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A Review on Pulse Oximetry Methods

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ABSTRACT: The main objective of this research paper is to study develop and designing of a stand-alone oximeter which allows the monitoring of oxygen saturation percent in human blood. To that, it is intended to develop an oximeter probe prototype to acquire the biological signals and then an acquisition and processing module integrates the data in order to estimate the oxygen saturation and heart rate.

The principles ofpulse oximetry are well studied and described in this review paper and are already used in modern healthcare with a remarkable credibility. So the solution oximetry of this paper will not for sure revolutionize the world: what's at stake is not to make an entire new device but it will only optimize the actual knowledge using off-the-shelf data analyze and hardware components.

I. INTRODUCTION

The most common cause of preventable disaster in the operating theatre and critical care environments is patient hypoxia. An instrument that would continually and accurately monitor the oxygen saturation of a patient's blood, preferably non-invasively, would facilitate detection of hypoxia before clinical signs are apparent, and enable the physician to initiate corrective actions before it is too late. Until the early 1980s, oxygen saturation was mainly calculated by obtaining arterial blood and examining the profile of the blood gases. However, the disadvantages of this method are that it is in vitro, with the risk of sample contamination, and more importantly is invasive and also not continuous. Although, several other ways of monitoring oxygen saturation optically have been proposed, like the Wood oximeter (Wood, 1948) and the Hewlett-Packard ear oximeter (Saunders, 1976), their success was limited. Since the early 1980s a new technique, namely pulse oximetry, has become widely used. Pulse oximeters (Yoshiya, 1980; Taylor, 1986; Griffiths, 1988; Blackwell, 1989) are used in many clinical settings, such as intensive care, surgery and emergency medicine to name just a few, for the continuous, in vivo, non-invasive monitoring of "arterial" oxygen saturation. The current situation regarding pulse oximetry is that of an extremely commercially successful instrument, mainly because of the ease of operation. Although several problems have been reported relating to the use of pulse oximeters, it has to be emphasized that pulse oximeters are very reliable clinical instruments in most cases, and this has been clearly proved over the last few years. Nevertheless it is widely acknowledged that the precise mechanism of their operation is not totally understood.

II. PULSE OXIMETRY THEORY

Although the principles of oximetry (described in the previous chapter) have been known since the turn of the century it was not until the early 1980s that the technique found widespread clinical use in the form of pulse oximetry. Since then the increase in use of pulse oximeter sin all critical care situations has been quite remarkable, turning it into one of the most important methods of monitoring in use today. All forms of oximetry rely upon the differences in the absorption spectra of haemoglobin (Hb) and oxyhemoglobin (Hb02). What has made pulse oximetry a success where other earlier oximeters failed is it's processing of the cardiac synchronous component of light scattered from tissue, related to the arrival of the "pulse". The theory of pulse oximetry has been developed by adapting the theory of in vitro oximetry. Consequently, the Lambert-Beer law has been used as the basic theory for the operation of pulse oximetry.

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This theory as is often presented and explained in the literature is discussed here in detail. The assumptions of this theory and therefore the limitations of pulse oximetry are highlighted.
The main operation of a pulse oximeter is the determination of a person's functional oxygen saturation. Arterial oxygen saturation, or SaO2, is the percentage of functional arterial hemoglobin that is oxygenated. Functional hemoglobins are a type of hemoglobin that is able to bind with oxygen. Non-functional hemoglobins cannot bind with oxygen. An example of non-functional hemoglobin is carboxyhemoglobin (COHb), which binds easily with carbon monoxide. When a functional hemoglobin binds with four oxygen molecules, it is considered an oxygenated hemoglobin (HbO2). When it is carrying less than four oxygen molecules, it is considered reduced (Hb). Functional oxygen saturation measured with a pulse oximeter is often called SpO2 because it is estimation based peripheral measurements and an assumption that only HbO2 and Hb are present in the blood. The presence of non-functional hemoglobins such as COHb can cause erroneous measurements. Therefore, SpO2 is a different measurement than SaO2.[1]

$$S_pO_2 = \frac{HbO_2}{Hb+HbO_2} \quad (1)$$

Oxygenated and reduced Hemoglobin differ in their absorption of light, a fact that pulse oximetry exploits to find the relative levels of the two hemoglobins. The most common pulse oximetry uses a red LED and infrared LED to shine light through a person's finger. A light detector is used on the other side of the finger to measure the transmitted red and infrared light.[2]

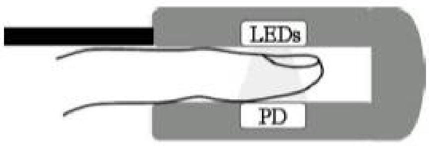

Fig. 1 Transmitter type sensor

The red and infrared LEDs are generally pulsed in an alternating fashion, so that one photo-detector can be used to measure the light intensity of both LEDs.
With a known measurement of red and infrared light transmitted through the finger, an estimate of the ratio between oxygenated hemoglobin and reduced hemoglobin can be determined based on extinction (absorption) curves at the various wavelengths of transmitted light. A typical oximeter works with 660nm red light, and 940nm infrared light. At 660nm, reduced hemoglobin absorbs about ten times as much light as does oxygenated.

