International Research Journal of Multidisciplinary Scope (IRJMS), 2024; 5(2): 699-705 IRJMS

Original Article | ISSN (O): 2582-631X DOI: 10.47857/irjms.2024.v05i02.0613

FPGA Based Efficient Detection of Blood Group and Hb-anemic Using Image Processing-VLSI Approach

Chairman M[1]*, Deepak M[2], Priyatharsini S[3], Maragatharaj S[4]

[1]Dept of Electronics and communication engineering, Karpagam Institute of technology, Coimbatore, India, [2]RTL Design Engineer, Incise Infotech Pvt Ltd, Noida, India, [3]Dept of Electronics and communication engineering, KIT-Kalaignarkarunanidhi Institute of Technology, Coimbatore, India, [4]Dept of Electronics and communication engineering, Knowledge Institute of Technology, Salem. India.
*Corresponding Author's Email: chairmankit2016@gmail.com

Abstract

During the critical situation of a patient, an immediate blood transfusion from others to a patient is necessary. The blood groups are AB, B, A and O. The identification of the blood group and Hb- anemic help to decide blood transfusion during emergencies. In order to check anaemia as well as to take complete blood count and to monitor a number of diseases, the hemoglobin test is an important one. But both tests are not possible in remote and village areas, because they require additional equipments and trained personnel which can be afforded only in lab. The conventional test methods involve the risk of infection, possibility of occurring human errors, more time consumption and noise interference. By addressing these limitations, an effective hardware system is proposed to detect blood group and Hb-anemic by exploiting image processing mechanism with FPGA based VLSI process. The front-end model was developed using MATLAB software, where the input blood sample images were converted into gray-scale and perform GLCM model to generate the statistical parameters. The back-end model was developed using XILINX FPGA Spartan 6 kit/ Altera Quartus II. The data with code is then fed to hardware kit to compare and correlate with the training samples using Stump Boost Regression Algorithm (SBRA). We considered World Health Organization (WHO)'s HCS method to detect Hb-anemic. The proposed system shows improved performance, optimal accuracy, less error rate and less time with low cost. This system can be used as a technician-free self-testing device, minimising the exposure of patients to clinical settings.

Keywords: Anemia, Blood Classification, Hemoglobin Color Scale, Stump Boosted Regression Algorithm.

Introduction

Blood is the most vital component of the human body, helping to transfer molecules like oxygen, food, metabolic wastes, etc. (1). Red blood cells (RBCs), platelets, and white blood cells are contained in liquid plasma to form blood. Blood groups are identified by antibodies and antigens present in plasma (2). The identification of the blood group and Hb-anemic help to decide blood transfusion during emergencies. By studying the antibodies and antigens in the blood, the blood group detection is done (3). In addition, a lack of certain Hb level leads to Anemia. Anemia is a type of disease in which a person lacks enough RBCs (4). Pregnant women, as well as young children, are themost vulnerable to this effect (5). RBCs carry fresh oxygen throughout the body. Hemoglobin is the protein inside RBCs. It carries oxygen .The blood group and hemoglobin tests are conducted manually in a laboratory (6). Unfortunately, the problem arises for the people who live in rural areas and mountain. The scarcity of enough lab facilities and trained personnel are noticed (7). To address these problems, researchers haveproposed a lot of techniques to identify blood group and Hb-anemic level (8).

By transforming the image to grayscale and using a local binary pattern with nearest neighbour search, the blood group was identified (9). MATLAB software was used to process the camera-acquired image utilizing a variety of processing methods, including pre- processing, HSL Luminance plane, morphological operations, thresholding, and quantification. Later, the pixel deviations were compared to determine the agglutination (10). The samples of blood are taken into three parts and reagents are added by the lab technician manually (11). **Problem Statement:** The conventional methods involves the risk of infection, time consumption, Noise Interference is more, the continuity of data rate is not consistent, the hardware test equipment for both blood group and Hb detection

