Anemia Detection using Image Processing

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ABSTRACT
Medical image processing provides state of the art techniques for the automatic diagnostic system to different diseases and is very common now days. These types of system provide cost effective health care facilities to patients. Anemia globally is prevalent most in developing countries and it is affecting 1.62 billion people, which comprises of 24.8% of the population. Like other developing countries, Pakistan has been facing problem of Anemia which is very common among women and children in Pakistan. In this paper, a non-invasive automatic detection of anemia is proposed by using image processing and pattern recognition techniques. A technique is developed to detect anemia by a digital photograph of a face image exposing conjunctiva as anemia can be identified by conjunctiva pallor. Eye region is detected by using famous object detection Viola and Jones algorithm and the method then enhances the contrast of image in preprocessing step. The conjunctiva segmentation is performed by using K-means clustering. Color based feature vector is then computed and by using these feature set, SVM classifier is applied to classify between anemic and non-anemic images. Two camps have been arranged locally to gather patients' data containing the images and clinical HB values. The results of proposed system are correlated with the clinical values and the proposed system showed reliable results when compared with clinical findings. The proposed system showed good accuracy when compared with clinical results.

KEYWORDS
Anemia, conjunctiva pallor, segmentation, K-means clustering, SVM classifier

1 INTRODCTION
Anemia is typically defined as hemoglobin (HB) concentration in blood is less than 13.5 gram/100 ml for men and hemoglobin (HB) of less than 12.0 gram/100 ml for women. Anemia, has numerous causes, such as chronic blood loss, iron deficiency and hemolysis, and is a common and major health issue. Globally, anemia is affecting 1.62 billion people, which comprises of 24.8% of the total population. The common most type of anemia across the world is iron deficiency anemia, which has been worsening by parasitic infection. Rapidly anemia identification through observation of palpebral conjunctiva pallor is standard medical practice.

a) b)

Figure 1. a) Normal Conjunctiva b) Pale Conjunctiva

Sheth TN [1] describes the relationship of pale conjunctiva to anemia presence According to Stoltzfus RJ clinically pale conjunctiva is very helpful to diagnose severe anemia in the population with areas where anemia disease is severe and prevalent [2]. Different results have been seen in clinical experiments to diagnose anemia by physical examination. One study showed that the specificity and sensitivity for diagnosing anemia varies with different proportions [3]. Study conducted in Bangladesh and Uganda showed that physicians had poor ability to assess children having severe anemia [4]. Physicians with ability to identify anemia clinically was not reliable even in US as well

[5]. Pregnant women having anemia has higher health risk to both mother and child [6]. Moreover, physically capacity is sufficiently decreased among laborers suffering anemia [7] Phlebotomy is the gold standard method which is laboratory based determination of HB [8].

Flow cytometry is currently the most widely used technique to measure HB. Developing countries may lack resources to measure hemoglobin concentration in blood where anemia is highly prevalent as it requires well equipped laboratory settings on large scale. Anemia may cause adverse effects if it is not treated on time. Endeavors of developing more easily for use and accurate, anemia detecting technologies have been under process for many years. Non-invasive technology has got more interest and attention by experts. The World Health Organization (WHO) is investing resources in determination of clinical parameters that can predictive anemia. In developing countries, most of the screening and detection depends on determining anemia clinically. A constellation of signs that can predict anemia is being used but, because of subjective measures they have showed different result. Color characteristics of conjunctiva can be related to HB level in blood and the representing those characteristics in a digital form depends on their related shades of Red (R), Green (G), and Blue (B) for every pixel. HB concentration can be assessed by digital color characteristics of a conjunctiva image [8]. To describe the relationship between the hemoglobin and color of the conjunctiva, a method is developed to correlate objectively color in digital images of palpebral conjunctiva to the known hemoglobin.

We presented an algorithm that correlate color of conjunctiva to hemoglobin and detects anemia. One major objective to design this type of technique is to use easily accessible and movable facility to develop an authentic method for estimation of HB as a screening tool for using in developing countries and during multiple casualty situations where facilities are insufficient. This designed method can be packaged into a reliable and movable platform, easy to use, and to provide quick results on a large scale of any environmental conditions. There are many other computer aided diagnostic (CAD) systems which are being developed for automated detection of different diseases [9-11].

2 PROPOSED APPROACH

The proposed method has dual phases in study and the first part consists of knowing hemoglobin values by clinical methods and second part is consisting of assessing hemoglobin blindly by applying proposed method. Our proposed method is consisted of four stages. In the first stage eye image is detected and cropped by applying viola jones algorithm, in the next stage conjunctiva is extracted by applying segmentation on the cropped eye image. Then color based features are extracted and in final stage classification is applied to differ among non-anemic and mild-anemic or severe-anemic patients. Figure 2 presents the overview of proposed method.

