental extremes, such as low ambient temperatures.The greatest disadvantage is that the fingertip sensor interferes with daily activates.

Reflectance mode eliminates the problems associated with sensor placement, and a variety of measurement sites can be used .However, reflection-mode PPG is affected by motion artifacts and pressure disturbances. Any movement, such as physical activity, may lead to motion artifacts that corrupt the PPG signal and limit the measurement accuracy of physiological parameters. Pressure disturbances acting on the probe, such as the contact force between the PPG sensor and measurement site, can deform the arterial geometry by compression. Thus, in the reflected PPG signal, the AC amplitude may be influenced by the pressure exerted on the skin.

Reflectance PPG sensors such as the MaxFast (Nellcor™, Mansfield, MA, USA) have been used clinically to measure continuous oxygen saturation non-invasively. Anecdotally, it gives false-positive readings occasionally. Further research is needed in this area.

The proposed module measures the PPG signal from the radial artery and the ulnar artery of the wrist or finger by means of a sensor shown in fifure2., whereas previous methods obtained signals from the capillaries in the skin[3]. Phototransistors and IR-emitting diodes were placed in an array format to improve the PPG signal sensitivity and level of accuracy. Various arrays were considered for optimization. A conductive fiber wristband was used to reduce external noise.

Fig.2 Sensor used for measurement

3)Arduino ATMEGA-328 Microcontroller

In our method we are using Arduino ATMEGA-328 microcontroller consist of 14 input and output analog and digital pins (from this 6 pins are considered to be a PWM pins), 6 analog inputs and remaining digital inputs. Power jack cable is used to connect arduino board with the computer. Externally battery is connected with the arduino microcontroller for the power supply.

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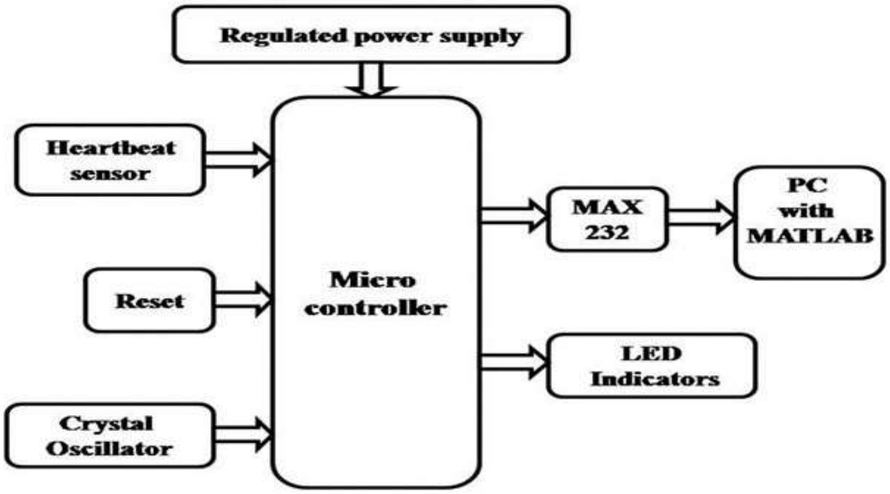

Fig.3 Block digram of proposed method

III. RESULTS

A graphical user interface is designed to display the parameters calculated from the analysis stage along with the PPG signal. When the subject places his/her index finger on the designed sensor, and runs the code in MATLAB it displays the GUI where upon clicking the start button, the acquisition of the PPG signal from the subject's finger begins and after the completion of 100 milliseconds acquisition time the heart rate and blood flow across the measurement site are displayed in beats per minute and liters/min respectively. The GUI displays the PPG signal of the subject on one side and the calculated parameters on the above as shown in below figures.

The data so acquired speaks volumes about the subject's heart functionality. In order to study the performance of the system, the experiment of estimating blood flow and heart rate was carried out on 40 subjects of different age groups. It was observed form the data collected that the changes in the blood flow happening across the measurement site showed a decreasing trend as the age group increased.

