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Digitized estimation of haemoglobin using image processing

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Abstract—Hemoglobin is the protein present in RBCs which carries oxygen to all the parts of the body. It is one of the important parameters to be measured for surgeries, during traumatic conditions, pregnancies etc. The first part of this paper gives an insight of hemoglobin color scale (HCS) which is used by many developing countries where there are no laboratories and the flaws of that device. The second part of the paper introduces a new method for the estimation of hemoglobin that is by image processing in MATLAB. The two approaches taken forward for the estimation and one of them being the appropriate one.

Keywords— Hemoglobin (Hb), HCS (Hemoglobin color scale), anemia, invasive, digital image processing, MATLAB, RGB analysis, histogram, intensity level analysis

INTRODUCTION

Anemia is a worldwide threat. Lack of Hemoglobin causes anemia, which has affected about 1.6 billion people which is about 30 percent of the total population according to WHO [1]. Anemia is found to affect most of the pregnant ladies, low hemoglobin count during pregnancy can be a serious issue [6,11]. Therefore, quick accurate hemoglobin estimation without any complex lab arrangement will be very resourceful.

Determination of hemoglobin percentage (Hb %) prior to any surgery has become an integral part of pre-anesthetic evaluation; the rationale being a mere belief or a custom inherited from our teachers than a valid scientific evidence [1,7,9]. The sole objective of an anesthesiologists is to ensure the adequate supply of oxygen; therefore HB % is one of those parameters which should be augmented easily for preoperative conditions. So, a need for quick estimation of hemoglobin with accurate values was felt by WHO, for critical conditions like pregnant women going into labor especially during trauma and in trauma patients [3,5].

The various methods of estimation of hemoglobin so far used: Hemocue, Blood gas analyzer, Sahli's hemoglobinometer, Colorimeter.

Estimation of hemoglobin using color scale:

A color scale was devised for estimating hemoglobin by matching the blood sample with ten levels of hemoglobin (3, 4, 5, 6, 7, 8, 9, 10, 12 and 14 g/dl). Its preliminary results showed good correlations with spectrophotometric readings. This device is used for estimating hemoglobin where no laboratory facilities are available. (Fig A)

Methods for assessing hemoglobin levels by matching a drop of blood on a piece of blotting paper against a color scale have been widely used in health centers in developing countries for the detection of anemia. In theory, they are attractive because of their simplicity, portability and low cost [4,8,11,12]. In practice, they are so grossly inaccurate, especially at lower hemoglobin levels, that they have little value according to the studies of G.J. Stott & S.M. Lewis. (G.J.Stot1& S.M. Lewis2. (1995). simple and reliable A method for estimating haemoglobin. *WHO BulletinOMS.*. 3 (1), 1-5 [1]

The image taken of the HCS was image processed to get RGB values and inter pixel distance, the red values showed notable differences between the high values of the sample and the blue and green data showed differences in the lower values as shown in the graph (Fig B) below.

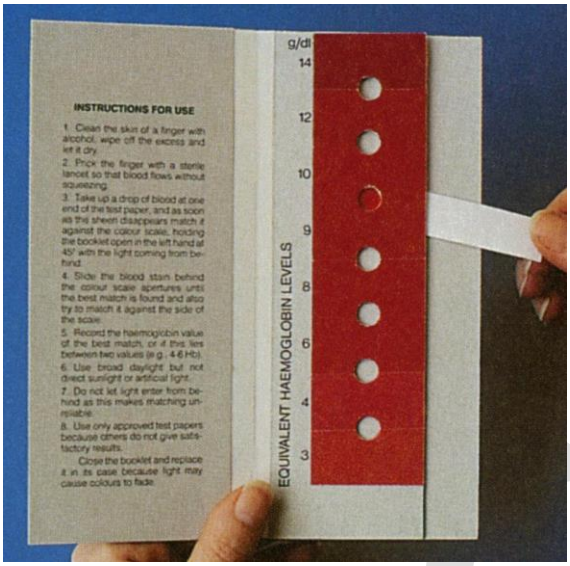


Fig A: HCS scale from[1] G.J.Stot1& S.M. Lewis2. (1995). simple and reliable A method for estimating hemoglobin. *WHO BulletinOMS*.. 3 (1), 1-5.

