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Non–Invasive Detection of Anemia Using MATLAB

Mohammad Yusuf[1], Kinnera Vinay Kumar[2], K.S.S.Rohith[3], Jallepalli Naga Raju[4]

M.R.N Tagore[5]

[1]U.G. Student, Department of ECE, VVIT, Nambur, Guntur, Andhra Pradesh, India

[2]U.G. Student, Department of ECE, VVIT, Nambur, Guntur, Andhra Pradesh, India

[3]U.G. Student, Department of ECE, VVIT, Nambur, Guntur, Andhra Pradesh, India

[4]U.G. Student, Department of ECE, VVIT, Nambur, Guntur, Andhra Pradesh, India

[5]Professor, Department of ECE, VVIT, Nambur, Guntur, Andhra Pradesh, India

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Abstract-*World Health Organization (WHO) identifies Anemia as maligning a quarter of the total world population, which is considered to be a health hazard condition marked by the deficiency of Red blood cells or hemoglobin in the blood stream. Hence, an automated, quick, and reliable detection of anemia is essential. Initial detection of anemia is actually undertaken visually by the physician after examining the color of the anterior conjunctiva of the eye and later confirming it with an invasive blood test. In our study, we have designed a technique for the automated detection of anemia through non-invasive visual method. In this, the main operation of the detection of anemia is by analyzing the anterior conjunctival pallor of the eye. It works by quantifying the conjunctival color from digital photographs of the eye taken with a smartphone camera of appropriate resolution under sufficient lighting conditions. These images are then further processed to attain the red and green component spectra of the conjunctiva color and compared against a threshold to determine whether the patient is anemic or not. Our study was aimed towards the automation of healthcare facilities in underdeveloped parts of the world lacking proper healthcare facilities like hospitals and healthcare centers. Thus, we have developed a computerized, noninvasive, simple, cost effective, easy to use, and portable primary screening test for anemia which can provide a viable alternative to invasive methods of anemia detection and have major humane impact in the underdeveloped areas of the world.*

Key Words : Detection of Anemia, image, photograph eye, conjunctival pallor, hemoglobin concentration, non-invasive method.

1. INTRODUCTION

In between the years 1995 and 2005, according to a study conducted by the world health organization (WHO), 24.8 percentage of the entire world population was considered to be anemic [1]. The Hemoglobin concentration in the human blood is considered as the gold standard for the detection of anemia. This is an intravenous process which needs specialized surgical equipment. Recently, finger prick blood sample is taken for lab testing. Higher chances, that it could affect the workers with blood borne infections [2]. Normally, many clinics examine the conjunctival pallor of the eyerapidly screen for anemia.Physicians generally pull down the eyelid and subjectively examine the color of the anterior conjunctival 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 conjunctival color can undermine the authenticity of the visual detection process [3]. To alleviate the problem of inter-observer disagreement and human error to make the visual detection process more reliable, color scale cards, which consist of the color spectrum and the corresponding hemoglobin concentration is used in many occasions [4].

Section 2 of this paper is about the existing methods for the detection of Anemia. Section 3 explains about our Non-Invasive method of detecting Anemia. The results and the discussion regarding that are given in Section 4. The Conclusion is provided in Section 5.

2. EXISTING METHODS

The primary component which contributes to the pigmentation found in human blood is Hemoglobin. It has a bias in reflecting the red component of the light falling on its surface compared to the green component which it primarily takes in. This is the key reason for the deep reddish appearance of hemoglobin [5]. Hence, by

comparing the red and green components of the RGB color spectrum of the conjunctival pallor, it is determined that a person is either Anemic or Non-Anemic. Many people are vulnerable to anemia, due to lack of proper healthcare and medical facilities in underdeveloped countries. This situation can be alleviated if an indication of anemia can be estimated without involving expensive blood tests, which are unavailable in many of these areas. Even the availability of doctors or medical workers is inconsistent. Detecting the presence of anemia in a patient, using non-invasive methods, which does not include expensive tests or even the presence of a doctor or medical worker is of great help. The presence of anemia in a person can be an indication of other diseases like jaundice and lack of nutrition. The detection of anemia can serve to indicate the presence of other diseases as well.

