Haemoglobin Detection in Blood by Signal to Image Scanning using Photo-Plethysmo-Graphic-Technique (PPG)

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Abstract

Background/Objectives: This paper aims to measure hemoglobin content in blood using Photo-Plethysmo-Graphic (PPG) signals. **Methods/Statistical Analysis:** An analysis of Photo-Plethysmo-graphic signals is done by illuminating a monochromatic light using Near Infra-Red (NIR) mounted on finger or earlobe. Calculation of hemoglobin content is derived using the attenuation of light through skin-bone-tissue-blood in that extremity, well known extinction coefficients of hemoglobin and data collected from the clinical study. The signal has been recorded by Sigview software and data to be fetched for computation by Photo-Plethysmo-Graphic (PPG) algorithm. The result of Photo-Plethysmo-Graphic (PPG) is taken for regressive analysis and finally the hemoglobin content has been determined. **Findings:** The proposed method can be used in medical labs for continuous measuring of haemoglobin values. Measurement of hemoglobin content in blood not only indicates the health of a patient but also helps a physician to decide on the course of treatment of many diseases.The method of measurement in vogue requires the withdrawal of blood from veins and analysis of the blood sample in a biochemistry laboratory. **Application/Improvements:** This work can be used in bio chemical laboratories for haemoglobin detection non-invasively. The System accuracy can be further enhanced by reliability of components used.

Keywords: Haemoglobin, Photo-Plethysmo-Graphic (PPG)

1. Introduction

Haemoglobin is a metal protein present in the red blood cells of blood plasma. It is the component which facilitates oxygen transportation from alveoli of lungs to the body cells and carbon dioxide from body cells back to the alveoli. Four compounds are present in blood, out of which Oxy Haemoglobin and Decoy Haemoglobin are present in significant concentrations. Since it is a vital ingredient of blood necessary for respiratory process, continuous monitoring of blood haemoglobin concentrations is indeed for monitoring health status of individuals, especially for pregnant women, anaemic patients and new bornbabies. Day to day monitoring of haemoglobin content in blood is at most important in the treatment of patients affected with 'dengue' fever. Today, to determine haemoglobin content in blood, a few cubic centimetres (cc) of blood is drawn from the veins of the patient and being tested. The drawn up blood is then subjected to chemical analysis and the haemoglobin content in terms of milligram of haemoglobin per decilitre (mg/dL) of blood is ascertained. To implement this procedure, the services of (i) a trained paramedical staff to extract the blood sample (ii) a laboratory technician to perform the chemical analysis and (iii) a pathologist to verify and interpret the results are required[1]. Moreover, the process of determining haemoglobin content in blood in conventional methods require few hours to a day for the result to get.

Additionally, if the drawn up blood samples are to be transported, extra care is to be taken to maintain the blood samples within the temperature range of 1 and 10 ºC. Many times it so happens that haemoglobin values measured in
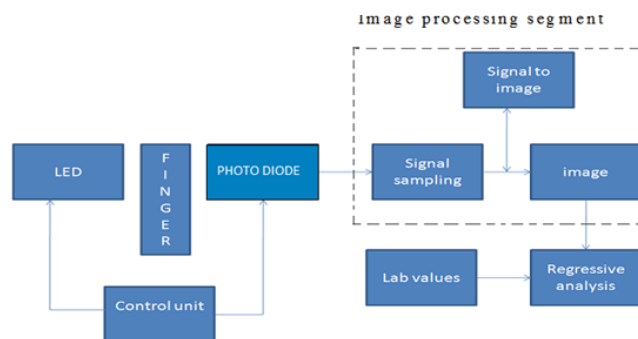
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different laboratories yield different values for the same sample. An added risk in the form of possible infection and/or haemolysis exists if blood is drawn using a syringe. The proposed method of haemoglobin detection is to get signal image scanning using photo-plethysmo-graphic technique, when extremity is placed near proximity to NIR. The rays emitted from NIR sensor is projected on extremity and the rays will be reflected back for measurement. The reflected rays are captured by photonic detector. By using image processing method, the measurement of the haemoglobin content in blood is estimated.

2. The Model based Method

The block diagram of the system for the measurement of Haemoglobin, from signal to image scanning using photo-plethysmo-graphic (ppg), is shown in Figure 1. The clip-on sensor to be mounted on an extremity (say the finger) of a patient being tested houses NIR on one side and a photonic or photo diode on the other side[2]. NIR emit invisible rays which are captured by photonic detector. The signal from the detector is recorded with Sigview software and then the recorded signal was processed using MatLab coding

Then signal to image conversion was done finally. A regressive analysis will be taken for the obtained values to determine the haemoglobin content. In this system there are various methods for the determination of the variance (σ), mean (μ), peak factor (Q) and dynamic range (D). In order to determine the haemoglobin content, variance and mean values are compared and output was plotted in PPG graph[3]. The input signal is fetched in to the Matlab coding and then the values of variance (σ), mean (μ), peak factor (Q) and dynamic range (D) are calculated.

