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Non-Invasive Anemia Screening Using Nails and Palms Photos

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Abstract

Anemia is a condition where the hemoglobin level is below standard. Hemoglobin is an iron-rich protein that gives blood its red color and is tasked with helping red blood cells carry oxygen from the lungs throughout the body, including essential body organs such as the heart, kidneys, and other organs. So that if anemia is allowed to drag on, it will interfere with the function of these organs and cause various kinds of diseases.This study applies the Naive Bayes method to detect anemia using digital images of the nails and palms as parameters. The image processing method used in this research is image segmentation in digital images of nails and palms so that they are separated from the background using the threshold method, after which the mean values of Red, Green, Blue, and their standard deviation are found. Furthermore, the value obtained will be processed using the Naïve Bayes classification method to categorize the palm image data entered into the anemia or non-anemia category. The proposed method achieves 90 percent accuracy for the paleness classification of nails and palms pictures. The proposed paleness screening method can be further fine-tuned to identify the intensity of anemia-like pathologies by using a controlled collection of local images that can then be used for potential benchmarking purposes.

Keywords: anemia, image processing, classification, Naïve Bayes

I. INTRODUCTION

According to a report by the World Health Organisation, Between 1995 and 2005, the organization (WHO) found 24.8 percent of the entire world population to be anemic (Tamir *et al.*, 2018). The prevalence of anemia in the world is estimated at 9 percent in developed countries and 43 percent in developing countries, which aims to reduce 50 percent of people with anemia by 2025 in women of childbearing age that aged 15-49 years (WHO, 2012). Women of childbearing age are a group that is prone to suffering from anemia and deficiencies of other nutrients, so they need special attention.

The way to find out whether someone has anemia or not can be through an invasive examination, namely by taking a blood sample. The concentration of hemoglobin in human blood for anemia diagnosis is known to be the gold standard. Taking a blood sample is an intravenous procedure that involves advanced surgery equipment. Figure prick blood sample has recently been taken for laboratory testing. Still, diagnostic tests take time and effort and could expose healthcare

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professionals to the risk of blood-borne infections, and sufferers must feel pain when taking blood samples (Dimauro *et al.*, 2018).

Apart from this invasive method, there are other, easier ways to detect anemia. This method is non-invasive by looking at the conjunctiva, fingers, palms, and tongue. The conjunctiva, fingers, palms, and tongue look slightly pale, which is a sign that the blood is deficient in hemoglobin. In (Zucker *et al.*, 1997) states that paleness of the palms and nails is the best parameter for detecting anemia with a sensitivity level of up to 90 percent. While conjunctival paleness has a sensitivity of 81 percent, and the tongue has the lowest sensitivity, 59 percent.

Referring to Zucker's research results, this study applies the Naïve Bayes method to detect anemia using digital images of the nails and palms as parameters. The image processing method used in this research is image segmentation in a digital image of nails and palms so that they are separated from the background using the thresholding method, after which the mean values of Red, Green, Blue, and their standard deviation. Furthermore, the value obtained will be processed using the Naive Bayes classification method to categorize the palms and nails image data entered into the anemia or normal category.

II. LITERATURE REVIEW

Anemia affects about 25 percent of the world's population (WHO, 2012). The highest prevalence of disease occurs in preschool-aged children. However, pregnant women are the group with the highest number of people affected. This is a potentially dangerous situation as the involvement of anemia in pregnant women can lead to maternal and perinatal mortality. Anemia leads to the inappropriate physical and mental growth of infants. When anemia co-exists with a lack of adequate nutrition and other risk factors, it induces a high infant and child mortality rate (Aparna, Sarath, and Ramachandran, 2017).

Over the years, many non-invasive approaches have been used, studied for the diagnosis of anemia, such as the existence of conjunctival paleness was used to assess the Hb level (Sheth *et al.*, 1997). The authors achieved 95 percent accuracy based on the conjunctiva paleness and found the 9 g / dl Hb threshold to exclude profound anemia. In a study conducted by (Chen, Miaou, and Bian, 2016), the palpebral conjunctival paleness of the patients was evaluated by the two proposed algorithms. The first algorithm is meant to be fast and straightforward, while the second is to be more sophisticated and powerful. The first algorithm consists of a simple two-stage classifier, namely a thresholding decision technique based on a feature called high hue rate (HHR) and a feature named pixel value in the middle (PVM), followed by the use of minimum distance classifier based on Mahalanobis distance. In the second algorithm, the authors use entropy, binarisation of HHR, and PVM of G components for classification using a support vector machine, and the result is that the second algorithm performs better than the first.

