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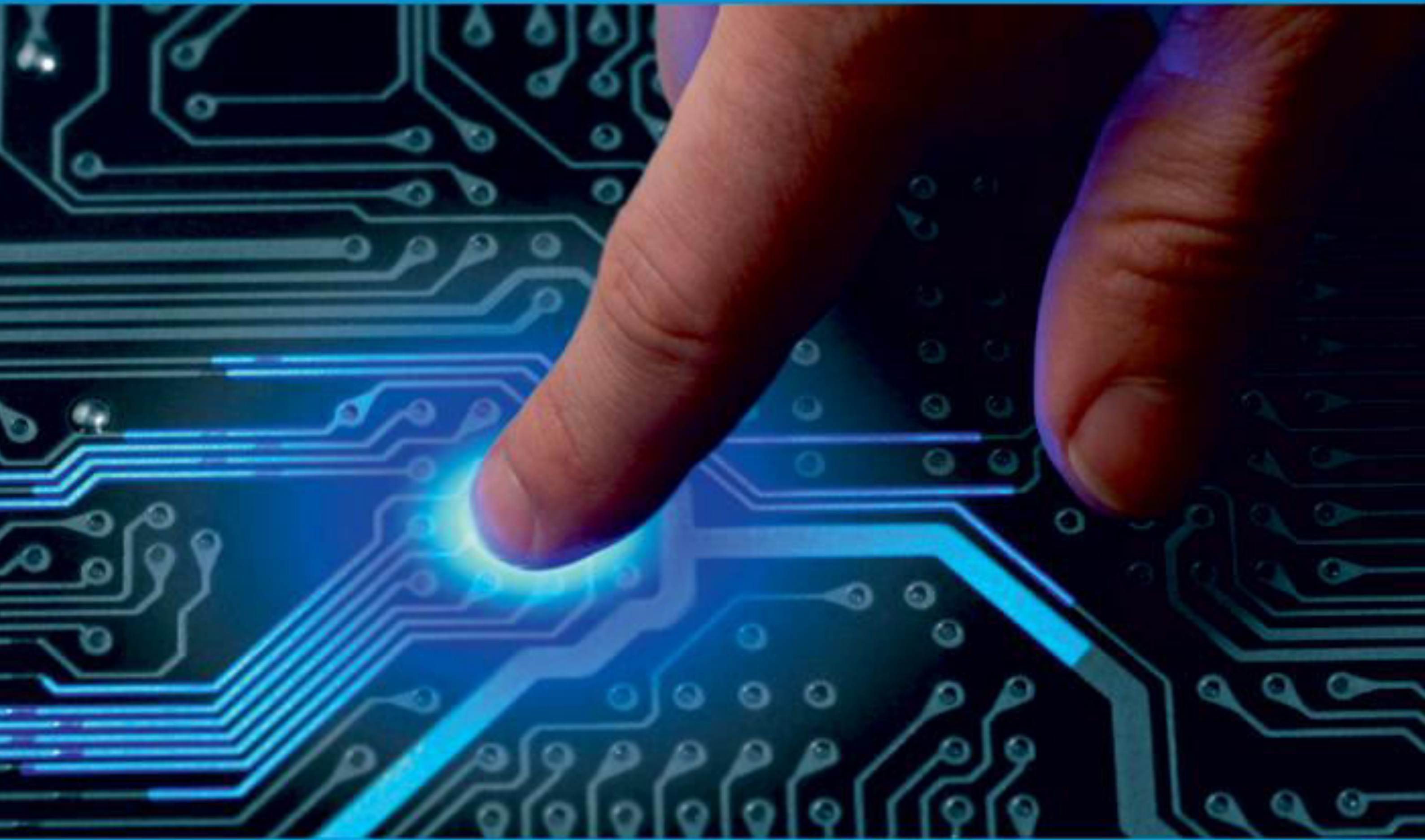

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# Non-invasive Hemoglobin Detection Using Image of an Anterior Conjunctiva

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**ABSTRACT:**As one of the most common clinical laboratory tests, blood hemoglobin (Hgb) tests are routinely ordered as an initial screening of reduced red blood cell production to examine the general health status before other specific examinations. Unfortunately, the current technologies for noninvasively measuring blood Hgb levels are significantly limited. For accurate and precise blood Hgb quantification, spectroscopic analyses of light absorption of Hgb in reflection spectra are extensively used to measure Hgb content in tissue. In this study, we designed a mechanism for the automated detection of HB level through non-invasive visual method using the light absorption property of hemoglobin.