3. METHODOLOGY

A flow chart constituting the entire process is presented in Fig. 1

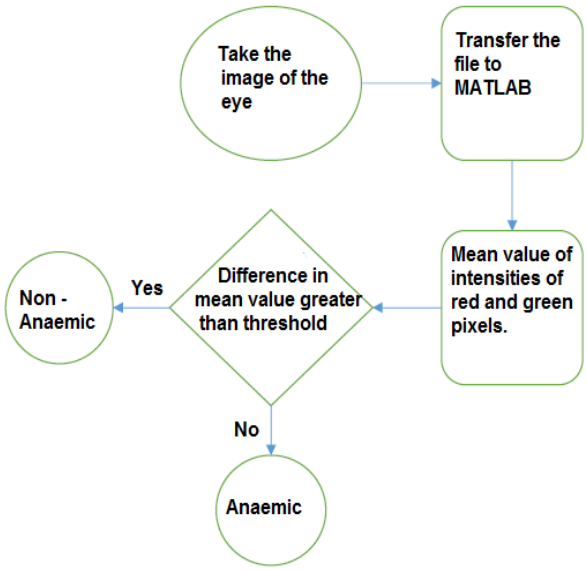

Fig - 1: A flowchart depicting the major parts of our algorithm

3.1 Taking the photograph

We first take a picture of the anterior conjunctiva of the eye in adequate lighting, with a standard back facing camera of a smartphone. We pull the lower eyelid softly with the thumb and take the photograph so that the anterior conjunctiva is in focus and as magnified as possible. The image has considerable effects according the quality of the picture. Improper picture may affect the whole process. So, the picture should be taken with the best camera available. The photo should be taken with stable hands as excessive shaking could blur the image and may result in erroneous readings. Also taking the picture in daylight is recommended.

3.2 Image Processing using MATLAB

The image that is captured is uploaded to MATLAB (Fig. 2), and then converted to gray scale (Fig. 3). **imfreehand** tool, in MATLAB image processing toolbox, is used to select the required region using the cursor (Fig. 4). The outer part of the selected image is converted to black (Fig. 5). The original image is now compared to this gray scale image (Fig. 5) and this gray scale part is cropped in the original image (Fig. 6).