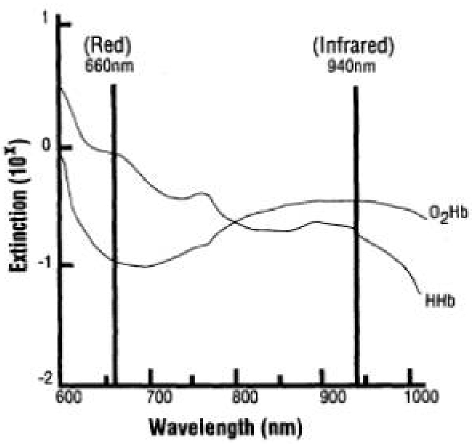

Fig.2 Extinction (absorption) of light from oxygenated and reduced hemoglobin [2]

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Because the flow of blood is pulsatile in nature, the transmitted light changes with time. A normal finger has light absorbed from bloodless tissue, venous blood, and arterial blood. The volume of arterial blood changes with pulse, so the absorption of light also changes. The light detector will therefore see a large DC signal representing the residual arterial blood, venous blood, and bloodless tissue. A small portion of the detected signal (~1%), will be an AC signal representing the arterial pulse. Because this is the only AC signal, the arterial portion of the signal can be differentiated. This AC signal is separated with simple filtering and an RMS value can be calculated.[2]

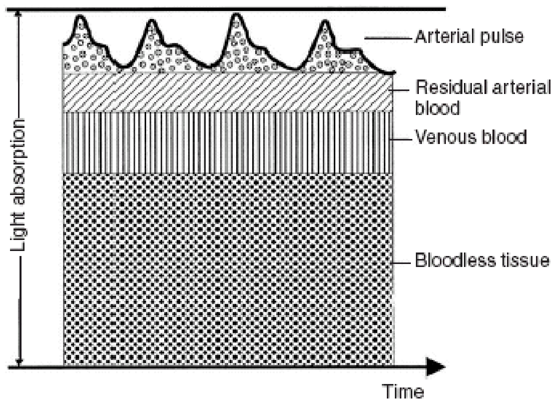

Fig. 3 Light Absorption by Tissue Type [2]

An intermediate value, known as the Normalized R ratio, is calculated using these signals.

$$R = \frac{\frac{RMS\ of\ AC\ (660nm)}{Peak\ DC\ (660nm)}}{\frac{RMS\ of\ AC\ (940nm)}{Peak\ DC\ (940nm)}} \quad (2)$$

This value represents a ratio of reduced to oxygenated arterial hemoglobin.

III. PULSE OXIMETRY METHODS

In this review paper two methods of measure SPO2 are discussed:

(a) Forehead Reflectance Pulse Oximeter

Increasing patient survivability by moving info and resources nearer to casualties within the field could be a major objective of casualty care analysis. The goal of Cynthia project is to integrate advances in communications and analysis technologies into an overseas sorting system that may expedite and improve care of the wounded. This approach may be wont to monitor troopers, initial responders, and casualties within the military and civilian domain.

ARTEMIS aims to boost field sorting by combining individual computing devices, a mobile agent info management network, a device capable of assembling pertinent physiological knowledge, AN assessment and alert system that analyzes device knowledge [14], a wireless routing system that transports and distributes knowledge among computers within the network, and a program that enables field and command personnel to access a person's health standing remotely also as issue treatment protocols. Cynthia uses an algorithmic program supported a sorting protocol known as begin (Simple sorting And fast Treatment) that was shown to be effective in multi-casualty incident sorting [5,6].

We selected to use the heart beat measuring device as our key device as a result of it's a straightforward, noninvasive, and wide used device that contains a wealth of data [10]. A forehead reflection factor pulse measuring device is right as a result of it may be placed at a lower place a headscarf, helmet, or facemask, and not be a hindrance to a soldier or initial answerer.

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Using a Forehead reflection factor Pulse measuring device To discover Changes In Sympathetic Tone Suzanne M. Wendelken1, Susan P McGrath1, Metin Akay1, George T. Blike2 1Thayer faculty of Engineering, Dartmouth. Hanover, NH, USA 2Department of medical specialty, Dartmouth Alfred Hitchcock center, Hanover, NH, USA.

