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An Effective Implementation Scheme Using Fpga For Hb Assessment

KEYWORDS: Hemoglobin (Hb), FPGA, Spectrophotometry,

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ABSTRACT *With neoteric progressions in most trivial fabrication techniques as well as developments in the photonics industry, a scope to develop non-invasive portable sensors for assessing micronutrients and other substances used to gaugeoverall health of human beings. The paper presents a novel hemoglobin assessment and classification scheme to measure the total hemoglobin concentration of capillary, venous or arterial blood. The classification scheme software was implemented on a Hardware Description Language and the code can be exported to an Field programmable Gate Array to develop a comprehensive and portable noninvasive Hemoglobin Assessment Scheme. The absorption coefficients and scattering coefficients were identified as performance indicators for the proposed scheme. The results obtained substantiate the effectiveness of the proposed scheme.*

1. INTRODUCTION

One of the constituents of blood plasma, red blood cells encompasses a metallic protein compound referred as Hemoglobin (Hb)[1]. The structure of Hb resembles quaternary structure, an edifice of four compounds with substantial presence of Oxy Hb and DeoxyHb. The oxygen transportation of from alveoli of lungs to the body cells, and of carbon dioxide from body cells back to the alveoli is expedited by this component.The red blood cells count deficiency in blood diminishes its oxygen-carrying capacity and referred as Anemia. This vivacious property highlights the undeniable significance associated with continuous assessment of Hb specifically for pregnant women, individuals, anemic patients and newborn babies primarily to evaluate the presence of anemia or the requirement for blood transfusion.A stable Hb is obtained in the diluent samples by breaking red blood cells through hemolysis process resulting dissolution of internal Hb [2].

Contemporary tools to access hemoglobin in blood entails invasive method, in which the blood sample is collected from the subject by perforating the finger of the same. The popularity of this technique is predominant and extensively employed across the world. The blood sample collection method uses needles resulting direct contact with the blood and it opens up ample scope for infection. A non-sterilized external environment includes multiple utility of the same needle, ambient temperature; inexperienced technicians escalate the possibility of inflicting infection on the subjects under assessment. The usage of superior chemicals, testing equipment and trained technicians may downsize the amount of infection wreaked on the subjects [1].

The modern enhancement of assessment systems facilitates non-invasive Hb measurement schemes offers reassuring opportunity for subjects in the emergency intensive care units [3, 4]. A method referred as pulse oximetry empowers non-invasive techniques to exhibit painless and relatively efficient Hb measurement. The necessity for appraisal of Hb count led to gamut of non-invasive measurement schemes including imaging[5],spectro-photometry[6],opto-acoustic spectroscopy[7,8], transmission spectroscopy[9,10].An additional cluster of schemes under spectrophotometry includes single-wavelength photometry, dual-wavelength spectrophotometry and derivative spectrophotometry[11]. The FPGA based Hb measurement schemes implementations were established on the principle that encompasses frequency calculation by intensity strength transformation and pulse counting. These systems demonstrate dual-wavelength spectrophotometry based open-loop control structures. The utility of these systems for exhaustive demographical scenarios is constrained by their complexity, cost and significant amount of inaccuracy measurement [12]. To address the constraints identified in the existing systems this paper presents a novel Hb state classification implemented on FPGA and utilizes single wavelength spectrophotometry.

The proposition of Hb measurement scheme can be efficiently realized by exploiting single-wavelength spectrophotometry. The link between the permeable characteristic and the wavelength of perceptible light for a binding element in bloodis shown in Fig. 1[13]. The graphical representation reveals the optimal permeability of the element as 540nm. This property can be employed to develop and realize Hb assessment schemes to yield precise measurement.

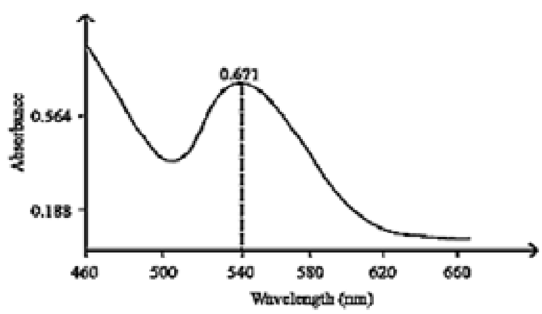

Fig.1 Plot between wavelength (nm) and Absorbance

Single wavelength spectrophotometry based Hb measurements schemes are founded on application of Lambert-beer law's statement[14].The law relates light intensity incident on blood and the absorption and scattering coefficients as described in Equation 1.