(Received 14th February 2024; Accepted 21st April 2024; Published 30th April 2024)

is not developed and also human errors while performing test for large number of datasets. By addressing these limitations, this paper proposes a highly efficient FPGA based detection method (12). **Existing Method:** In the existing system, image processing techniques integrate with android app is used to detect the blood group and Hb levels. The detection of blood group is by taking blood samples and perform some image processing steps likegray scale conversion, edge detection, segmentation, binary conversion and computation (13). The Hb level detection follows WHOs hemoglobin color scale (HCS) method (14). The another paper proposed a testing system based on Spartan 3e FPGA to determine blood type using serum and saliva immunoglobulin percentage data. Theclassification of blood group is also done by integrating Image Processing techniques with Raspberry pi (15). **Solution Statement:** Due to the Integration of Image Processing and VLSI approach, Image processing based front-end design is developed, Machine learning based analysis module is created and so the processing delay is being reduced. Hardware model developed for detection of both tests. **Proposed System:** In this, FPGA based approach is evaluated for the classification of blood samples and Hb- anemic detection. Initially, we take three drops of blood which are mixed with antigens A, B, and D by placing them serially. The captured image is then processed. The front-end model is developed using MATLAB software, in which the input blood samples images are converted into gray-scale image and GLCM model is developed to generate statistical data. These fetched data with code is then feed to Spartan kit in the form of array file to compare and correlate with the training samples in order to detect blood group and Hb-anemic which helps to identify whether the person has anemia or not. The detection result was displayed using Altera design software. Here, by using VHDL, we have proposed the analysis system based on FPGA which is reprogrammable (16). Thus, the proposed work helps to develop a real time product or system.

Methodology

The block diagram of proposed system for detecting blood group and Hb-anemic is shown in Figure 1. The description of each module is also provided below. **Image Collection:** The important and first step in image processing is the image collection. It is the process of retrieving an image from a source, with the help of any hardware's like cameras, sensors, etc. Here, the blood image sample databases are collected from various sources and real time blood samples are taken for processing. (1). **Color Conversion:** The need for converting color image into grayscale image is that it reduces computational requirements, simplifies the algorithm (i.e., reduce code complexity: from 3D pixel value to 1D value), noise reduction and for easier visualization. In order to collect particular information, these gray images are suitable for all image processing techniques (2). The grayscale image looks like gray image, because it has shades of gray in between and it is different from one-bit black and white images. The contrast ranges from weakest intensity (black) to strongest intensity level (white) (3). **Median Filtering:** It is one of nonlinear filtering technique to reject noise from an image and it is used widely in digital image processing. This filter works by sliding the filter window pixel by pixel over entire image, in order to replace each pixel value with the median value of neighboring pixels. Thresholding operation is also done in median filtering. It preserves edges during removal of noise. **GLCM - Gray Level Co-Occurrence Matrix:** Feature extraction is needed to take required datafrom animage. Example, the texture analysis is used to collect characteristics of textures and for segmentation of objects. GLCM is one of its kind and here it is formulated to obtain only four second order features namely contrast, correlation, homogeneity, energy by using corresponding function (4). For motion picture estimation, these features give high accuracy. The various set of texture information are being generated by each feature relationship based on grayscale, kernel size and direction. Each feature properties and corresponding relationship are discussed below. **Correlation:** The correlation calculates the linear dependency of gray levels in an image between its pixel and neighboring pixel. The correlation ranges from 1 to -1 and its value is NaN for constant image. The equation of correlation is given below:

$$Correlation = \sum_{i,j=0}^{N-1} P_{ij} \frac{(i-\mu)(j-\mu)}{\sigma^2} \quad [1]$$

$$\sigma^2 = \sum_{i,j=0}^{N-1} P_{ij} (i-\mu)^2 \quad \mu = \sum_{i,j=0}^{N-1} iP_{ij} \quad [2]$$