**KEYWORDS:** Non-invasive Technique; Hemoglobin (Hb); Fuzzy Logic;eye; anterior conjunctiva.

## I. INTRODUCTION

Hemoglobin is the iron-containing oxygen-transport metalloprotein in the red blood cells.Hemoglobin in blood carries oxygen from the lungs or gills to the rest of the body.Hemoglobin level detection is necessary for diagnosis and triage of multiple medical conditions including sickle cell anemia and chronic anemia. The hemoglobin (Hb or Hgb) level measurement test ranks as one of the most common laboratory tests ordered. Early detection of hemoglobin level can be useful for diagnosis. Sometimes the test may take some time, and the result is not instantly available at the point-of-care. It produces a delay in diagnosis which influences the treatment and outcome.

Examination of the conjunctiva pallor of the eye is usually used to rapidly screen for anemia in many clinics, Physicians generally pulls down the eyelid and subjectively examine the color of the anterior conjunctiva pallor membrane. The clinical sign for anemia detection can prove to be quite useful in many cases, but still the lack of inter-observer agreements in many situations and low sensitivity of anterior conjunctiva color can undermine the authenticity of the visual detection process. Color scale cards, which consists of the color spectrum and the corresponding haemoglobin concentration is used in many occasions to alleviate the problem of inter-observer disagreement and human error to make the visual detection process more reliable. Haemoglobin is the primary constituent which contributes to the pigmentation found in human blood. It possesses a bias in reflecting the red component of the light falling on its surface compared to the green component which it predominantly absorbs. This is the chief reason for the deep reddish appearance of hemoglobin. Hence, by comparing the red and green components of the RGB color spectrum of the conjunctiva pallor, it is possible to obliquely estimate the haemoglobin concentration in the human blood stream.

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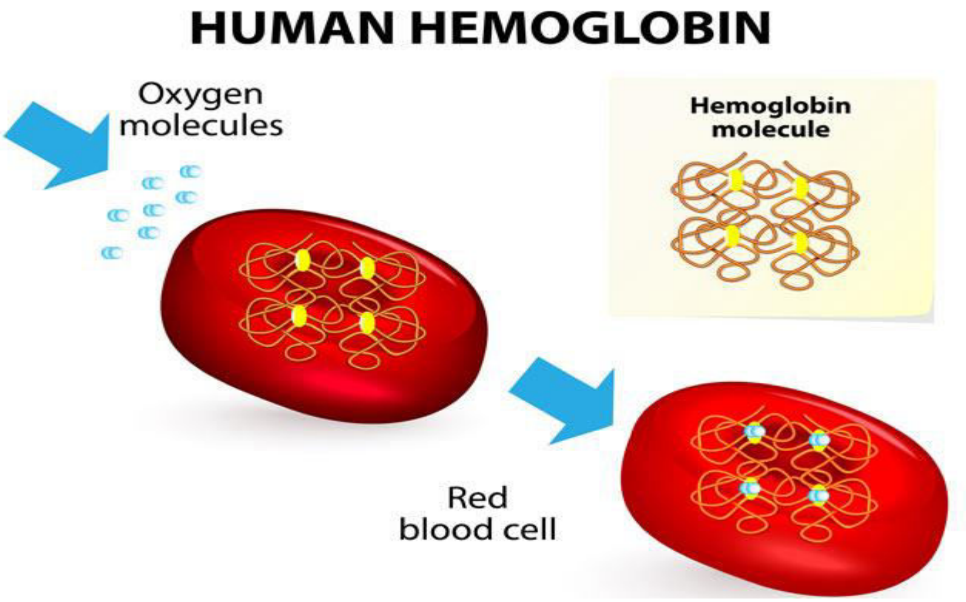


Fig 1: Structure of hemoglobin.