$$KL[C_0] = \log\frac{I_{in}}{I_o} + A_{SO} \quad \text{-------} \quad (1)$$

The law can also be applied to light intensity incident on benchmark diluent and the absorption and scattering and absorption coefficients as described in Equation 2

$$KL[C_1] = \log\frac{I_{in}}{I_o} + A_{S1} \text{------} \quad (2)$$

Eq. (3) can be obtained by subtracting Eq. (1) from Eq. (2)

$$C_1 = \frac{1}{KL}\log\frac{I_{in}}{I_o} + \frac{1}{KL}(A_{S1} - A_{SO}) \text{-------} \quad (3)$$

Eq. (4) can be formed by reframing Eq. (3),

$$C_1 = \frac{1}{KL}\log\frac{I_{in}}{I_o} \text{-------} \quad (4)$$

Where I_{in}= incident light intensity

I_0 = emission intensity

A_{SO} = Absorption and scattering

K = Absorptivity

L=Thickness

The Hb classification schemes implementation is catered by distinctive class very large scale integration (VLSI) processors. The VLSI architectures possess structural symmetry and precise arithmetic operational capability to facilitate classification schemes realization. The innate parallelism of classification schemes can be fulfilled by using the enormous amount of indistinguishable and synchronized processing elements of FPGA. This paper proposes an FPGA based implementation of Hb classification scheme for non-invasive Hb assessment.

2. LITERATURE SURVEY

The VLSI processor offers comprehensive utility to an array of applications including medical diagnostics, High Energy Physics Environment (HEPE) and biomedical assistive systems [15].The Classification Problem methodology can be streamlined by classifying the datasets into two major categories homogenous or heterogeneous. The constituents of homogenous datasets necessitate common accuracy requirements. Image datasets that includes face detection or recognition belongs to homogenous category [16].The elements of heterogeneous datasets unveil significant assortments amidst their extensive value ranges. The characteristics can be continuous, indexing, Boolean or categorical land they oblige for a multitude of accuracy measurements[17].

A methodical appraisal of FPGA architectures discloses that it encompasses embedded multipliers or digital signal processing blocks (DSPs) and memory blocks as granular. The performance proficiency of FPGA can be enhanced by grafting of hard logic such asmultipliers onto the programmable fabric. Contemporary FPGAs are empowered with enormous expanse of parallel computational power, optimal malleability and comprises large number of DSP blocks and well-ordered memory size blocks.The multiple facets of classification problems includes size, instantaneous constraint value changes that entails integrated chips to demonstrate a swift response to program restructuring and redefinition. [18]. The FPGA architecture outsmarts Application-Specific-Integrated-Chips to cater the requirements of classification problems. It was observed that power consumption of the FPGAs is found to be economical compared to conventional processing units. By utilizing moderate number of supports vectors in the decision function, one of the most critical characteristics of the classification schemes implementation, execution time can be optimized. This supposition points to a development of cascade structures in effectively accomplishing SVM classification tasks with enhanced speed. The proposed architectures by [19, 20, 21] supply input to block labeled with '(n+1)' from the output of a block labelled with 'n' to return a classification decision.

The perplexing characteristics of the classification problems include ambiguity and granularity shall be effectively managed by Fuzzy system. The ambiguity of the event is designated by Fuzziness and randomness describes the vagueness in the manifestation of an event. The relation between two extreme ends of the system is found to be nonlinear. Fuzzy if then rules is a structure for apprehending knowledge that comprises in exactitude. The number of rules upsurges exponentially with the facet of the input space (number of system variable). This rule eruption is called principle of dimensionality and is a general delinquent for mathematical models[22]. This difficulty can be commendablycontrolled by the single input rule model (SIRM). Commonly in fuzzy IF THENELSE conditions were used.In multifarious delinquent number of instances are subjected to AND operation to transact the strongconditions. But the number of rules to be engaged is amplified exponentially. Based on number of appraisals rule framework can be condensed. In this fuzzy processor measured light wavelength and derived wavelengthare the two input parameters. The values occupied by the Fuzzy variables are related to the true value of the event. Fuzzy system employs Member Function as a substitute to conventional numeric value system [23]. The execution flow associated with the Fuzzification process is ability to fuzzifying the crisp inputs to deal with the crisp input the fuzzy system must convert it intofuzzified quantity. For this purpose fuzzification interface is used[24]. For applying fuzzy rules a rule base block is incorporated [25]. But to provide the results to the outside world defuzzification unit performs the FUZZY to CRISP conversion [26]. To make correct decision the decision making block is added. This is shown in Figure1.

