

A Survey on Non-Invasive Measurement of Hemoglobin Using Various Techniques

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Abstract: Anemia is a globally feared health hazard. To reduce the inconveniences due to anemia (hemoglobin) Hb levels needs to be measured. There are number of methods available for assessing Hb value in blood. At present invasive methods are utilized to assess the Hb concentration. For this reason blood was taken and analyzed. The inconvenience of this method is the delay between the blood collection and its examination which does not permit the continuous patient observing in critical situations. This paper discusses the various techniques for measuring haemoglobin non-invasively.

Keywords: Dynamic spectrum, Hemoglobin (Hb), Magnetic PlethysmoGram, Non-invasive Blood Pressure, Pulse co oximetry, Photoplethysmogram signals, Pulse wave.

1. Introduction

Anemia is a diminishing in the total amount of Red Blood Cells (RBCs) or hemoglobin in the blood or a brought capacity of the blood down to convey oxygen. At the point when anemia goes ahead gradually, the symptoms are frequently dubious and may incorporate inclination tired, shortness of birth or a poor a capacity to work out. It goes ahead immediately frequently has more prominent side effects, which may incorporate confusion, loss of cognizance, or increased thirst. It must be significant before a person turns out to be perceptibly pale. It is the most common blood disorder, influencing about 33% of the worldwide populace. It influences about 1 billion individuals. In 2013, anemia because of iron inadequacy brought about around 183,000 passings – down from 213,000 passings in 1990. It is more typical in ladies than men, amid pregnancy, and in kids and the elderly. It increases expenses of medical care and brings down a man's efficiency through a decreased ability to work. Anemia goes undetected in numerous individuals and manifestations can be minor. The symptoms can be identified with a fundamental reason or the frailty itself. In very severe anemia, the body may adjust for the absence of oxygen-conveying ability of the blood by increasing cardiac output. If it is left untreated it will lead to many problems. So hemoglobin levels needs to be measured.

2. Literature review

Murtadha Al-Khabori et.al [1] proposed a method to assess the hemoglobin in ordinary blood donars which is based

on non-invasive pulse co oximetry. The goal of this investigation is to approve the pulse co oximetry based hemoglobin calculation in ordinary blood donars. They led an imminent observational examination on 106 in a tertiary care hospital blood donation center over a time of about month. They played out a Spot Hemoglobin obsession (Sp Hb) utilizing Masimo Pronto-7 Pulse CO-oximetry, and contrasted it with a venous example Hb focus (Reference Hemoglobin; Ref Hb) estimated using Abbott CELL-DYN Sapphire hematology analyzer. Age, sexual orientation, weight, stature, pulse and reference hemoglobin were utilized in the multivariable linear regression model of the distinction in measurement. In this aggregate of 106 donars (98 males, 8 females) were enlisted with a mean age and Ref Hb. The correlation coefficient value was calculated with the mean variation between the Sp Hb and Ref Hb. A great association was establish between the two Co-oximetry Hb measurements.

Daniel Almeida et.al [2] presented a likeness between invasive blood pressure and a non-invasive blood pressure monitor in sedated sheep. The motivation behind this investigation was to assess the exactness of the petMAP in anesthetized sheep experiencing a surgery. Checking pulse under general anesthesia in animals is essential to avoid hypotension and poor tissue circulation. 13 sheep were enlisted to calculate the correctness of the petMAP, a handy non-invasive blood pressure monitor. Animals were sedated with midazolam, fentanyl, ketamine, propofol and asserted with isoflurane in oxygen for ovariectomy. Invasive and non-invasive (petMAP) Bp analysis were reported concurrently each five minutes. Compatability between Invasive Blood Pressure and Non Invasive Blood Pressure was calculated by calculation of bias and 95% Limits Of Agreement utilizing the Bland-Altman method and correlation coefficient. The reason behind this examination configuration was to make a typical situation seen when sheep are utilized as surgical model in research contemplates, with pulse extend changing from hypo- to hypertensive state .