2.1 Detection of Eye Region

Eye region is detected by using famous object detection Algorithm called viola jones algorithm. Viola-Jones method [12] explores input image by using sub window which is capable of detecting features. Objects of multiple sizes in image are detected by this scaled window. Scale invariant detector is developed in this method that runs through image multiple times, with different size every time. As the detector is scale invariant, so regardless of the size of the image it requires same number of calculations.

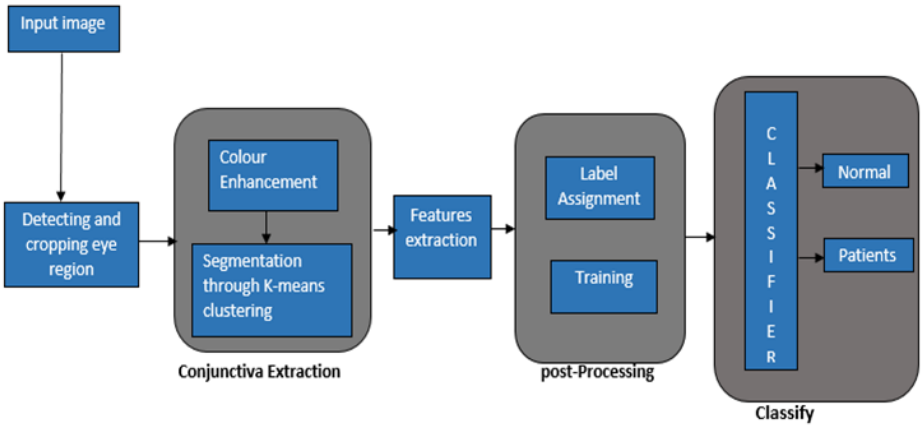

Figure 2. Proposed method

Cascaded detector is used in viola jones algorithm. Simple detectors are used in first stage. Complexity of detector is increased in the further next stages to analyses features' complexity in detail. Detector is constructed from Haar like features and integral image. Viola and Jones uses a simple classifier for feature selection that is built from efficiently computational features using AdaBoost [13] [14]. Viola-Jones prescribes accepting many false positives in the initial stages. Resultantly the numbers of false negative in final stage classifier supposed to be very less.

Figure 3. Eye Detection Using Viola Jones algorithm column 1) input images Column 2) Eye detection using algorithm in a yellow square window column 3) cropped eye region

2.2 Conjunctiva Extraction:

As conjunctiva pallor is associated with anemia so extraction of conjunctiva is important to detect anemia [1]. To extract conjunctiva, segmentation is performed on the cropped eye image.

2.3 Segmentation of Image

Image segmentation is the process of dividing the image into meaningful form and is very important for the analysis of image, visualization, object representation and many other tasks in image processing. Segmentation divides an image into the regions with similar properties such as color, gray level, brightness, contrast and texture [15] [16]. The purpose of segmentation is subdividing the objects in the image and in case of medical image segmentation the goal is to:

- Analyzing anatomical structure
- Identifying the interested regions i.e. locating lesion, tumors and other abnormalities
- Measuring volume of tissue to measure tumor growth and decreasing the size of tumor with treatment.
- Helps in the treatment planning before radiation therapy and in calculation of radiation dose.

In our proposed method segmentation is done by k-means clustering algorithm. Segmentation is performed by K means clustering. It requires following two steps.

1. Image Enhancement
2. K means clustering

2.3.1 Image Enhancement

Image enhancement is the way to improve image quality to make it look better. It highlights the interesting details of image and

makes visually appealing. Histogram equalization is applied to enhance the contrast of image and it will spread intensity over full range [17]. Histogram equalization spreads the contrast of input image on the entire available dynamic range evenly. Image is processed by transforming RGB color space into HSV color space. HSV stands for Hue; Saturation Value Brightness is equivalent to intensity. Hue shows the dominant wavelength of color stimulus and color purity is shown by color purity. Hue and saturation when combined both are called chromaticity co-ordinates.

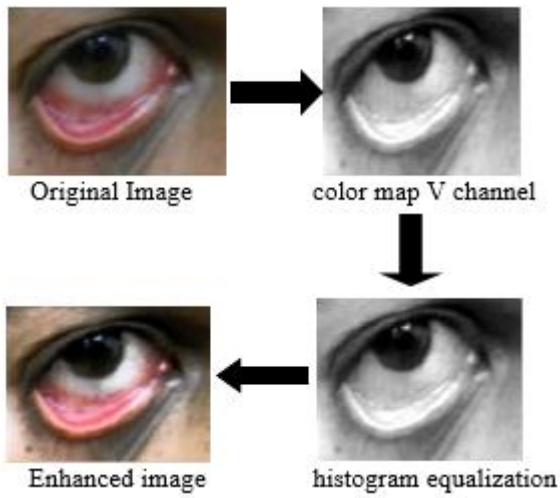

Figure 4. Eye Enhancement

2.3.2 K-means Clustering

K-means is an important unsupervised algorithm for clustering that classifies input data points into numerous classes based on the inherit distance from each other. In this algorithm, number of cluster is defined first. This algorithm supposes data features from the vector space and finds clusters in them. Around the centroid, the points are clustered $\mu i \forall i = 1 \ldots . k$ that has been obtained by minimizing the objective

$$V = \sum_{i=1}^{k} \sum_{x_j \epsilon S_i} (x_j - \mu_i) \qquad (1)$$

Where k shows clusters S_i, *i= 1, 2 ……. k.* following flow diagram shows the steps of k means clustering.