3. IMPLEMENTATION

3.1DATA COLLECTION

The experimental setup includes a set of light sources at the wavelengths of 741 nm and 805 nm. There is a signal generator that drives the light sources by a 300 Hz square wave 5 V peak to peak. The transmitted light energy is received with a photo diode. The demodulated signal from the photodiode is amplified and converted in to digital signal by analog to digital converter. Processing of the signal is done through microcontroller. The basic block diagram of the whole setup is shown in Fig.2 and the circuit diagram is shown in the Fig. 3. Transmitter sources are expected to radiate 4.0mw (741) & 6.5mw (805) so that the complete fingertip can be penetrated for more accurate results. At the wavelength of 741nm as the light that has penetrated the skin and tissues would have been partially absorbed by Hb products. The absorption level is decided by the extent of population of Hb in blood .At the wave length of 805nm, a portion of the light that has penetrated the skin is scattered and a portion

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of it is absorbed. Again the absorption level is decided by the extent of population of Hb in blood. So the strength of the transferred light gives an indication of the amount of total Hb (reduced and oxygenated) present in blood[27].

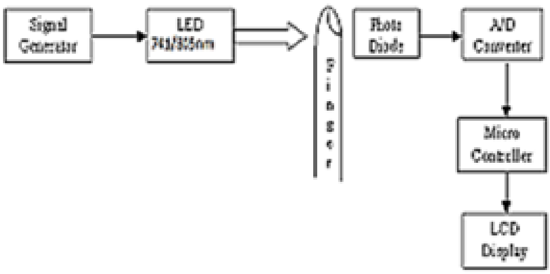

Fig.2Block diagram of Optical measurement Set up

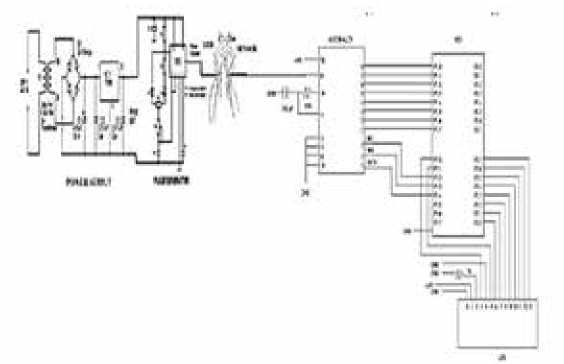

Fig.3Schematic of Optical measurement set up

3.2IMPLEMENTATION

This paper proposes an algorithm founded on mathematical model to exert extricate operations on information and the algorithm resembles the architecture of structure of brain neural synapses edifice and the VHDL design flow is shown in Fig. 4

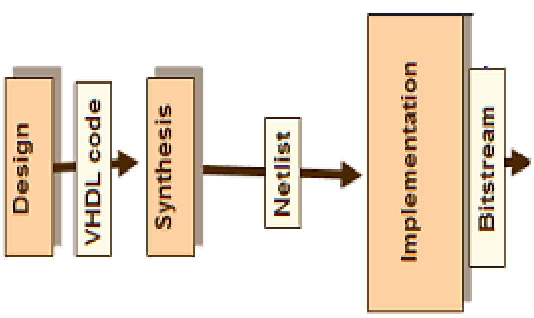

Fig.4 VHDL Design Flow

The proposed design flow exhibits nonlinear mapping ability and provides a potential solution platform for various research arenas as shown in Fig. 5. This algorithm proposes three layer architecture to accomplish the objectives. The arrangement and interlinking structure of the proposed architecture consists of three stages of processing includes acquiring inputs, processing the acquired data and a stage to deliver the outputs with minimal deviation from the expected efficiency.

1. Start
2. Initialize
3. If accepted Key value is Zero GOTO step 2
4. If accepted Key value is NULL Refresh
5. If accepted Key value is VALID
   i. Read Digital Equivalent of Hb Value
   ii. Access Hb Classified dataset values
6. Calculate the distance between the new entrant and classified dataset values
7. Iterate Step 6 till each and every classified data set value is extracted.
8. Choose the minimum distance among the calculated distance values.
9. Label the result yielded by Step 8 as the bench mark value and associate the respective classified data set with the new entrant.

4. RESULTS

The training data corresponding to scattering and absorption values for the two different wave lengths & is loaded concurrently in the FPGA hardware (shown highlighted as 1, 2, 3 and 4). The implementation details in hardware are listed in Table 1. Figure 5 to figure 7 shows two sets of study corresponding to the state identification Hb1 and Hb3. The detected state is also indicated in figure 6 and figure 8 for the states Hb1 and Hb3 respectively.