## II. RELATED WORK

In(K S Srinivasan') authors extract the R G B pixel values from the image then, A multivariate regression analysis is carried out to find if there is a correlation between the difference in R, G and B values before and after applying pressure and the Hb value of the blood of the person. The software used is from NCSS, Utah, USA. The analysis of data was over after about 550 iterations. The analysis resulted in defining a relationship between Hb value and the primary colors that we have taken. The multivariate regression analysis gave the equation in terms of R, G and B values for Hb. In(Gopal, 2019) authors propose a non-invasive hemoglobin concentration measurement method using PPG characteristic features which is obtained from fingertip video and symbolic regression of multigene genetic programming. In this paper, 39-time domain and 6 frequency-domain features were extracted from PPG signals, additionally gender and age are added to these features. A correlation-based feature selection method was applied to select best features to train and develop a mathematical model. Promising result have been found using the model both for training and testing dataset.In(Hasan, 2017) authors use the smartphone camera to record the fingertip videos of different sickle cell patients and their clinical Hb records. They extract the red, green and blue (RGB) pixel of the video image and make the histogram of selected frames for each video. The averaged histogram values of those selected frames are used as an input feature matrix in the regression analysis. Linear regression as well as the partial least squares (PLS) algorithm is applied to the input feature matrix. Fifteen fingertip videos are recorded before blood transfusion, and rest of the videos are captured after two weeks of their blood transfusion. Matlab tool is used for the data analysis and visual image presentation of the RGB image histogram values, masked RGB image, and the confusion matrix of this paper. The result generated from linear regression and the goodness of fit of PLS model shows the reliable performance of this research work.In(Tehrani, 2019) authors define how each pixel of the input image is mapped onto a specified list of segmentation centers (obtained from the previous block). Usage of the Fuzzy Inference System (FIS) is the solution of this paper to allocate a segmentation center to each image pixel. The rules which the FIS utilizes are designed based on the color of each pixel and its nearby neighborhood.The experimental results illustrate the superiority of the proposed method over the state-of-the-art methods in the image segmentation.

## III. PROPOSED ALGORITHM

- The flow of the project is the flow chart given below.
- Here, an image of anterior conjunctiva of eye is taken with the help of smart phone camera in suitable lightning conditions.
- The input of this image along with age and gender is given to the system.

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- Removal of noise is done by applying Median filtering on target image. It reduces the impulse noise also known as salt & pepper noise.
- The desired conjunctive area is cropped from the image.
- The FIS is loaded into the system. This FIS contains a set of predefined rules, are used to obtain the red, green and blue pixel mean values.
- The obtained pixel values are substituted in the formula obtained using multivarient regression analysis. The final estimated hemoglobin is hence obtained

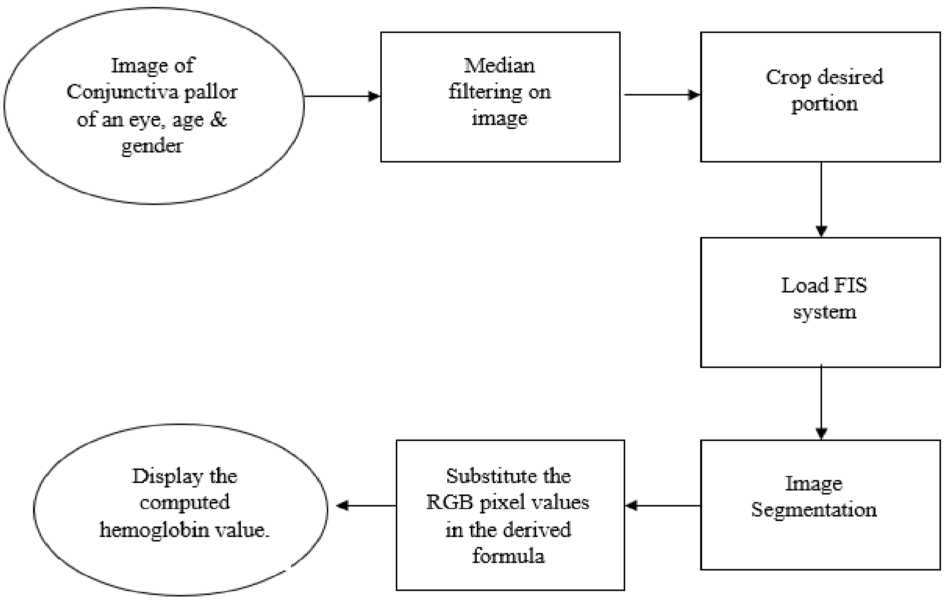


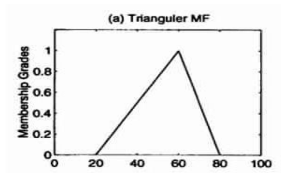

Fig 2: system work flow.