,

Where i and j denotes row number and column number of the pixel matrix; P_{ij} denotes elements i, j of the GLCM; μ- Mean of GLCM; N- Number of gray levels in image; σ^2- intensity variance of all reference pixels. **Contrast**: The contrast calculates the certain amount of local variations present in image between its pixel and neighboring pixel. It gives the average gray level difference between neighboring pixels and its range= (0, 1). The equation of contrast is:

$$Contrast = \sum_{i,j=0}^{N-1} P_{ij}(i-j)^2 \quad [3]$$

Energy: The energy establishes the spatial ordering of a picture and, utilising texture, provides the GLCM sum of square elements. It worth is high if the window is expertly structured. The square root of the textural character of the ASM (Angular Second Moment) is all that the energy is. Energy has a value of 1 for constant images and ranges from 0 to 1. The energy equation is:

$$Energy = \sum_{i,j=0}^{N-1} (P_{ij})^2 \quad [4]$$

Homogeneity: The homogeneity determines how tightly the elements are distributed in the GLCM diagonal to the GLCM. Homogeneity has a value of 1 for diagonal GLCM and ranges from 0 to 1. Homogeneity weight values are the polar opposite of contrast weight values. The homogeneity weight value for contrast is $(i-j)^2$, and it is $1/1+(i-j)^2$. Below is presented the homogeneity equation [5] as below:

$$Homogeneity = \sum_{i,j=0}^{N-1} \frac{P_{ij}}{1+(i-j)^2}$$

Adaptive Histogram Equalization (AHE): The global contrast of images is increased by AHE. The equal distribution of intensities on the histogram is done by adjusting the AHE. Histogram equalization allows to gain a higher contrast for lower local contrast areas. This can be done by using a certain transformation function (5), which stretches out the range of the most prevalent intensity values.

Consequently, it improves the definition of edges in each area of a picture (6). AHE has possibility to amplifythe noise level which ranges from certain decibels, during that time we use contrast limitedAHE (CLAHE).

FPGA based VLSI Approach for Blood Group and Hb-anemic Detection: Data Collection- The GLCM statistical parameter values (correlation, contrast,homogeneity, and energy) after MATLAB process are collected and stored as MATLAB file. This file is then converted to array text file. This array file with code is then fed to Spartan 6 kit for further processing. VHDL Data Input Process in Spartan 6 Hardware and Result Analysis: Here, we use a more classy type of chip called FPGA Spartan board (7). A hardware chip includes several circuit blocks. Each circuit block is comparable to a PAL or PLA. This Development kit is used as evaluation platform for training, testing and developing designs based on the user requirement (8). Analysis module consists of digital logic designed architecture made up of flip flops, Look up Table (LUT) (9) and gates etc which called Stump Boosted Regression Model (SBRM). This model compares the training and testing values of the parameters generated from the preprocessed data sample to classify blood groups and Hb-anemic detection using boosted decision stump which is created on the basis of base and weak learners. SBRM algorithm acts as an adjustable suggestion maker. Utilizing a VLSI system, the concept's functionality is realized. A decision stump is a type of machine learning model that consists of a single-level decision tree. Basedon the value of a single input property, it generates a forecast. The stump contains one leaf for each conceivable feature value for nominal features and two leaves for below and above threshold values for continuous features. Decision stumbling blocks are employed in machine learning algorithms as constituents (called "weak learners" or "base learners"). The Hb-anemic level of a blood sampleis estimated based on the closest match with WHOs HCS (10). Using GLCM features, the threshold values are determined using correlation which shows the equivalent intensity level of RBCs (11) and it is compared with HCS to find out the Hb level in order to detect anemia (12). After analysis, the processed output is viewed using Altera design software which is configured with FPGA kit during data processing.