Table1. Data loaded and the respective time instants

S.no	**Data Loaded**	**Time at which instantiated**
1	Training data (both λ1 & λ2), (both scattering and absorption)	11ns to 21ns
2	Training data 2 (both λ1 & λ2) (both scattering and absorption)	31ns to 41ns
3	Training data 3 (both λ1 & λ2) (both scattering and absorption)	51ns to 61ns
4	Training data 4 (both λ1 & λ2) (both scattering and absorption)	71ns to 81ns
5	Training data 5 (both λ1 & λ2) (both scattering and absorption)	91ns to 101ns
6	Noisy Data	11ns to end of state detection
7	State-1 Detected	230ns

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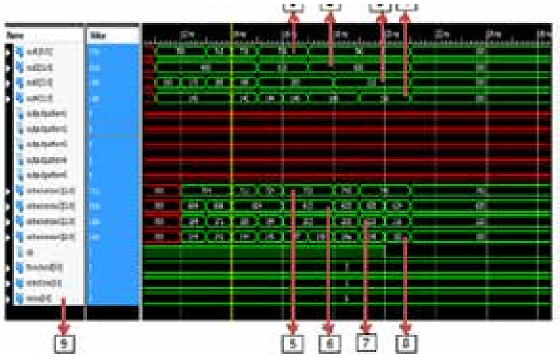


1-Training data$_1$ (λ_1) scattering *2-Training data$_1$ (λ_2) Scattering*

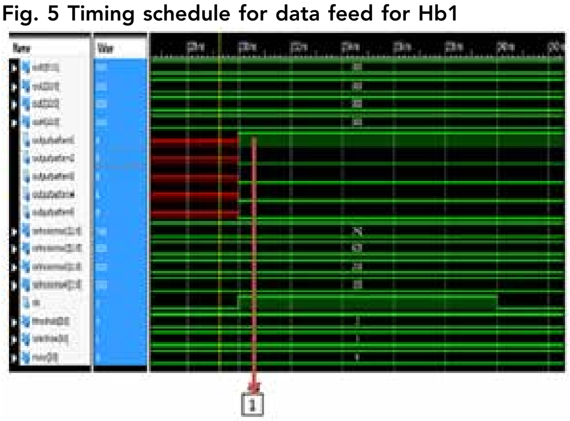
3-Training data$_1$ (λ_1) absorption; 4-Training data$_1$ (λ_2) absorption;

5-Noisy data$_1$ (λ_1) Scattering; 6-Noisy data$_1$(λ_2) Scattering;

7- Noisy data$_1$ (λ_1) absorption; 8- Noisy data$_1$ (λ_2) absorption;

9-Range for noise

Fig. 5 Timing schedule for data feed for Hb1



1-*Identified state$_1$;*

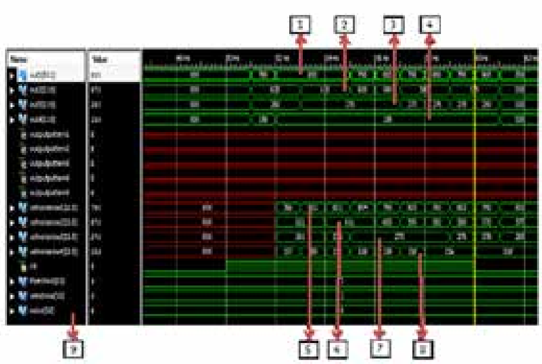


Fig. 6 Identification state Representation Hb1

1- *Training data$_3$ (λ_1) scattering; 2- Training data$_3$ (λ_2) scattering*
3- *Training data$_3$ (λ_1) absorption; 4- Training data$_3$ (λ_2) absorption*
5- *Noisy data$_3$ (λ_1) scattering; 6-Noisy data$_3$ (λ_2) scattering*
7- *Noisy data$_3$ (λ_1) absorption; 8-Noisy data$_3$ (λ_2) absorption*
9-Range for noise

Fig.7 Timing schedule for data feed for Hb3

1-*Identified state$_3$;*
Fig. 8 Identification state Representation Hb3

6. CONCLUSION

This paper had proposed and implemented an algorithm to pursue non-invasive technique to measure Hb of a blood sample and assess the actual amount of abnormality associated with it. This procedure enables the patient to position his or her fingers in between the device without inflicting pain and discomfort. This algorithm exhibits feasibility and it shall be implemented to address real time environment scenarios. The wide-ranging and accommodating characteristics of the proposed algorithm were substantiated by the results obtained.

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