Ahmet Res it Kavsaoglu et.al [3] proposed a method which utilizing the distinctive features of the Photoplethysmogram signals and various machine learning algorithms for the prediction of the hemoglobin non-invasively. In this intended work, Photoplethysmogram signals from thirty three

individuals were incorporated into ten periods and forty distinctive features were extorted from them. Besides these features, sexual orientation information, height, weight and age of every subjects were also examined as the features. Hemocue Hb-201™ device was used to measure the blood count and haemoglobin level simultaneously. The best features were selected by using RELIEFF feature selection and correlation based feature selection. The hemoglobin level was predicted by using selected features and different machine learning algorithms.

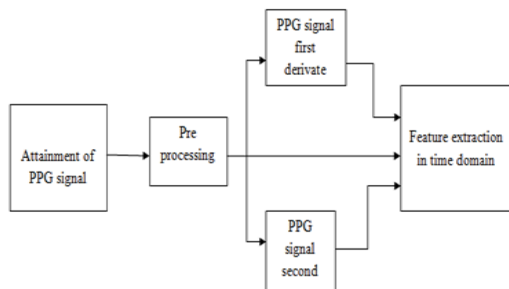


Fig. 1. PPG signal and its derivatives feature extraction block diagram

To calculate the performance of the machine learning techniques various performance measures were used. The promising results were acquired (Mean Square Error -0.0027) by utilizing the selected features. In this manner the proposed technique may clinically be utilized to figure the hemoglobin level of individual without taking and assessing blood tests.

Li Zhen et.al [4] presented a Non-invasive fetal detection of haemoglobin Bart's disease by cardiothoracic ratio during the first session. To assess the adequacy of the sonographic cardiothoracic ratio in early pregnancy for the forecast of fetal hemoglobin (Hb) Bart's disease. The ladies in danger of Hb Bart's ailment were given the choice of a non-invasive way to deal with disclude an influenced pregnancy between eleven weeks and thirteen weeks and six days of pregnancy, with a routine rescan following a fourteen days interval at a Chinese tertiary obstetric centre over a time of one and half years. The fetal cardiothoracic ratio, a sonographic marker, was determined, and invasive testing arose in cases of fetal cardiomegaly. The determination of fetal Hb Bart's ailment depended on DNA investigation from chorionic villus sampling. One fifty four at-risk cases were studied in this, Because of an unsuitable scan five cases (four at eleven weeks of gestation) were exposed to direct invasive testing. The non-invasive ultrasound examinations were carried out successfully for the rest one forty nine cases. 34 influenced pregnancies were reported, counting one gathered on rescan. The susceptibility of the non-invasive approach was 97.1% and the precision was 100%. The desire for an invasive test was decreased, and all influenced pregnancies apart from one were analysed before fourteen weeks of growth. Pregnancies with and without Hb Bart's disease can be differentiate accurately by cardiothoracic ratio. In early pregnancy, this non-invasive approach can be

utilized for the prevention of Hb Bart's disease.

C.Bergek et.al. [5], studied the effects of a sympathetic block on Plethysmographic measurement of haemoglobin concentration SpHb, PVI, and PI with the Radical-7 apparatus which is growing in fame. 20 patients experienced hand surgery under brachial plexus block with one Radical-7 enforced to every arm. Estimations were taken up to twenty mins after the block had been started. From the non-blocked arm Venous blood samples were drained. When the last ten mins of the study, SpHb had upraised by 8.6%. The PVI reduced by 54%, and PI raised by 188% in the blocked arm. Every one of these progressions were statistically noteworthy. In the non-blocked arm, these parameters did not deviate notably. Brachial plexus block notably corrected SpHb, PVI, and PI, which denotes that regional nervous control of the arm highly disturbs plethysmographic estimations attained by the Radical-7. After the brachial plexus block, SpHb raised and PVI reduced. The results are clarified to indicate that sympathetic tone strongly affects readings of these parameters by the Radical-7 pulse co oximeter.