2.4 Features Extraction

After conjunctiva extraction, feature set has been computed for every image to classify it into three classes. Features that are used for the detection of anemia are listed below:

1. ***f1-f3:*** Red(R), Green (G) and Blue (B) channel of RGB colour space
2. ***f4-f6***: Hue (H), Saturation(S) and Intensity (I) channel of HSI space
3. ***f7-f9***: Cyan (C), Magenta (M) and yellow (Y) colour feature from CMYK space.
4. ***f10-f12***: In-phase and quadrature information from YIQ colour space
5. ***f13-f15***: Luma, blue difference and red difference information of YCBCR colour space
6. ***f16-f18:*** Lightness and color opponent dimension from LAB colour space

The extracted features are appended in an array.

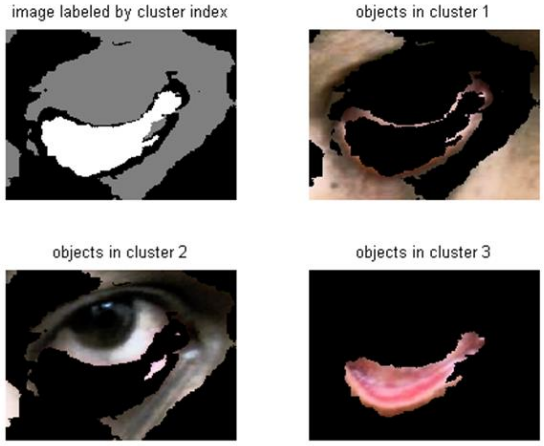

Figure 5. Segmentation of eye Image

2.5 Classification

The features of image with hemoglobin level 6-7.5 are labelled 0. The features of the images with haemoglobin level 8-9 is labelled as 1 and

features of images with haemoglobin level 9.5-10 is labelled 2. As the training procedure trains up to only two labels at a time, we put label 2 equal to 1 so that we're only left with label 0 and 1, and we then train and classify it. In the next process we put label 1 equal to 0 so that we're left with only labels 0 and 2 and we train and classify these. In the last process we put the label 0 equal to 1 so that we're left with only label 1 and 2 and then we train and classify these two. We note the accuracies from these three steps. Classification is done by using supervised classifier called SVM classifier, it discriminated multiple classes with maximum margin. We have three classes in our case that are no anemia, mild anemia and severe anemia class. Least square Support Vector Machine (SVM) is applied by using LS-SVM toolbox [18] for the implementation of radial basis function (RBF). Image is tested to check the HB level.

3. EXPERIMENTAL RESULTS

Table 1. **Performance of the Proposed Algorithm**

Type	Number of images classified as Anemic	Number of images classified as Non-Anemic
Anemic	49	7
Non-Anemic	4	17

For evaluating the proposed system, multiple images were taken from POF hospital Wah Cantt. Images were provided with the known HB measured clinically. The proposed Algorithm was then applied on the images to classify them into one of three class that are no-anemic, mild-anemic or severe-anemic. Table 1 shows the number of anemic patients and non-anemic people classified correctly and number of non-anemic people and anemic patients classified incorrectly.

Sensitivity, accuracy and specificity are calculated from following equations given below.

$$\textit{Sensitinity} = \frac{TP}{TP+FN} \quad (2)$$

$$\textit{Accuracy} = \frac{TP+TN}{TP+TN+FP+FN} \quad (3)$$

$$\textit{Specificity} = \frac{TN}{TN+FP} \quad (4)$$

Where TP is True Positive, FN is False Negative, TN stands for True Negative and FP for False positive. In our case images classified as anemic correctly is true positive and True Negative is non-anemic images classified correctly. While False Positive is anemic images classified as non-anemic and non-anemic images classified as anemic is False Negative respectively. Proposed algorithm has achieved 85% accuracy, 0.92 sensitivity and 0.70 specificity respectively

4 CONCLUSION

As anemia is a common health disease globally and is affecting billions of people around the world especially in developing countries. In this paper an algorithm is proposed to detect anemia by a single image exposing conjunctiva as pallor of conjunctiva is associated with anemia presence. Eye image in the system is detected by using Viola Jones algorithm and after cropping eye image segmentation is done to extract conjunctiva by k means clustering algorithm. Color based features are extracted and finally images are classified as anemic or non-anemic. The system is very useful for the developing countries where resources are limited.

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