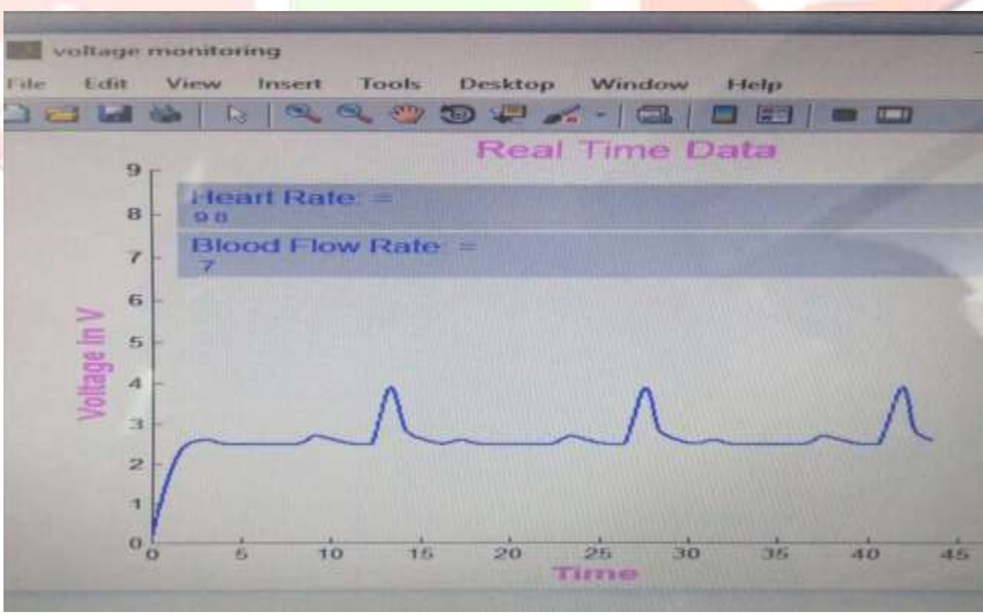

Fig.4 Output of first person

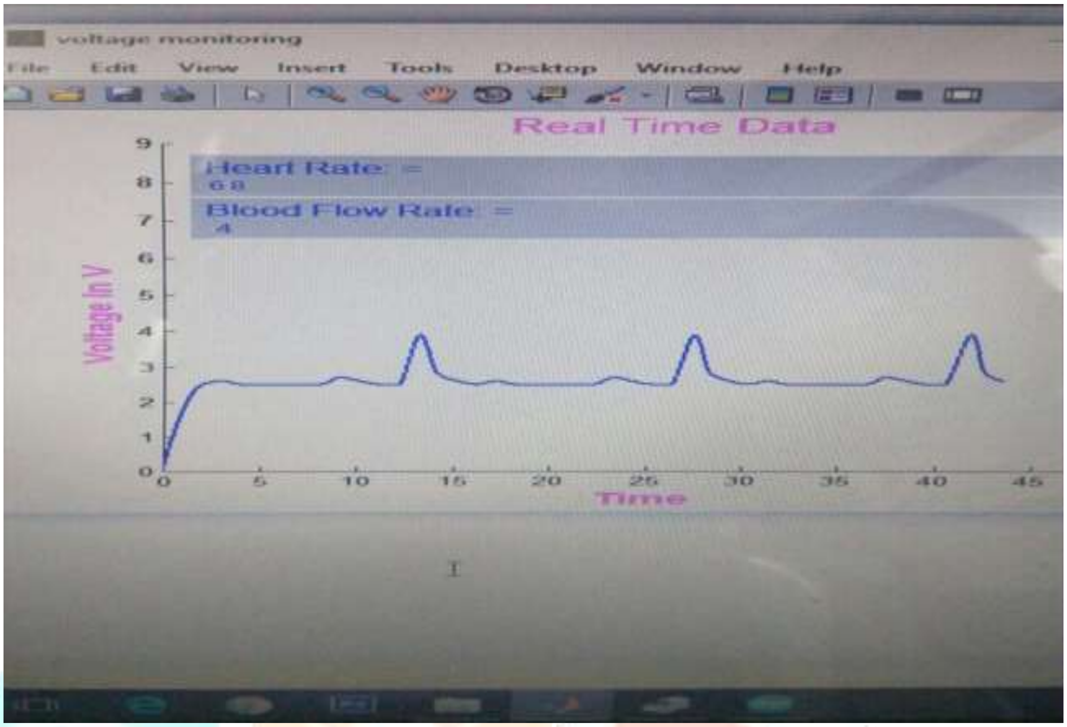

Fig.5 Output of second person

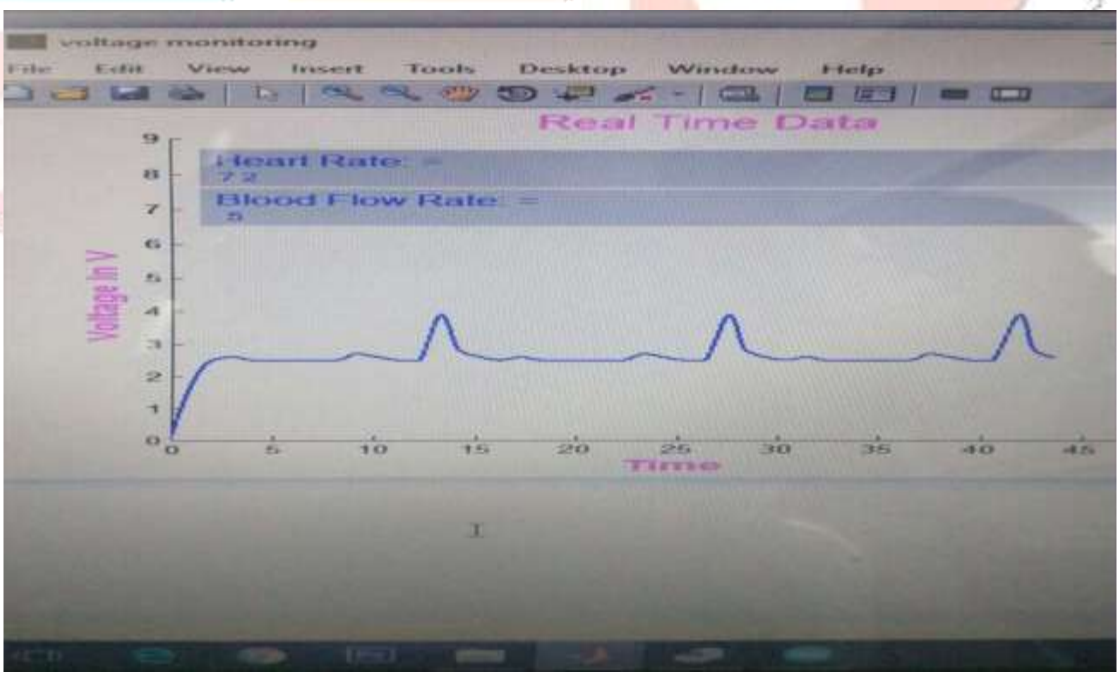

Fig.6 Output of third person

IV.CONCLUSION AND FUTURESCOPE

The PPG signal acquired has a good amount of diagnostic information which helps assess the functionality of heart and other organs. PPG can be applied in many different clinical settings, including clinical physiological monitoring, vascular assessment and autonomic function In this method we intended to design a system, which gives very accurate result than the existing devices in the present day world. This system has a heart beat sensor and PC interfaced to the micro controller. The micro controller is programmed in such a way that it takes input from the heart beat sensor when a finger is inserted into it and displays the value on the PC continuously.This method can be extended by using RS485 which also uses wired mechanism, but distance can be increased. Also, wireless technology like Zigbee can be used which eliminates the wired mechanism. Also, GSM module can be used to send the monitored blood flow rate and heart rate values values.

V.REFERENCES

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