Non-Invasive Techniques for Detection of Hemoglobin in Blood:A Review

Komal Bhatia[1], Mandeep Singh[2]
Centre for Development of Advanced Computing, Mohali, Punjab, India

***Abstract*—Hemoglobin is the most important blood parameter. Hemoglobin is the protein in red blood cells that carry oxygen to the body. Low level of hemoglobin can be due to disease like anemia and high hemoglobin level may be due to polycythemia Vera. Conventional methods are mostly used to calculate hemoglobin level. These methods involve pricking of blood with needle and sending it to laboratory for further analysis this result in delay and chances of infection. Now a day's many non invasive techniques such as colour analyses, pulse oximetry and photoplethysmography has been evolved that can be used to determine hemoglobin level in blood non-invasively. This paper gives review of the work has been done in this field. The proposed work deals with the utilizing the non invasive technique like pulse oximetry and design a portable, simple, low cost and easy to operate device to determine hemoglobin in real time.**

***Keywords*— Non-invasive hemoglobin level detection techniques; pulse oximetry; colour analyses; PPG.**

I. INTRODUCTION

Anemia is a global public health problem affecting human health as well as social and economic development in both developing and developed countries. This health problem can affect every stage of life. This problem is mostly found in pregnant women and young children. In accordance to the health statistics published by WHO anemia affects 60% population in developing countries. It is estimated that nearly 1.6 billion people suffer from Iron Deficiency worldwide [1]. Anemia is one of the most common blood disorders, occurs when total volume of Red Blood cells becomes significantly low or we can say amount of hemoglobin in these cells become low.

Anemia may result due to processes like defective red cell production due to lack of essential nutrients in the diet or increased utilization of nutrients such as during pregnancy. Anemia may also be due to increased red cell destruction (hemolysis) due to parasitic diseases such as malaria and it may be the result of Blood loss, resulting from heavy menstrual flow.

Anemia can be detected by measuring hemoglobin level in the blood. It is essential to detect the hemoglobin level in one's blood. Many techniques or methods are used to detect hemoglobin in blood documented in detail by World Health Organization [2]. There are many conventional methods and are invasive in nature used traditionally in hospitals and laboratories like Copper sulfate method, Lovibond type comparator method, Hematocrit method by centrifuge. Grey wedge photometer method, Hemocue method and cyanmethemoglobin method [2]. In these methods blood is ejected from the patients and the blood sample is analyzed.

Invasive methods come with many disadvantages as for these methods well trained and experienced technicians are required. In these methods chemical process such as enzyme reaction is required before the final value of concentration is read and reagents involved are expensive. One more disadvantage of these techniques is that time required for analysis of the blood collection which does not allow real time monitoring in critical situations. So, it is required to find simple non invasive techniques for estimation of hemoglobin level in blood.

Now days, Non Invasive techniques have been of special interest. Noninvasive technique allows pain free operation with minimum risk of infection [3]. With the advancement of technology and researchers continuous efforts many low cost, simple non invasive technologies came in existence. Researchers and scientist are putting more efforts to develop devices which may provide more accurate data for real time patient monitoring.

II. RELATED WORK

Hemoglobin level in person's blood can be estimated by analyzing the colour of the blood. H Ranganathan proposed a technique in which the photograph of the blood samples were taken for analyses and the samples were colour coded to get some values. By using artificial neural network computational models the strong relationship between blood colour and the hemoglobin was found by taking colour coded values of samples as input and hemoglobin value determined by conventional method as output[4]. In this method blood sample was needed for colour analyses. It required skilled technicians and risk of infection. Researcher K S Srinivasam proposed a technique for non invasive diagnoses of anemia in which two photograph of the thumb are taken [4][5]. First of all the photograph is taken without welling of blood and then the photograph is taken with the welling of blood in the thumb. The blood colour can be identified as skin colour or skin texture, of the person is nullified or cancelled by analyzing the two photographs. Setup was made to get standard size of the two photographs and coincidence area of two photographs, before and after the occlusion of blood should be similar. The author found a strong relation between change in Red, Green, Blue colour and hemoglobin value [5]. This method is simple, non invasive and does not require skilled technicians.

Another widely accepted and found to be most effective non invasive technique is pulse oximetry. Pulse oximeter is used for continous monitoring of heart rate of patients in hospital. Research scholar Kumar.R presented Noninvasive Sensor Technology for Total Hemoglobin Measurement in Blood. The author used fingertip pulse oximetry technique [3].

Dr. Raid Saleem Al-Baradie proposed that this technique can be used to design a non invasive hemoglobin measurement system [6]. The author in his research compared the digital value obtained after converting the signal obtained from photo

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detector with the hemoglobin value measured by conventional method stored in look up table using micro-controller and displayed the result on LCD. This device is under test. So using this technique a portable device for measuring hemoglobin value in blood can be designed.