From the recorded signal, the maximum peak value will be calculated and scaled for signal to image conversion. To convert signal from time domain to frequency domain, Hanning window technique is used for the coherent amplification of the signal (k). In order to remove the redundant parts of computation FFT has been used. For signal to image conversion, the obtained signal was converted to matrix form. The variance and mean are the constant factors used for comparison with the obtained peak factor for determination of haemoglobin. On determination of the peak factor obtained from the various readings of samples, it must be taken for regressive analysis.

3. Regressive Analysis

In the regressive analysis, the obtained values of variance (σ) and peak factor (Q) are fetched as the input of x and y axes and processed with the Matlab and the output must be obtained in PPG graph.
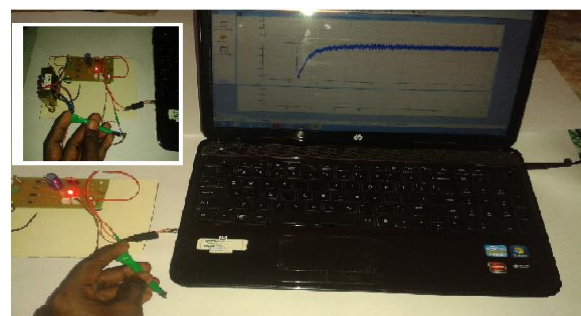
4. Execution

4.1 Recording of Signal

The control circuit consist of a step down transformer for reducing voltage and provide supply to the circuit. NIR and photonic are placed near to each other in order to capture the signal reflected by the blood molecules during motion[4]. The pin output will be connected as the input to the laptop at the adopter port as shown in the Figure 2.

The signals are recorded with the help of Sigview software and given as input to the Matlab code as shown in the Figure 3.

Then the signals are executed using Matlab and after the execution of each signal, the values for variance, mean,

Figure 1. Block diagram of Haemoglobin measurement by signal to image scanning using photo-plethysmo-graphic (ppg).

Figure 2. Picture of the prototype unit with electronics and the laptop PC. The inset shows the capturing of signal using sensors.

peak factor and dynamic range are obtained and plotted using graph as shown in Figure 4, Figure 5, Figure 6 and Figure 7.

For each patient, minimum of ten readings must be taken and the values of variance, mean, peak factor and dynamic range obtained after execution of Matlab program must be tabulated. In this method for the initial measurement of haemoglobin, the blood samples of the patients are taken and the lab results were compared with that of the regressive analysis. The Table 1 below shows the values
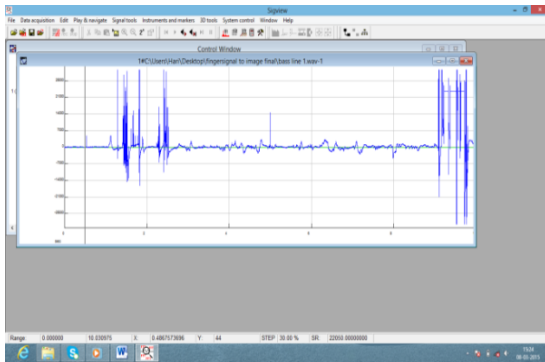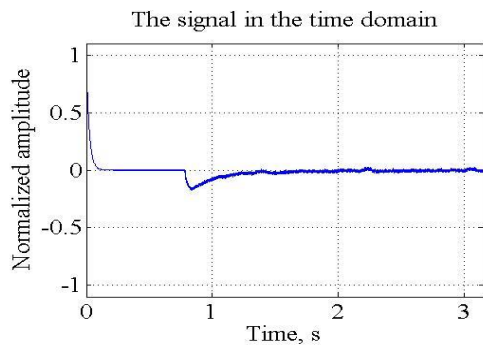

Figure 3. Signal recording using sigview.

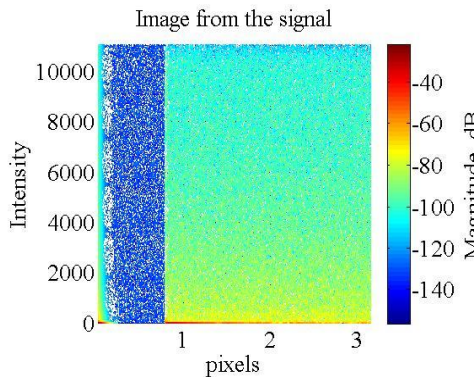**Figure 4.** Plot for variance (σ) after Matlab Execution.

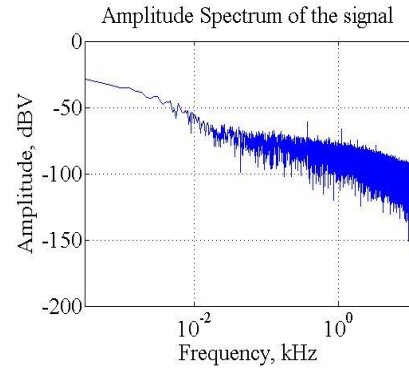**Figure 5.** Plot for mean (μ) after Matlab execution.