Rezuana Bai et.al. [6] proposed a technique for determining the concentration of hemoglobin in arterial blood, non-invasively. For this they utilized a magnet which is placed just above the radial artery of a person whose hemoglobin concentration is to be found out. The flux created by the permanent magnet was sensed to acquire a signal called Magnetic Plethysmo Gram (MPG). In this the authors determined an analytical model for a magnetic plethysmogram. By using this proposed analytical model, a method of calculation of the concentration of hemoglobin in arterial blood is determined. It has been exhibited that utilizing a Magnetic Plethysmo Gram (MPG), hemoglobin concentration in arterial blood can be assessed. Since MPG is a non-invasive method, the technique of determining the concentration of hemoglobin introduced here is also non-invasive. Results of the limited clinical study on just 10 volunteers presented here, though do not provide clinical validation, but indicates that it is indeed possible to evaluate hemoglobin concentration using the MPG. The proposed method of measuring haemoglobin concentration utilizing MPG provides better results compared to the method based on the photoplethysmography.

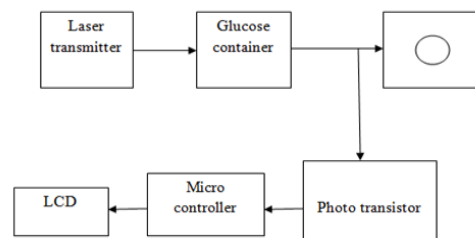


Fig. 2. RL-BGM device for the output voltage and refractive index of various GCS in in-vitro measurement

H.Ali et.al. [7], implement compact and cost-effective non-invasive device using visible Red laser Light of wavelength 650

nm for Blood Glucose Monitoring (RL-BGM).

The handheld RL-BGM device operates on +5V and precisely shows blood glucose concentrations within 10 seconds. The RL-BGM device has four fundamental components which are the 650 nm red laser transmitter, photo-sensor, Arduino-UNO and LCD display. The shortcomings such as the retention of light in human tissue, higher Signal to Noise Ratio and lower accuracy were present in the existing near infrared based Blood Glucose Monitoring techniques. These burdens have avoided near infrared techniques from being engaged for commercial Blood Glucose Monitoring applications. The Red Laser light-Blood Glucose Monitoring device has three major technical benefits over near infrared. Not at all like near infrared, has Red laser light had thirty times better transmittance through human tissue. Furthermore, when compared to near infrared the refractive index of laser light is more delicate to the variations in glucose level concentration resulting in faster reactions times seven to ten seconds. Red laser light additionally shows both higher linearity and precision for Blood Glucose Monitoring. The designed Red Laser light-Blood Glucose Monitoring device has been tried for both in-vitro and in-vivo cases and several experimental results have been created to ensure the accuracy of the proposed Blood Glucose Monitoring sensor.

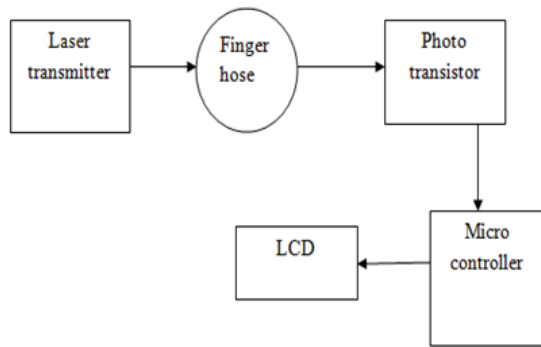


Fig. 3. Non-invasive RL-BGM device for In-vivo measurement

Volkan Turgul et.al [8] pretending the Effects of Skin Thickness and Fingerprints to Highlight Problems With Non-Invasive RF Blood Glucose Sensing From Fingertips. From the collection of obtainable measurement sites in the human body, fingertips arrive to be a good choice owing to a perfect amount of supply of blood and similarity in terms of biological layers present. The blood glucose noninvasive RF measurement commits on the disclosure of the deviation in the permittivity of the blood utilizing a resonator as a sensor. Although, the deviation in the permittivity of blood owing to the variation in glucose content has a limited range producing in a very tiny shift in the sensor's frequency response. Measurement results may be delayed because of the conflict between the measurements. These conflicts often result from the different thickness of the biological layers and deviation of fingerprints which are ideal to all human. Hence, the causes of biological layers and