Sanchez-Carrillo (Sanchez-Carrillo *et al.*, 1989) developed a colorimetric instrument for non-invasive hemoglobin quantification, using a color tone specific to that found in the conjunctiva. The findings obtained are very favorable for the determination of hemoglobin concentrations in patients with values of up to 13 g / dl. The digital image of the conjunctiva is examined in Suner's work (Suner *et al.*, 2007), and the variations in the colors red, green, and blue are calculated in the photograph. The authors plan to construct a compact and accurate hemoglobin estimation method for use in developing countries or where resources are limited.

Other sections of the body have also been considered for the diagnosis of anemia. For example, in (Yalçin *et al.*, 2007), palmar, oral, and conjunctival paleness sensitivities for the detection of thalassemic children with anemia were 93.2, 80.7, and 90.9 percent, respectively. Cases with Hb values less than 11 g / dl might easily be found by conjunctival pallor, independent of serum ferritin levels. However, there have been relevant associations between the presence of palmar or buccal paleness, and the presence of anemia in children with serum ferritin levels below 2500 micron / L. Palmar paleness alone had the highest sensitivity and the lowest specificity to diagnose anemia in cases of beta-thalassemia. Conjunctival paleness was more useful than oral and palmar paleness in cases with elevated levels of ferritin. In other studies in (Zucker *et al.*, 1997), extreme nailbed or extreme palmar paleness had the highest sensitivity (62 percent and 60 percent, respectively) compared to significant conjunctival paleness (sensitivity = 31 percent) to detect children with severe anemia in outpatient environments. Children with mild anemia were better characterized by the appearance of the navel or palmar paleness (sensitivity = 90 percent for both signs) compared to conjunctival paleness (sensitivity = 81 percent).

Considering other body regions, we need to consider factors that might compromise the objective assessment of hemoglobin (e.g., skin pigmentation). Generally, palms that have normal hemoglobin levels will be reddish. According to Duke's research (Duke, 1928), the palms are the surface of the skin whose color varies widely unless a person is anemic or plethoric, and the color can give an idea of the amount of hemoglobin that is actually in the general circulation. Therefore, palms paleness can be indicated by a lack of hemoglobin levels. Zucker's research confirmed the results of Duke's experiment that palms paleness had high accuracy in detecting anemia. Likewise, normal nails have a reddish color because there are many capillaries. Below is the difference in the color of the palms and nail between people with anemia and not. In a healthy person, the color of the palms and nails is reddish, while people with anemia have a pale color of the palms and nails.

Figure 1. The different color of the palms and nail between anemic and not

III. RESEARCH METHODOLOGY

The proposed method of anemia detection is shown in figure 2.

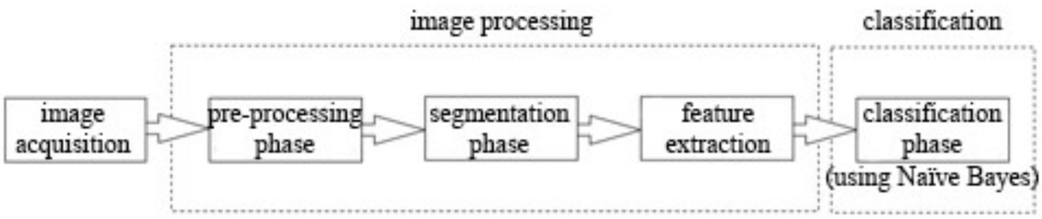

Figure 2. The architecture of our proposed methodology

III.1. Image Acquisition

The capture of nails and palms using the rear camera of a smartphone with a 16MP camera specification with the flash off. Image is taken during the day without direct sunlight so that objects can show their true colors. When taking the picture, the distance between the camera and the nails is approximately 6cm, and the palm is about 15cm. In this study, 20 training data were used, 9 with anemia and 11 without anemia.

III.2. Pre-processing Phase

The image that has been taken using a smartphone camera will be transferred to a laptop and used as an input image for the anemia detection system. Then the image enters the pre-processing phase, which means that the resolution will be equalized to 400x299. This equalization of resolution aims to standardize the data that is entered into the system.