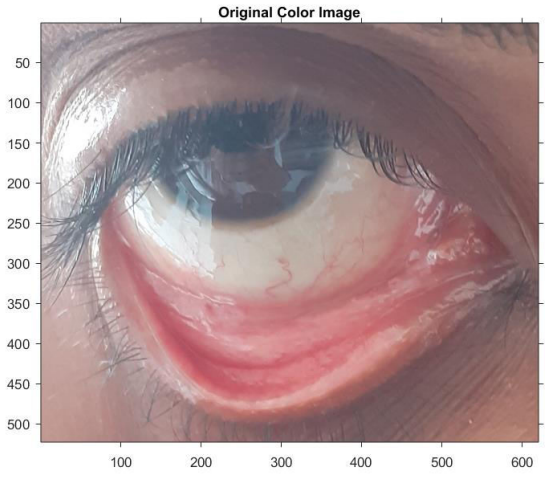

Fig- 2: Color Image

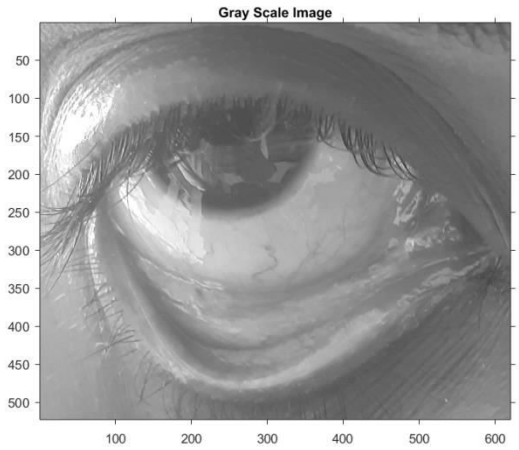

Fig- 3: Gray Scale Image

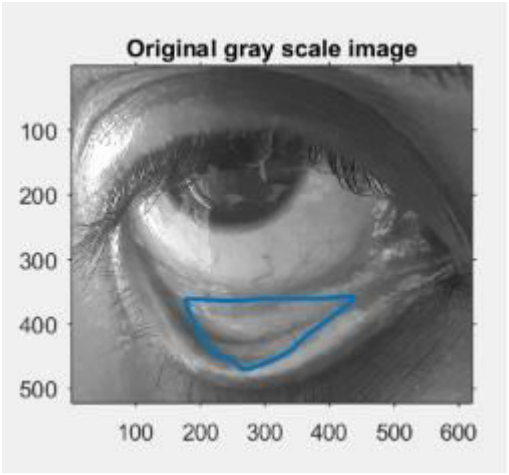

Fig- 4: Gray Scale Image with selected part

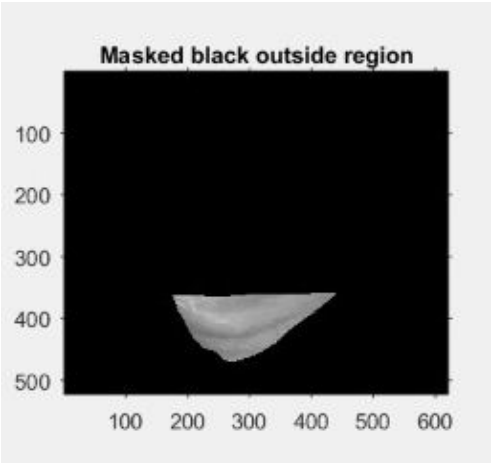

Fig- 5: Cropped Gray Scale Image

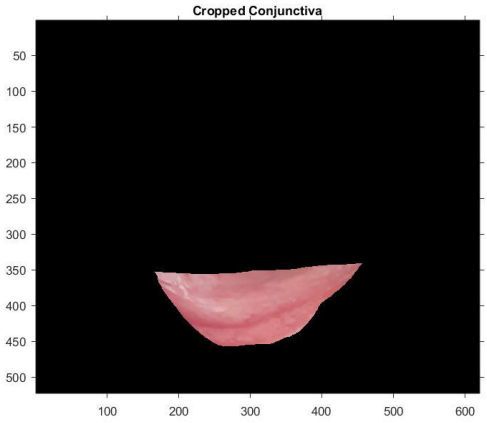

Fig- 6: Cropped Color Image

3.3 Detection of Anemia using RGB

Then, extract the RGB color of Anterior Conjunctiva. Next, the red color intensity of the RGB spectrum was compared to the green color intensity to determine whether the person was anemic or non-anemic. Then, the mean red pixel intensities and green pixel intensities are calculated. Compared to non-anemic patients, we found that the difference between the two means was small for anemic patients. To determine the threshold value, a number of eye images of a subject whose anemia level was previously known, were analyzed. Based on inspection of data for anemic and non-anemic patient we manually selected a threshold difference of means. We found that a mean difference of 1.5 was suitable for our given data.

4. RESULTS AND DISCUSSION

The algorithm decides the state of a patient by averaging the color intensity of the red and green spectrum and then comparing the two values. A suitable threshold is estimated and if the difference between the two spectrums is greater than the threshold value then the algorithm labels that patient as Non-Anemic. The difference is calculated as:

Mean red color intensity – Mean green color intensity

So in case of moderately anemic patients, the value of the difference can also come out to be negative. This happens when the mean red color intensity is less than the green color intensity.

The deficiency of red blood cells or Anemia still persists to be one of the major causes of health hazard in many underdeveloped regions throughout the world [1]. The

first step towards mitigating the risks of anemia is the early detection of this syndrome. Most conventional methods of anemia detection rely on a chemical blood test performed on the intravenously acquired blood sample of the patient in question. However, due to the lack of proper medical facilities or hospitals in many areas, this intravenous method of anemia detection becomes highly inconvenient at certain times. In many patients, the detection of anemia is eventually delayed until it causes irreversible organ damage which may even lead to death in certain occasions.

Our method of the detection of anemia requires no intravenous blood samples and can be quite conveniently administered requiring only the availability of a camera enabled smart phone which is becoming increasingly available in recent times. The process is user friendly with requires no prior specialized skills to operate making it very convenient to administer.

The table below shows the patient's actual anemia state as per the blood test report, their hemoglobin level and the predictions made by our algorithm.

TABLE 1: List of patients with their actual anemia state and the predictions made by our algorithm.

Patient Number	Actual Hemoglobin level (gram/100 ml)	Presence of anemia according to blood report	Anemia Prediction though our process
1.	8.0	Yes	Anemic
2.	11.0	No	Non-Anemic
3.	10.0	No	Anemic
4.	9.3	Yes	Anemic
5.	10.2	No	Non-Anemic
6.	15.3	No	Non-Anemic
7.	6.8	Yes	Anemic
8.	12.1	No	Anemic
9.	7.3	Yes	Anemic
10.	12.4	No	Non-Anemic

5. CONCLUSION

To summarize, we have perfected a non-invasive process for the successful detection of anemia with 78.9% accuracy. The process involves taking a picture of the conjunctival pallor of the eye using the camera of a smartphone with suitable regulation in sufficient lighting. The image taken is next transferred to a computer by any means.RGB spectrum of the anterior conjunctival pallor is processed bya computer program that processes the image to extract and compares it with a pre-determined threshold value to conclude whether the subject is anemic or not. The value of the threshold is determined based on our collected data so the quantity of the data has a considerable impact on the accuracy of the system and a larger and more diversified collection of data injected into our algorithm would substantially boost the accuracy. Furthermore, the threshold of anemic and non-anemic patients can also depend on his/her geographical location which can be incorporated into the program if data from different regions is available. In the less developed regions of the world.This method of anemia detection can prove to be a vital method in the fight against anemia. This can result in a significant increase in the health conditions in those areas along with a sufficiently less deaths caused by the effects of anemia. Moreover, this method can also be used to detect the lack of blood caused by other means like blood loss due to physical injury of various organs of the body.

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