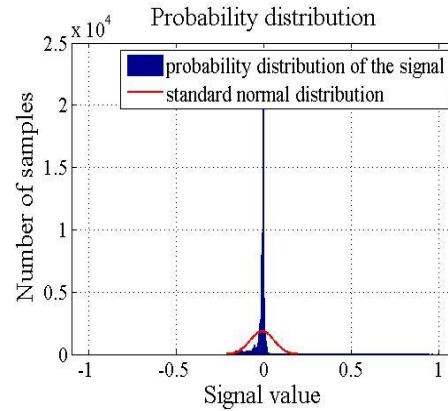**Figure 6.** Plot for peak factor (Q) after Matlab execution.

Figure 7. Plot for dynamic range (D) after Matlab execution.

Table 1. Parameters obtained for different patients after Mat lab execution

Name	Variance(σ)	Mean(μ)	Peak factor(Q)	Dynamic range(D)	Lab value
Patient1	0.23739	−0.000154	12.4909	53.7862	13.4
Patient2	0.069987	−0.011129	22.9912	84.3001	13.4
Patient3	0.19129	0.000529	14.3663	57.0374	13.4
Patient4	0.067838	−0.010262	23.2724	84.4632	13.4
Patient5	0.21652	−0.000620	13.2899	61.2441	13.4
Patient6	0.071449	−0.011741	22.8044	84.1441	13.4
Patient7	0.20924	−0.001982	13.5868	53.7327	13.4
Patient8	0.23085	−0.003332	12.7324	52.2557	13.4
Patient9	0.06872	−0.010921	23.7324	84.1823	13.4
Patient10	0.067674	−0.009805	23.3015	84.6187	13.4

of variance, mean, peak factor and dynamic range obtained after execution of Matlab program of 10 patients.

The parameters obtained after Mat lab execution must be taken as the input for the regressive analysis for the calculation of haemoglobin value.
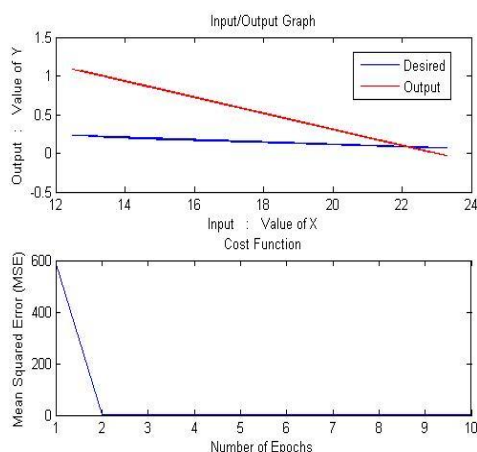
4.2 Output and Regressive Analysis

The values obtained after Mat lab execution were plotted in the graph as shown below[5]. Figure 8 below depicting series1, series2, series3, series4 and series5 represents the variance (σ), mean (μ), peak factor (Q) and dynamic range (D) and result (lab value) obtained from clinical laboratory.

4.3 Determination of Haemoglobin from Signal to Image using PPG Technique

From the signal to image conversion using PPG technique, the output of the system were obtained using regressive analysis and the content of the haemoglobin will be displayed as lab value in the program and the output graph obtained is shown in Figure 9.
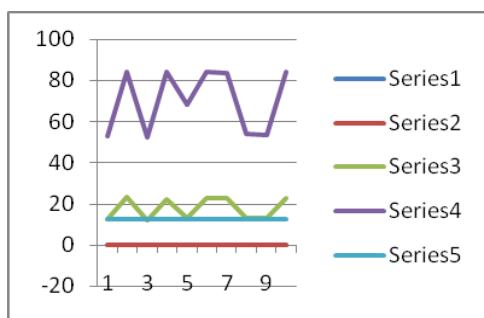
Figure 8. Graphical output representing the variance (σ), mean (μ), peak factor (Q) and dynamic range (D) and result (lab value).

Figure 9. Regressive analysis output.

5. Conclusion and Future Work

Measurement of haemoglobin content in blood not only indicates the health of a patient but also helps a physician to decide on the course of treatment of many diseases. The empirical method of measurement requires the withdrawal of blood from veins and analysis of the blood sample in a biochemistry laboratory. In this work of signal to image scanning, the Near-Infra Red (NIR) monochromatic radiations are passed and detected by photonic sensor and the output was measured with the help of the Mat lab coding. The final output was displayed in Photo-Plethysmo-Graph (PPG). In future the accuracy of the system can be improved by further increasing the efficiency of components used and thereby reducing the error occurred in the system.

6. Acknowledgement

7. References

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