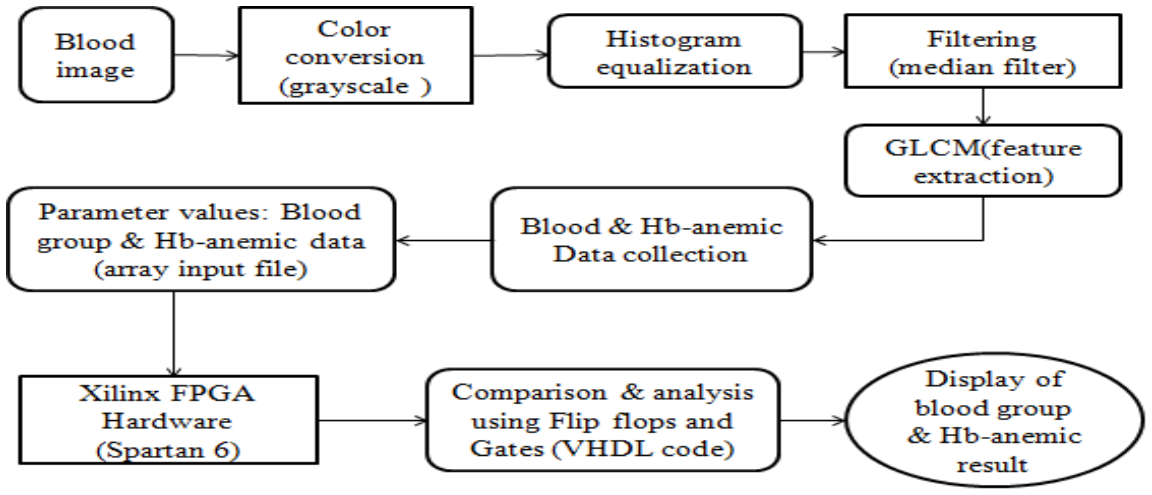

Figure 1: Block diagram of Proposed System

Results and Discussion

Agglutinated blood sample datasets were collected from Kaggle website (http://www.kaggle.com/). The agglutinated real time samples were collected from M/S Anderson Lab andDiagnosis Centre, Tambaram sanitorium, Tamil Nadu.We have collected 56 datasets and 8 real time samples. Figure 2(a) and Figure 2(b) shows the blood image database and real time samples respectively. During slide testing,the three drops of blood are taken and antigens mixed with A, B and D by placing them serially and it is left for fewminutes in order to take place agglutination process.After that, snapshot of this image is taken for furtherprocessing. The Figure 3 shows the gray scale image which is the result of converted of true RGB color image togray image. This gray image is used for further imageprocesses in order to enhance or collect some of thefeatures of an image like GLCM etc. These images have shades of gray in between. We infer that due to AHE, thedifference between pixels is greatly equalized. Thestatistical features of image were improved as a result of enhanced image quality. Figure 4 shows the median filteredimage. This filter is used to remove impulsive, salt-and-pepper and random noise in the image. Here, the edges getpreserved during the removal of noise and the images getsmoothed than a gray scale image and so it prevents theloss of statistical data.

Figure 2(a): Input blood database sample

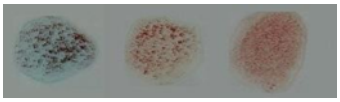

Figure 2(b): Input real time blood sample

Figure 3: Gray scale image of Fig 2(b)

Figure 4: Median filtered image of Fig 2(b)

Figure 5 shows the GLCM feature extraction graph which represents the statistical values like contrast (p), Correlation (o), energy (q) and homogeneity(r) in X-axis with respect to the probability value (range from 0 to 1) of pixel levelin Y-axis. These statistical values are used in the classification of blood group and Hb-anemic detection. Figure 6 represents the processed real time input image in MATLAB. The agglutinated input test sample is processed and separated as A, B category and polarity (+/-). If the separated A, B image is in plain dark color, then it is an O category not A or B and if polarity image is in plain dark color, then it is negative, otherwise it is positive. But here, the processed image clearly shows that both A and B do not have plain dark color, so it is decided as AB category and polarity not have plain dark color, so it indicates positive. Therefore, the input sample belongs to AB + ve group and similar process is followed for other datasets to identify the blood group from the separated images. The Figure 7 shows the FPGA Spartan

6 hardware snapshot. The collected data from MATLAB were accessed and feed as array file to FPGA hardware. The Figure 6 shows the classification of blood group of Figure 2(b) in FPGA based system.