Another technique proposed by researchers is PPG. PPG is an optical technique that can be used to detect the blood volume changes in micro vascular bed of tissues. It is simple and low cost technique. This Non- invasive technique is gaining popularity in the field of biomedical due to its advantages over the conventional methods of pricking. It is often used non-invasively to make measurements at the skin surface. Toshiyo Tamura briefly presents the history of PPG and recent developments [7]. Author has also discussed the applications of Photoplethysmography (PPG) technology which can be used to develop small pulse rate sensors. These devices, consisting of infrared light-emitting diodes (LEDs) and photo detectors, offer a simple, reliable, low-cost means of monitoring the pulse rate noninvasively.

The main components of PPG sensor are light emitting diode and photo detector. PPG sensor has two modes of operation i.e. Reflectance and transmission [7]. In reflectance mode photodiode detects the light that is back scattered or reflected from the bones or blood vessels and in transmission mode photodiode is fitted on opposite side of the led and it detects the light which is transmitted through the medium. Figure 1 shows transmission type PPG.

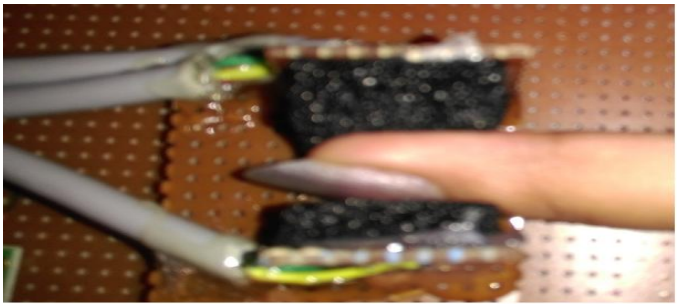

Figure 1: Transmission mode

Rutuja laulkar proposed a design for reflectance type PPG sensor and its application to calculate heart rate from the signal displayed on digital storage oscilloscope [8]. Reflectance type PPG is shown in Figure 2.

Figure 2: Reflectance mode PPG

The PPG technique it is required to monitor the waveform or signal on digital storage oscilloscope or by interfacing PC. Researcher Rajashree Doshi proposed a design of non invasive optical sensor for the hemoglobin determination [9]. In this research paper the author got result that the ac component of the PPG signal is proportional to the hemoglobin measured using conventional method.

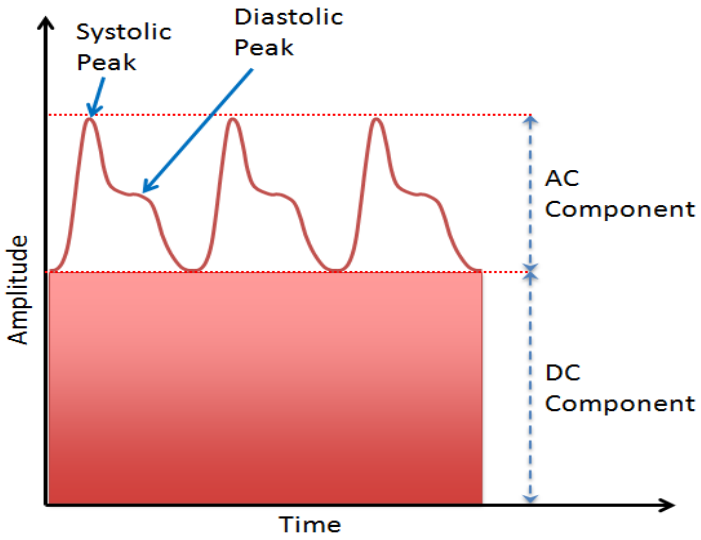

Figure 3: Variation of light attenuation by tissues

The PPG signal detected contain two parts i.e. pulsatile part called as AC component and non-pulsatile part called as DC component. The DC component is due to light absorption by skin, tissue, venous blood, and non pulsatile arterial blood. The AC component is due to light absorption associated with pulsatile arterial blood flow, and it is only 0.1% of the total detected PPG signal [7]. The AC component of the PPG signal contains desired physiological information. So, in order to extract the AC component filter circuit can be designed. The AC component magnitude is between 0.1 and 1 % of the DC component. The waveform obtained from PPG signal consist of Systolic Peak and Diastolic Peak which is shown in figure 4 and it is synchronized to heart beat. The PPG waveform can be observed and monitored on the screen with the help of software like Lab VIEW it is possible to handle data on laptop or PC.

K. Ashoka Reddy used photoplethysmographic (PPG) principle and presented a design of a virtual instrument for the measurement of parameters like pulse rate and oxygen saturation in arterial blood [10]. He cut the cost by interfacing the sensor to a PC utilizing the audio channel of the sound card, thus reducing the expensive analog to digital converter hardware. FM modulation and demodulation are employed to match the frequency response of the audio channel and PPG waveforms of red and IR. An empirical relationship was developed for the computation of the oxygen saturation in arterial blood using the red and IR PPG data and the well-known extinction coefficients of hemoglobin with and without oxygen.