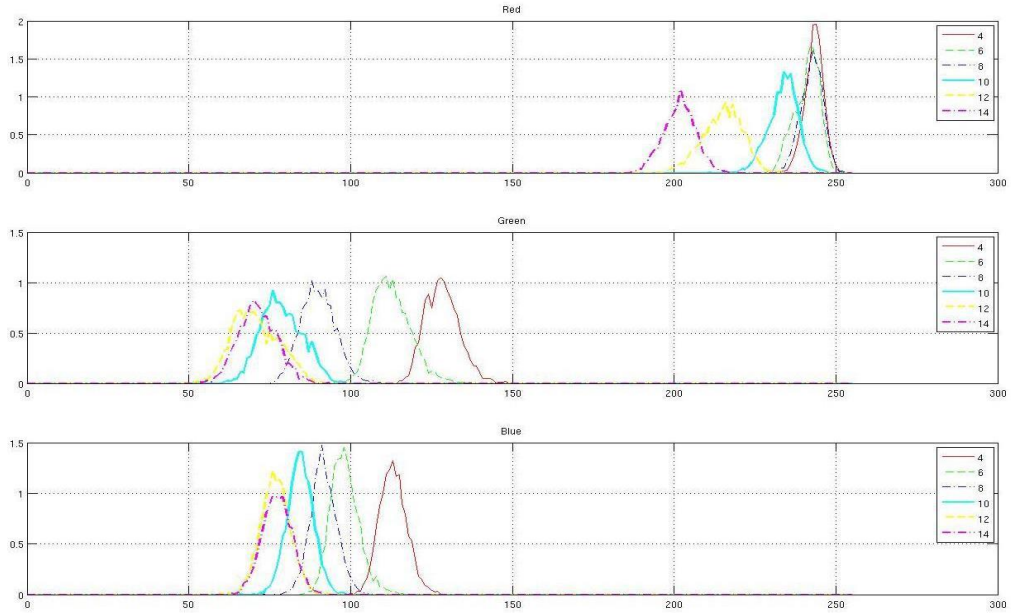


Fig B: RGB graph from [2] Rajendra Kumar M. 1,2, Hemant Misra 2, Sujit Hiwale 2, Manjunath Ramachandra 2. (2014). Digital WHO Hemoglobin Color Scale: Analysis and Performance. *eTELEMED 2014 : The Sixth International Conference on eHealth, Telemedicine, and Social Medicine*. 6 (1), 1-6

Flaws in these methods:

- Printing errors: the printed colors on the scale can differ depending on different manufacturers
- Absorbent paper: the paper should be of proper thickness a little variation can result in wrong estimation.
- Illumination: the intensity of light can affect the readings

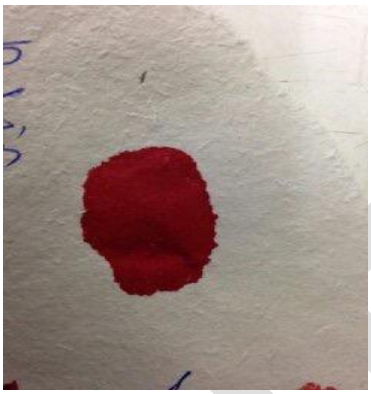
- Effect of time: time taken for the sample to dry. If the sample is dried excessively the readings can be wrong.
- Accuracy & Human errors: hence the accuracy depends on the light source and color standards and also at the angle at which the scale is being held.

ESTIMATION OF HEMOGLOBIN USING IMAGE PROCESSING METHOD:

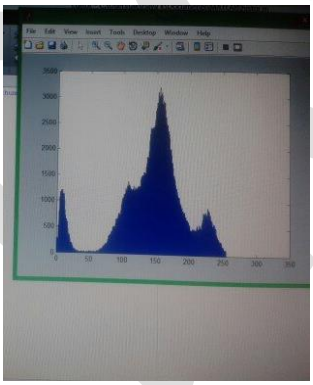
The basic idea behind the digitization of haemoglobin estimation is to use simple MATLAB image processing techniques for quick results. Our first approach to the samples was histogram analysis and when that failed to show appropriate results we switched to analysing the pixel region that is intensity levels according to the RGB Scaling.

The following steps were carried out for our first approach i.e. histogram analysis:

1. Normal Whatmann filter paper, lancet, cotton, alcohol swabs, 8MP camera, perfect illumination are the materials required.
2. Apply alcohol on a finger and prick it with the help of lancet.
3. Draw a drop of blood on the filter paper.
4. Let it dry for 30-45 seconds.
5. Capture the image of the dried sample within 30-60 seconds.
6. Histogram analysis was done on MATLAB.



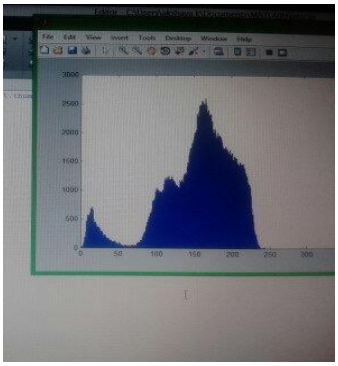
(a)



(b)

Fig.1. (a), (b): the first figure is the image of blood sample for which the histogram analysis was done. The second image (b) is the histogram of the sample which shows a particular intensity peak on i-t graph.