III.3. Segmentation Phase

Segmentation is needed to extract the nails and palms from the captured image. Image segmentation of the nail and palm area consists of 2 stages, namely:

1. Convert RGB to YCbCr
2. Thresholding

The first step in image segmentation is to convert the image colour space from RGB to YCbCr. In converting RGB colour space to YCbCr using the following matrix:

$$\begin{array}{lllllllll} Y & = & 16 & + & (65{,}481.R' & + & 128{,}553.G' & + & 24{,}966.B') \\ Cb & = & 128 & + & (-37{,}797.R' & + & -74{,}203.G' & + & 112.B') \\ Cr & = & 128 & + & (112.R' & + & -93{,}786.G' & + & -18{,}214.B') \end{array} \quad (1)$$

After the nail and palm images have a new pixel value, a threshold will be performed with a threshold value.

$$Cb \geq 77 \ \& \ Cb \leq 127 \ \& \ Cr \geq 133 \ \& \ Cr \leq 173 \quad (2)$$

From this value, the system will mark pixels that meet the requirements by changing the pixel value to a value of 1, while pixels that do not meet the criteria will be changed to a value of 0. From the thresholding process, a binary image will be generated that separates the object from the background. Then the system will change the image to RGB again with the background that has been removed.

III.4. Feature Extraction

RGB value is used as a parameter of this study. From the segmented image, the system will then calculate the average RGB value of the picture. Then obtained two results, namely the average RGB nails and the average RGB palms. The RGB average value of the training data will be entered into the database, while the RGB average value of the test data will be used as input in the classification process.

III.5. Class Labelling

Class labeling is done if the data entered is in the form of training data. There are two types of classes in this study, namely Normal and Anemia. Class labels in this study were determined when data collection was carried out using EasyTouch GCHQ. Labeling aims to train the algorithm so that it can provide classification results for further data.

III.6. Naïve Bayes Classification

The classification process using the Naive Bayes algorithm is carried out if the data entered is in the form of test data. In the Naive Bayes algorithm, there are three stages, namely:

1. Calculating the prior probability
   In calculating the prior probability required, the number of anemia respondent data and the normal respondent data contained in the training data. Because the number of classes in this study amounted to two, the prior probability is also two, namely the probability of prior anemia and normal prior probability. The formula used to calculate the prior probability is as follows:
   Probability of prior anemia = amount of anemia data/amount of data (3)
   Normal prior probability = amount of normal data/amount of data (4)

2. Calculating the mean and standard deviation
   The mean and standard deviation of the features in the training data will be used when calculating the probability of feature occurrence. In this calculation, the training data will be separated according to the label, namely normal and anemia data. The formula used to calculate the mean and standard deviation is as follows:
   Mean :
   $$\mu = \frac{1}{n}\sum_{i=1}^{n} x_i \quad (5)$$
   Standard deviation
   $$\sigma = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(x_i - \mu)^2} \quad (6)$$
   From the results of these calculations, 24 values will be obtained.

3. Calculate the probability of the feature appearing
   The RGB value of the test data will look for the chance of its appearance using this calculation. Because in this study, the data used is in the form of continuous data, the formula for calculating the probability of a feature appearance is as follows:
   $$P = (X_i = x_i \mid Y_i = y_i) = \frac{1}{\sqrt{2\pi\sigma ij}} e^{-\frac{(xi-uij)^2}{2\sigma^2 ij}} \quad (7)$$
   From this formula, the chance of the feature or so-called likelihood will be generated. There are two likelihoods generated, namely normal likelihood and anemia likelihood.

4. Calculating Posterior Probabilities
   The last step in the Naive Bayes algorithm is to calculate the posterior probability with the formula:
   $$Posterior = \frac{Prior \times likelihood}{evidence} \quad (8)$$

The calculation of the posterior probability is by multiplying the prior probability by the likelihood that has been previously calculated—then divided by the value of evidence. The evidence value is the sum of the normal likelihoods and the anemia likelihoods. The final result of this calculation is the probability of posterior normal and the probability of posterior anemia.

After the system has calculated the posterior probability, then the system will determine the classification results. The classification result is determined by comparing the posterior probability values. Classes with a higher posterior probability value will be used as the result of the classification.

IV. FINDING AND DISCUSSION

The approach discussed in this paper has been applied to a set of 20 data and gives a consistent result. The segmentation phase of palms and nails has been shown to play an essential role in the detection of anemia. Figure 3 shows the original image, and the converted YCbCr image is shown in figure 4. Figure 5 is showing the results of the thresholding process. And the final results of the segmentation phase are shown in Figure 6.