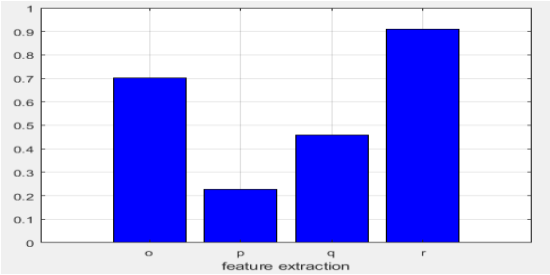

Figure 5: GLCM feature extraction of Fig 2(b)

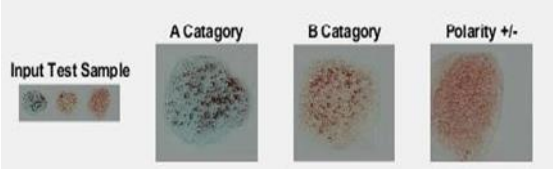

Figure 6: Processed input image of Fig 2(b)

Figure 7: FPGA Spartan 6 hardware snapshot

SBRA compares the training and testing values of theparameters generated from the preprocessed data to classify the blood group and Hb-anemic level detection. The Altera design software is configured with FPGA hardware kit in order to display our detection result. Here, we got AB +ve blood group type as result for given input real time test sample which is same as the inferred result from the anemic detection of Figure 2(b). Normally, the hemoglobin level ranges from 6 to 14. The RBCs count of a blood sample is used to identify the Hb level. Our proposed system does not indicate the exact Hb level which rangesfrom 6 to 14, because the RBC's count is unable to find it accurately. But the GLCM statistical feature (correlation) provides equivalent RBC's intensity level. Hence, this intensity level is used to identify whether the respective blood sample has anemic disease or not. Here, the Hb-anemic prediction is classified into three categories as Low, Medium and High based on the WHOs HCS. 'Low' indicates the Hb level as below 9 which shows that the person has severe anemia.'Medium' indicates the Hb level as between 9 to 11 which shows that the person has Moderate anemia. Similarly, 'High' indicates the Hb level as between 11 and 14 which shows that the person have not anemia. Here, the Altera software displays the Hb-anemic prediction as 'Medium', so it clearly states that AB +ve blood group person has moderate anemia. Similarly, we processed other datasets to detect and display the blood group and Hb-anemic level in this hardware model in the same manner as stated above with optimal accuracy. Weinfer that this FPGA based system collect data and predicts the result correctly as same as when we tested in laboratory, so the time consumption is greatly reduced as compared to manual testing process.

The performance metrics of proposed system were calculated as below:

Accuracy = (TP+TN) / (FN+TP+FP+TN) [6]

Sensitivity = (TP) / (FN+TP) [7]

Specificity = (TN) / (FP+TN) [8]

Where FN is False Negative, TP is True Positive, FP is False Positive and TN is True Negative. Hence the accuracy, sensitivity and specificity have been calculated as 0.9531 (95.31%), which are all same and also far comparable to those mentioned the device utilization report shown in Table 1 provides the detailed information with respect to the architectural performances of the module illustrated. Among the family of FPGA boards, the Spartan 6 is used for verification and validation of the design. The environmental characteristics of the device are stated according to the board specifications. This report represents the summary of slice logic utilization. The proposed design power consumption is optimum which exposes the design's performance and so it became an energy efficient system. Thus, the proposed design's performance analysis is greatly analyzed.

Table 1: Device Utilization Summary

Slice LogicUtilization	Used	Available	Utilization
The quantityof slice registers	79	54,576	1%
Utilization of flip-flops	79		
Utilization oflatches	0		
Numbers employed inlogics of AND and OR	0		
Logic numberfor the number of slice LUTs	102	27,266	1%
Number onlyutilizing the 06 output	96	27,288	1%
Number onlyutilizing the 05 output	75		
Utilizing the numbers 05	9		
Utilizing thenumbers 06	12		

Conclusion

In this research, we proposed an efficient FPGA based system for detecting blood group and Hb-anemic level. The test results show optimal accuracy, improved performance, reliability and less error rate by implementing required solution methodology. Here, no one needs to buy an additional device for testing. Thereby, a cost-saving detection strategy has been possible. The new approach of Hb-anemic detection process by comparing with WHOs HCS is inspired by manual HCS lab method. By using FPGA based approach, this system can able to process large number of data samples and determine the outputs in short duration of time without any human errors and also the trained technician is not required for conduction of the test. Hence, our proposed system helps to create a hardware system environment to determine both the test in one single system and it also helps to design portable electronic device for self-test. So, it greatly reduces the number of clinical visits for simple diagnostic tests. Thus, by considering the above mentioned features and advantages, we can develop a highly effective system which gives better quality for health service.