Jae G. Kim studied about extinction coefficients of hemoglobin for near-infrared spectroscopy of tissue [12]. Historically, for spectrophotometric experiments, biochemists utilized Beer-Lambert's law which gives the relation between light absorbtion and hemoglobin concentration as:

$$OD = \text{Log}\ (I0/I) = \varepsilon cL$$

Where OD is the optical density can be calculated using intensity of incident light (I0) and intensity of transmitted light (I). In the above defined formulae c is the concentration of hemoglobin, ε is the extinction coefficient and L is the length of light path through solution.

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III. PROPOSED WORK

From the above discussed techniques colour analysis method is typical and a portable system cannot be designed using this technique. Using pulse oximetry and PPG techniques a simple, low cost, small and smart device can be designed which will not need any technician to operate. Anyone could be able to operate it and carry it to offices, college or anywhere and the person suffering from problem of low hemoglobin level can check the hemoglobin after regular intervals.

A. Block Diagram:

Block diagram of proposed work has been shown below in figure 4

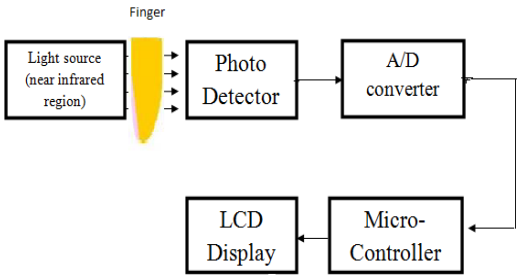

Figure 4: Block Diagram

B. Hardware:

In the proposed technique first of all sensor has to be designed. The design of PPG sensor which requires two LED i.e. RED led of 660nm and INFRARED led of wavelength 940nm. These two wavelengths are selected because at 660nm wavelength absorbance of deoxyhemoglobin greatly exceeds the absorbance of oxyhemoglobin where as at 940nm wavelength absorbance of oxyhemoglobin greatly exceeds the absorbance of deoxyhemoglobin. Red and infrared led are driven alternatively. It is switched on only for a short interval during the measurement and switched off after the measurement, through the I/O pins of microcontroller.

C. Software:

Then utilizing Beer-Lambert's Law the optical density of blood can be calculated at both wavelength.

$$OD = Log (I0/I) = \varepsilon cL$$

Then utilizing MATLAB software an equation defining the relation between optical density and hemoglobin level can be derived. Then the microcontroller can be programmed to calculate the hemoglobin value using the derived equation with optical density calculated from the signal obtained from photo detector as the input.

IV. CONCLUSION AND FUTURE SCOPE

Conventional methods used to determine hemoglobin level are time consuming and involve risk of infection and chemicals used in these methods are costly. Many non invasive techniques like colour analyses, pulse oximetry and photoplethysmogrphy has been mentioned in this paper. This paper reviews how these non invasive techniques can be helpful in designing a portable device which will allow pain free, low cost, and simple and real time monitoring of hemoglobin level in blood.

These techniques can also be used to measure other parameters in the blood non-invasively. Blood glucose level can also be measured by studying the relation between glucose level and the input signal.

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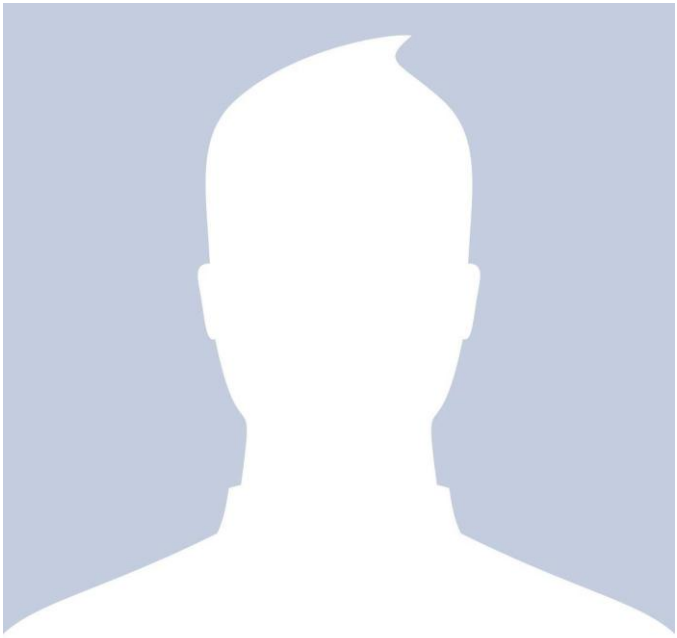
Komal Bhatia is pursuing her M.Tech degree in Electronic Product Design and Technology from Centre for Development of Advanced Computing (CDAC), Mohali, Punjab, India. She has completed her B.Tech degree in Electronic and Communication from RBIENTW, Punjab, India. Her area of interest includes Biomedical.

Mandeep Singh is currently associated as a Engineer with Centre for Development of Advanced Computing, Mohali (160071), India (A Scientific Society of the Ministry of Communications and Information Technology, Govt. of India) He has more than 10 years of experience in various geographies. He received his Bachelor of Technology in 2003 and Master of Technology in 2008 in Electronics and Communication Engineering respectively. He has published about 22 papers in International and National Journals and Conferences. He has guided 20 M.Tech thesis.



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