fingerprints in fingertips were studied which are revealed in this paper.

Mikko Peltokangas et.al [9] examining both dynamic arterial blood pressure PWs (Pulse Wave) and blood volume PWs in this paper. Mortality is caused by atherosclerosis in the aged population and influences arterial wall properties causing variations in determined arterial pulse wave. The PWs are reported non-invasively from multiple measurement points from the upper and lower limbs from fifty two healthy (22–90-year-old) volunteers without known cardiovascular diseases. For every signal, numerous parameters were calculated, by incorporating these parameters twenty five distinct novel parameters were created. The outcomes were calculated in respect of age and heart rate dependence of the parameters. In general, the results show that 14 out of 25 tested combined parameters have stronger age dependence than any of the individual parameters. The highest attained linear correlation coefficients between the age and combined parameter and individual parameter equal to 0.85 ($p < 10^{-4}$) and 0.79 ($p < 10^{-4}$), respectively. The vast majority of the joined parameters have additionally enhanced segregation capacity while arranging the test subjects into various age gatherings. This is a promising outcome for further examinations, however show that the age reliance of the parameters must be considered in further investigations with atherosclerotic patients.

Xiaoqing Yi et.al [10] proposed a method for measuring haemoglobin non-invasively using dynamic spectrum. Spectroscopy strategies for non-invasive hemoglobin (Hgb) estimation were meddled by individual distinction and specific weak signal. With a specific end goal to address these problems the authors propose an advance methods based on Dynamic Spectrum, including instrument design, spectrum extraction algorithm, and modeling approach.

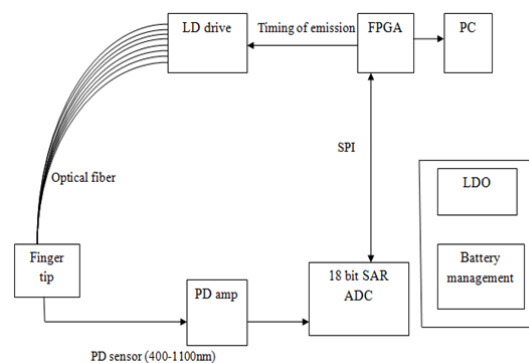


Fig. 4. The dynamic spectrometer block diagram

The light sources from the eight laser diodes with the wavelength (600 nm to 1100 nm) are accepted by the instrument and it records photoplethysmography signals at eight wavelengths concurrently. For the purpose of reduce the optical design, the authors alter the light sources with orthogonal square waves and design the corresponding demodulation algorithm, in place of adopting a beam-splitting

system. A new developed algorithm named difference accumulation has been proved to be effective in enlightening the efficiency of dynamic spectrum extraction. 220 subjects are engaged with the clinical test. An extraordinary learning machine adjustment shows between the dynamic spectrum data and hemoglobin levels. The prediction set value of correlation coefficient is 0.8645 and the root-mean-square value is 8.48 g/l. The outcomes show that the Hgb level can be inferred by this methodology noninvasively with adequate exactness and precision.

3. Conclusion

Anemia is the most common blood disorder. If it is left untreated it will lead to many problems. So hemoglobin levels need to be measured. In this paper various methods for measuring hemoglobin non-invasively were discussed in detail with their proposed methodology. The experimental result for these various methods was stated clearly. The document starts from here. And the section 2 continues accordingly.

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