B.*Extraction of pixel values*

Fuzzy Inference System is used to extract the pixel values by setting some rules. Fuzzy Inference System is the key unit of a fuzzy logic system having decision making as its primary work. A fuzzy set is completely characterized by its membership function (MF). Triangular MF is used to characterise

A triangular MF is specified by three parameters {a, b, c} as follows:

$$\text{triangle}(x; a, b, c) = \begin{cases} 0, & x \le a. \\ \dfrac{x-a}{b-a}, & a \le x \le b. \\ \dfrac{c-x}{c-b}, & b \le x \le c. \\ 0, & c \le x. \end{cases}$$



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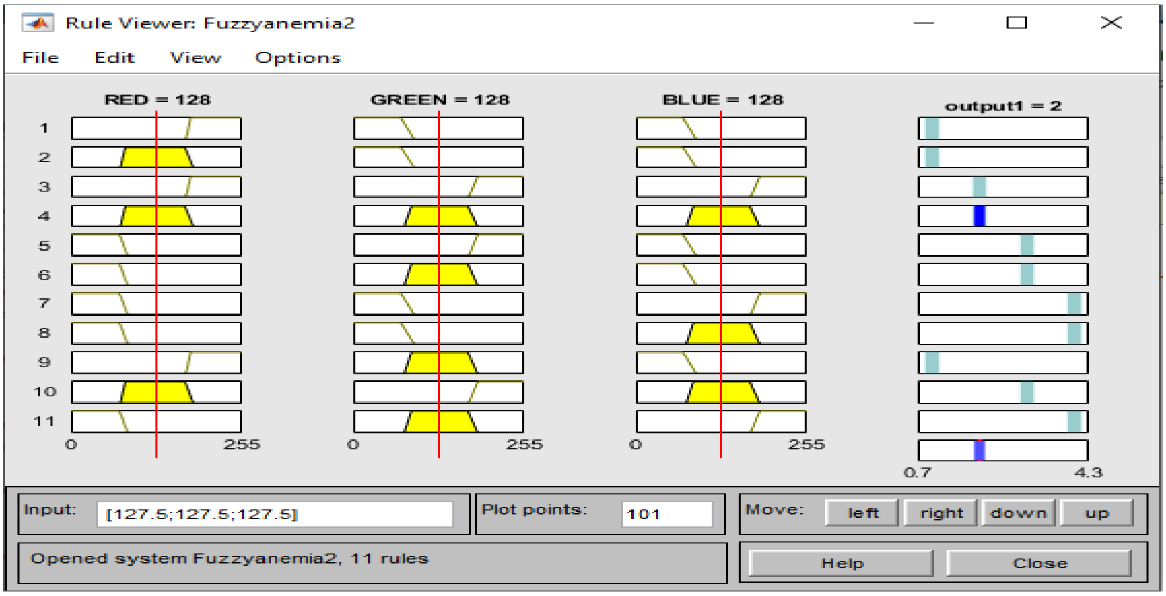


Fig 3: Rule viewer

C. *Multivariate regression analysis*

Multivariate Regression is a supervised machine learning algorithm involving multiple data variables for analysis. A Multivariate regression is an extension of multiple regression with one dependent variable and multiple independent variables. Based on the number of independent variables, we try to predict the output.

- A multivariate regression analysis is carried out for about 200 sampels to find if there is a correlation between the R, G and B values and the Hb value of the blood of the person.
- All the data such as the name of the person (for identity), age, sex, Hb level estimated using the cyanmethemoglobin method, R, G and B values are then tabulated.
- The analysis of data was over after about 550 iterations. The analysis resulted in defining a relationship between Hb value and the primary colors.
- Multivariate Regression is a supervised machine learning algorithm involving multiple data variables for analysis. Based on the number of independent variables, we try to predict the output.
- The multiple regression equation: $y = b_1x_1 + b_2x_2 + \ldots + b_nx_n + c$.
- The simplified equation hence derived is:(K S Srinivasan')

  **Hb = Nr / Dr,**

  **where,** $Nr = 11.5 - 3.7R - 1.4G - 0.1B + 0.08R^2 + 0.03RG + 0.02G^2 + 0.1RB + 0.04GB + 0.01B^2$, $Dr = 1 - 0.3R - 0.2G + 0.02B + 0.07R^2 + 0.004RG + 0.003G^2 + 0.02RB + 0.005GB - 0.0005B^2$

## IV. PSEUDO CODE

INPUT: An image of Conjunctiva pallor of an eye, age, gender.

OUTPUT: Estimated hemoglobin level.