(A)



(B)

Fig.1.1. (A), (B): the first image is the blood sample of the same subject but the arrangement of the sample is different. The second image (B) is i-t graph that is the histogram of the sample.

But as we can observe from all the figures the histogram graph for both the samples are different but the peak value remains the same which implies that the intensity level of the samples although of different orientation but of the same subject showed same intensity peak. Although the intensity peaks didn't change by the orientation of the image but we couldn't find any discrete method to differentiate and find the hemoglobin range. Hence this method failed and we proceeded with our next method of intensity level analysis based on RGB scale.

The following were the steps for our second approach:

Before analyzing original samples we implemented the method on the standard hemoglobin color scale by taking and processing each color individually.

Sr.no.	Haemoglobin levels	Intensity range
1.	14	108-119
2.	12	120-126
3.	10	127-134
4.	8	135-142
5.	6	143-147
6.	4	148-152
7.	3	153-160

Table. 1: intensity range of the HCS (hemoglobin color scale) (rough outline)

The above displayed table (1) is the intensity range of HCS (figure. A) Which showed slight deviation from the original samples.

Hence we analyzed original samples and requested the subjects to check their hemoglobin levels with conventional methods also. So we proceeded by:

- Apply alcohol on a finger and prick it with the help of lancet.
- Draw a minute drop of blood on the filter paper.
- Let it dry for 30-45 seconds.
- Capture the image of the dried sample within 30-60 seconds.
- Pixel region was found on MATLAB.

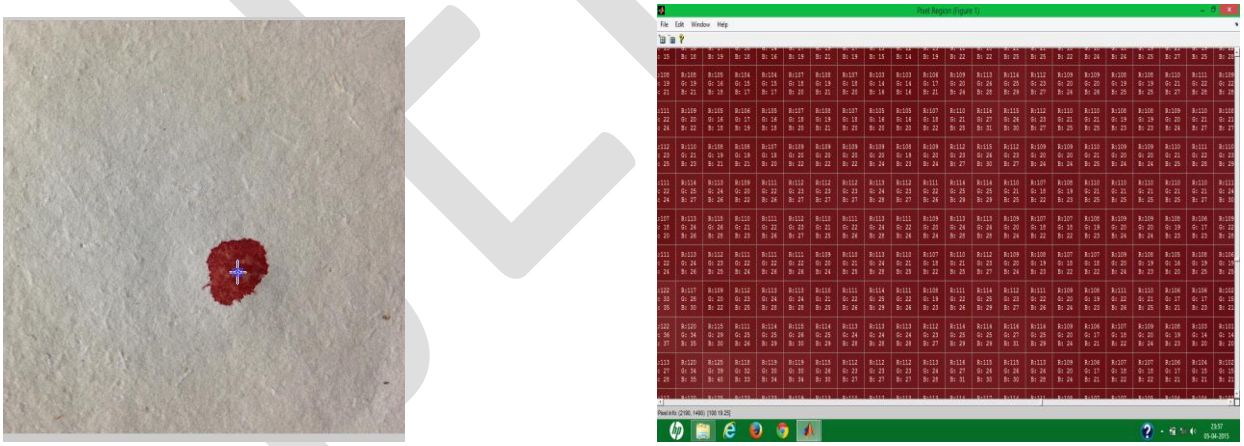


Fig 2: Hemoglobin value= 13

Sr.no.	*subjects*	*Intensity range*	*Hb value by image processing*	*Hb value by conventional method*
1.	*A*	*106-116*	*13*	*12.5*
2.	*B*	*117-123*	*12*	*12*
3.	*C*	*124-134*	*10*	*10*

4.	*D*	*135-142*	*8*	*8.5*
5.	*E*	*130- 137*	*9*	*9*

Table.2: Hemoglobin values obtained by image processing and by conventional methods

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CONCLUSION

As a conclusion, this research successfully determine discrete intensity range for a particular hemoglobin value by the approach of finding the pixel region of sample i.e. image processing on MATLAB. We will further put our efforts to device a method into a low cost standalone device that will be able to determine the hemoglobin level of a subject during emergency or any traumatic conditions. We have tried two main methods, out of which the RGB color scale method was appropriate. We have collected samples and found that the range of the hemoglobin values fall at a particular RGB color level.

We have come to the conclusion that hemoglobin ranges have their particular intensity levels. One major issue to be worked on in this method is decimal point precision as this method will give only discrete values of hemoglobin. Also, the hemoglobin estimation is only available till 14g/dl which has to be raised to 20g/dl as it is concerned with the new born hemoglobin estimation.

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