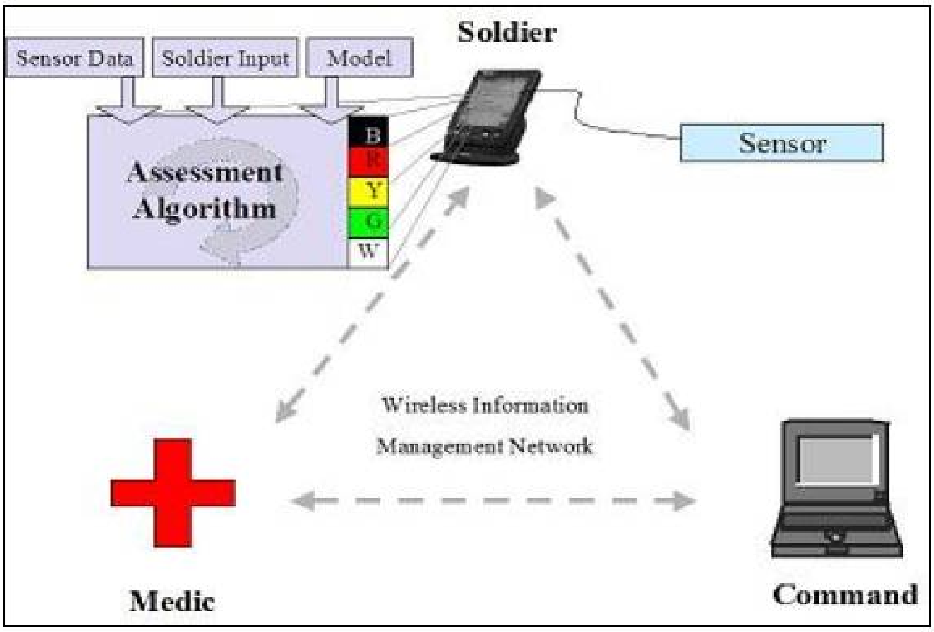

Fig. 4: Block diagram for ARTEMIS[17]

Pulse oximetry utilizes the various absorption of sunshine properties of element contained haemoglobin (HbO2) and deoxygenated haemoglobin (Hb) to calculate pulse rate and element saturation (SpO2). Several of pulse oximeters use red and infrared LEDs to probe blood vessel pulsations. The wave shape, referred to as the photoplethysmogram (PPG), resembles a pulse pressure wave shape. Recent studies have shown that variations within the PPG amplitude and pulse dimension correlate with changes in pulse pressure and tube-shaped structure (sympathetic) tone [3,8,11,12]. Additionally, there's a metastasis signal imprint upon the PPG signal [11,12]

Common battleground injuries like a gunfire wounds, blast injuries, injury, chemical burns, or severe dehydration area unit typically in the middle of blood disorder and shock. This leads to a unforeseen decrease in blood pressure. In effort to take care of blood pressure and blood flow to the brain, the sympathetic system, the a part of the involuntary system answerable for increasing blood pressure and flow rate, is powerfully activated by the receptor reflex. This leads to blood vessel constrictions that show up as amplitude variations within the PPG [11,12].

In addition to the peak and dimension of the pulses within the PPG, pulse rate variability (HRV) has been shown to be Associate in Nursing affectional indicator of involuntary system activation [7,4,13]. Low frequency parts within the HRV signal (approx. 0.1 to 0.2 Hz) correspond to each sympathetic and parasympathetic activity whereas higher frequency parts (approx. 0.2 to 0.5 Hz) correspond to solely parasympathetic activation [13]. Thus, by taking the magnitude relation of low frequency energy to high frequency energy within the HRV signal, it's doable to quantify the amount of sympathetic activation [13].

(b) Helmet-Mounted Pulse Oximeter Sensors

Remote physiological observation of troopers in combat things has become progressively vital in recent years. So as to produce quick and effective treatment to wounded combatants, medical personnel want quick and reliable measurements of the soldiers' physiological conditions exploitation wearable sensors the pinnacle region has been shown to produce usable measurements of blood vessel Spot utilizing pulse oximetry [l5].

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Branche, et al [16] showed that coefficient of reflection sort pulse measuring device sensors, mounted on a soldier's helmet or restraining straps, will give stable readings underneath resting conditions while not the utilization of a double-sided tape ordinarily accustomed secure these sensors to the skin.
Soldiers typically engaged in activities that cause their bead and helmet to endure several varieties of abrupt motion, shock, and vibration. Since body motion will introduce vital measure artifacts that consequently will cause the readings to become unstable or render the knowledge useless, we have a tendency to conduct a series of preliminary studies to check the potential interferences caused by typical motion artifacts related to higher body movements.

IV. CONCLUSION

In this paper concept of pulse oximetry and calculation of SPO2 mathematical formulation is discussed. Fingertip design include a transmitter and a receiver, IR LED of 940nm wavelength and red LED of 660nm wavelength is used as transmitter part and photodiode or phototransistor can be used as detector. The main issue of pulse oximetry is its mechanical design to make the device immune to noise generated from environment. Different methods of SPO2 measurement is discussed in this review paper.

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