METHOD:

Step 1: Input image, Age and Gender.

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Step 2: Perform Median filtering on image.

Step 3: Crop desired portion.

Step 4: Load FIS system.

Step 5: Perform the Segmentation.

Step 6: Calculate mean value of red, green, blue and white pixels.

Step 7: Calculate hemoglobin count.

Step 8: Display hemoglobin level.

Step 9: Exit system.

## V. RESULTS

The images were taken with the help of local medical clinics, few photographs of patients were procured with their clinical medical reports. The obtained value using the formula derived from multivariate regression are as follows in reference to respective clinical reports.

| SI. NO. | HB. Value by clinical test | HB. Value obtained |
|---|---|---|
| 1 | 7.9 | 9.2 |
| 2 | 6.5 | 5.6 |
| 3 | 8.9 | 10.2 |
| 4 | 10.5 | 9.5 |
| 5 | 9.1 | 11.5 |
| 6 | 10.9 | 11.3 |
| 7 | 12.1 | 13.1 |
| 8 | 15.6 | 14.3 |
| 9 | 16.1 | 14.9 |

Table 1: Obtained HB levels.

The hemoglobin level with the equation from multivariate regression has been obtained. After that hemoglobin level from 9 subjects tested using non-invasive device and invasive device, then value of two methods will be compared to know maximum absolute error of the device. The noninvasive device gives results with error maximum 2.4 gr/dL.

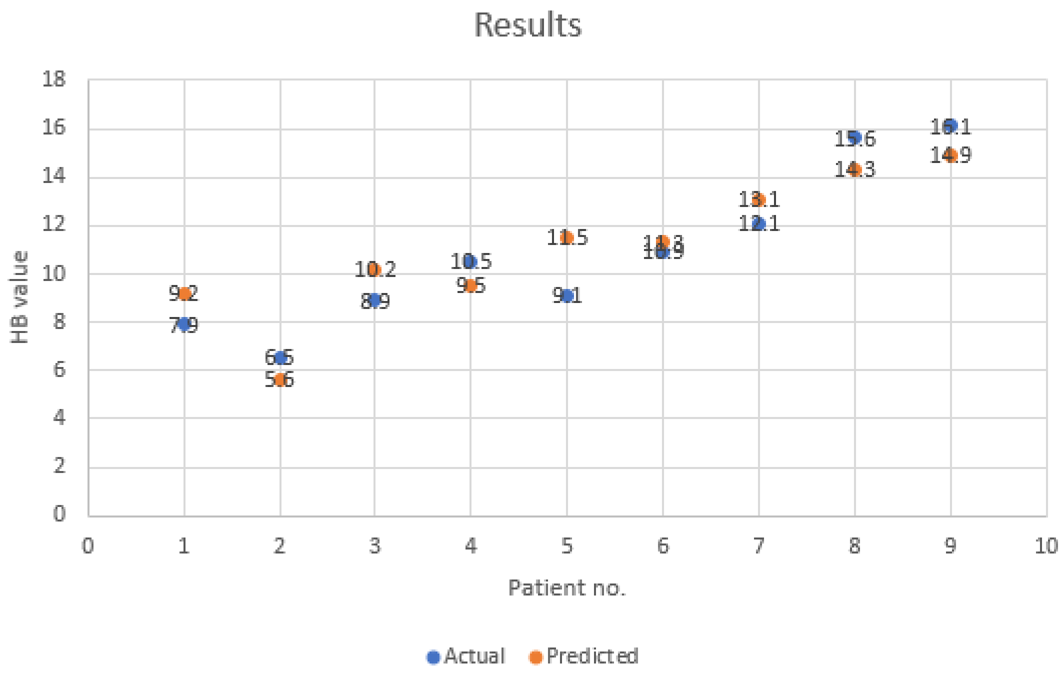


Fig 3: Graph displaying results.

The figure (Fig 3) is a graphical representation of the difference between the actual HB levels and the once that are predicted using the non invasive method discussed above.

## VI. CONCLUSION

This paper shows the devlopment of non-invasive method the estimate the hemoglobin value of a patient. The fuzzy inference system is successfully used to extract the pixel values from the target image. R, G, B mean values are found to be further used in the formula. A formula is derived using multivarient regression analysis in terms of RGB values to obtain the corelation between the RGB values and blood hemoglobin level. The final estimation of hemoglobin level is done using this formula with maximum error of 2.4gr/dL.

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