
Portable system for the prediction of anemia based on the ocular conjunctiva using Artificial Intelligence

Abstract

Anemia is a major health burden worldwide. Examining the hemoglobin level of blood is an important way to achieve the diagnosis of anemia, but it requires blood drawing and a blood test. In this work we propose a non-invasive, fast, and cost-effective screening test for iron-deficiency anemia in Peruvian young children. The initial results show promising evidence to detect anemia by conjunctival pallor and Artificial Intelligence techniques using photos taken with a popular smartphone.

1 Introduction

Anemia is a global public health problem with major consequences for human health. It affects 24.8% of the world's population [1] and 43.5% of Peruvian children [2]. It is assessed by the level of hemoglobin (Hb), which is the most reliable indicator. Current clinical methods primarily rely on invasive determination of blood Hb via blood extraction. It demands high labor, instrumentation costs, and is a time-consuming procedure which exposes the personal to blood-transmissible diseases.

Over the last decades, various algorithms and devices have been designed in order to estimate the level of hemoglobin or determine the state of anemia based on the color of the conjunctiva. In [3] [4], a good correlation between the concentration level of Hb and the conjunctival pallor was obtained via a smartphone-based system. In [5], the authors analyzed color features of the palpebral conjunctiva based on a standard gray card with the aim of correcting the colors of the images based on ambient lighting. In their experiment, they found a moderate correlation between the hue and the color features. In [6], the authors taken into consideration the spectral reflectance of the conjunctiva for clear anemia cases, but the equipment used are not commonly available and highly expensive. In [7], it was proposed a new feature and the authors compared two different classification methods based on a support vector machine and an artificial neural network, obtaining relatively good performance. The novelty introduced in [8] is about the use of a combined approach based on a modified Kalman filter and penalty regression, obtaining relatively good results.

In this work we propose a computer-based method that can diagnose anemia by just analyzing recorded images of patients' palpebral conjunctiva, which can be fast, cost-effective, and globally applicable and popular enough to replace a physician's visual examination for anemia diagnosis, especially in the rural areas of developing countries where medical resources are limited.

2 Methodology

The proposed system works with images captured from a smartphone camera. The images are processed at UPCH servers in order to to predict Anemia and the result are returned to the smartphone. Conjunctiva extraction is performed via automatic segmentation using CNNs, then R and G components of the Erythema Index (EI) are calculated. Finally, using these values and a neural network regressor, the prediction of Anemia is estimated. Fig. 1 shows the diagram of the system.

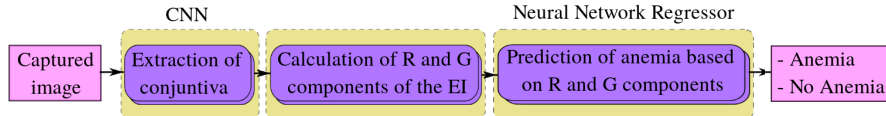


Figure 1: Diagram for the proposed system

The dataset was collected with a popular smartphone in three state medical centers from Lima with the respective authorization, obtaining about 400 young children samples. In order to have a gold standard value, clinical method was carried out to label each sample with its hub value and Anemia level. Extraction of the conjunctiva was carried out by an automatic conjunctiva detector using a MobileNet CNN and the automatic segmentation is performed by a Convolutional Encoder-Decoder. Based on the conjunctiva region, the EI was determined using the equation reported by Yamamoto et al [9]: $EI = \log(R) - \log(G)$ where R and G are the brightness of the conjunctiva in red a green channel. In order to normalize the images due ambiental lighting, each channel's brightness were adjusted by multiplying its brightness by $200/MB$ where MB is the mean brightness of the color calibration card's white square. Finally, based on the R and G components, the Hb value is predicted by a neural network regressor, and employing the predicted Hb value, each image is classified as anemia or no anemia. The complete system was implemented in Python and using Tensorflow.

3 First Results

The improvement of the system is under development and the final results no prepared, however the initial results are presented in this work and show promising evidence to detect anemia. As explained in the methodology section, the first part of the system is the extraction of the conjunctiva by CNNs. As we can see in the Fig. 2, the implemented CNNs achieve successful results.



Figure 2: First results of the autimatic conjunctiva detector

Furthermore, taking into consideration different cut-off points for anemia prediction, the initial proposed neural network regressor achieves promising results. As the Table. 1 shows, accuracy for two classes, sensibility and specificity are evaluated for each cut-off point. The best results are obtained from the cut-off point of Hb = 11, which gives a sensitivity of 77.58%.

Table 1: Results of the neural network regressor for different cut-off points [%]

Cut-off point	Hb = 9	Hb = 10	Hb = 11
Accuracy	93.53	77.07	42.96
Sensitivity	22.49	52.21	77.58
Specificity	94.20	78.40	36.03

4 Conclusions

In this work we demonstrated that our system is capable to predict anemia with a sensitivity of 77.58% via images captured from a popular smartphone and using Artificial Intelligence techniques. Despite the fact that this project is still in development, the initial results show promising results and up to date several modifications are still to be evaluated, so better results will be obtained. Therefore, our system provides a fast, cost-effective, and globally useful tool for anemia evaluation, especially in the Peruvian rural areas where medical resources are limited.

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