Abbreviation

Nil

Acknowledgement

Nil

Author Contribution

All Authors contributed entire manuscript in writing, reviewing, implementing and analysis.

Conflict of Interest

The authors declare no conflict of interest.

Ethics Approval

The research does not involve human participants.

Funding

No

References

1. Khaleduzzaman K, Mahmud MH, Debnath T, Sarker S, Podder PK. Detection and implementation of blood group and Hb level by image processing techniques. Aust. J. Eng. Innov. Technol. 2021;3(5):73-81.
2. Noorbasha F, Dinesh T, Panda BP, Jaideepsai B, Kishore KH, Jagadeesh GN. Design of FPGA based System to determining the type of Human Blood Group. International Journal of Innovative Technology and Exploring Engineering. 2019;10(7): 876-889.
3. Nagapranitha DR, Malhotra A, Anand S, Shruthi CN. Automated blood group determination using image processing techniques with integration of Raspberry pi. DSCE. JETIR. 2021;2(9): 936-948.
4. Ghosal S, Das D, Udutalapally V, Talukder AK, Misra S. sHEMO: Smartphone spectroscopy for blood hemoglobin level monitoring in smart anemia-care. IEEE Sensors Journal. 2020 Dec 14;21(6):8520-9..
5. Han J, Li Z, Zheng W, Zhang Y. Hardware implementation of spiking neural networks on FPGA. Tsinghua Science and Technology. 2020 Jan 13;25(4):479-86.
6. Darlis D, Murwati H, Priramadhi RA, Ramdhani M, Nugraha MB. Functional simulation of human blood identification device using feed-forward artificial neural network for FPGA implementation. In2018 International Conference on Signals and Systems (ICSigSys) 2018 May 1 (pp. 142-145). IEEE.
7. Jayakumar P, Yeddu Nitish Kumar, Padmanabhan S, Suthendran K, Madan Sujith. Identification and Analysis of Blood Group with Digital Microscope Using Image Processing. IOP Conference Series. 2020; 2(8): 233-242.
8. Dewantoro P, Gandana CE, Zakaria RO, Irawan YS. Development of smartphone-based non-invasive hemoglobin measurement. In2018 International Symposium on Electronics and Smart Devices

(ISESD) 2018 Oct 23 (pp. 1-6). IEEE.
9. Reddy NS, Jana S, Gopi K. Novel Image Based Blood Group Identification from Agglutinated Images. International Journal of Recent Technology and Engineering. 2019; 4(6): 458-469.
10. Xavier FP, de Araujo Silva LG, Regis CD. ABO/Rh Blood Typing Method for Samples in Microscope Slides by Using Image Processing. IEEE Latin America Transactions. 2018 Mar;16(3):885-90.
11. Dhande A, Bhoir P, Gade V. Identifying the blood group using Image Processing. Int. Res. J. Eng. Technol. 2018 Mar;5:2639-42.
12. Zafar R, Nawaz S, Singh G, d'Alessandro A, Salim M. Plasmonics-based refractive index sensor for detection of hemoglobin concentration. IEEE Sensors Journal. 2018 Apr 12;18(11):4372-7.
13. Wang M, Lee KC, Chung BM, Bogaraju SV, Ng HC, Wong JS, Shum HC, Tsia KK, So HK. Low-latency in situ image analytics with FPGA-based quantized convolutional neural network. IEEE Transactions on Neural Networks and Learning Systems. 2021 Jan 12;33(7):2853-66.
14. Dalvi A, Kumar Pulipaka H. Determination of blood group using Image processing. Int J Sci Eng Res. 2018 Mar;9:24-7.
15. Muthumanjula M, Bhoopalan R. Detection of white blood cell cancer using deep learning using CMYK-moment localisation for information retrieval. Journal of IoT in Social, Mobile, Analytics, and Cloud. 2022 May 16;4(1):54-72.
16. Yamin A, Imran F, Akbar U, Tanvir SH. Image processing based detection & classification of blood group using color images. In2017 International Conference on Communication, Computing and Digital Systems (C-CODE) 2017 Mar 8 (pp. 293-298). IEEE.