Figure 3. Original images

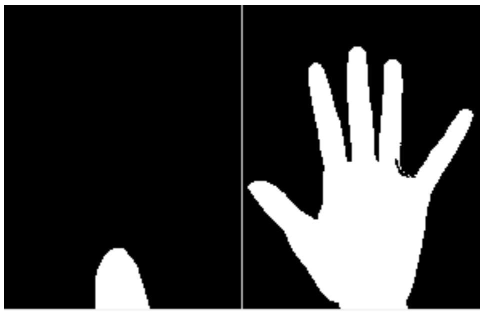

Figure 5. The results of the thresholding process

Figure 4. The results of converting RGB images to YCbCr

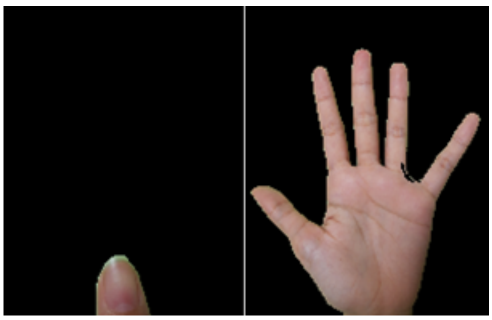

Figure 6. The final results of the segmentation phase

Features have been extracted from the segmented image and are fed into the Naive Bayes algorithm. The final classification result using the Naive Bayes algorithm is presented in Table 1.

No.	Gender	Red (Nails)	Green (Nails)	Blue (Nails)	Red (Palms)	Green (Palms)	Blue (Palms)	Classification Result	Real Health
1.	Man	10,8203	8,2319	7,6407	91,9273	65,3126	57,4411	Normal	Normal
2.	Man	6,9716	4,5646	3,9806	75,2219	52,3098	44,0345	Normal	Normal
3.	Man	7,3628	4,892	4,4663	71,3881	49,6842	43,2266	Normal	Normal

No.	Gender	Red (Nails)	Green (Nails)	Blue (Nails)	Red (Palms)	Green (Palms)	Blue (Palms)	Classification Result	Real Health
4.	Woman	7,5341	4,8289	3,9381	75,3181	51,7156	41,6804	Normal	Normal
5.	Man	6,8761	4,6685	4,1461	68,7053	49,6385	43,009	Normal	Normal
6.	Man	6,3405	3,8069	3,2829	75,4801	53,1568	45,1126	Normal	Normal
7.	Woman	7,7212	6,0955	5,5226	77,976	53,756	46,0153	Normal	Normal
8.	Woman	11,7507	9,1182	8,731	65,7629	38,3309	37,5125	Normal	Normal
9.	Man	7,3888	5,134	4,7729	74,1291	55,1458	47,5367	Normal	Normal
10.	Woman	3,8745	2,383	2,1598	66,4126	46,316	41,665	Anemia	Anemia
11.	Woman	4,4336	2,6751	2,4734	62,9435	42,3062	38,8184	Anemia	Anemia
12	Woman	6,0126	4,3023	4,1231	52,6928	38,4062	36,0015	Anemia	Anemia
13	Woman	6,2002	3,592	3,034	70,2798	50,9621	45,6075	Anemia	Anemia
14	Woman	5,4726	3,2891	3,1356	62,9458	42,9716	40,5157	Anemia	Anemia
15	Woman	12,064	9,7376	8,664	53,2128	37,7922	30,4427	Normal	Anemia
16	Woman	4,3318	3,284	2,8891	55,0697	42,8738	39,4613	Anemia	Anemia
17	Man	7,4126	5,8331	5,7138	69,5089	52,4607	47,7522	Normal	Anemia
18	Woman	4,8782	3,6105	3,3856	62,2684	48,4811	46,5654	Anemia	Anemia
19	Woman	13,5913	10,0281	9,7325	62,0607	46,891	45,17688	Anemia	Anemia
20	Woman	12,8112	9,4579	7,6676	55,4666	43,0193	41,0868	Anemia	Anemia

V. CONCLUSION AND FURTHER RESEARCH

In this research, anemia can be detected by non-invasive methods. A method was implemented for the identification of clinical symptoms of anemia from digital photographs of palms and nails so that it can minimize time and effort and eliminate the risk of blood-borne infections. And so, anemic sufferers do not need to lose their blood or experience pain. The proposed method achieves 90 percent accuracy for the paleness classification of palms and nails pictures.

The limitation in this study is that the color model that is processed in image processing is the RGB color model, in which this color model has the disadvantage of not being able to distinguish black and white. Also, the images of the palms and nails were taken during the day with a good lighting environment. This research implies that the use of the Naïve Bayes classification method causes classification problems, which are complicated to become simpler but have high accuracy results.

Future research can strengthen the method for processing images with limited lighting. Also, the proposed pallor screening method can be further adapted to identify the intensity of anemia-like pathology using controlled local image collections, which can then be used for potential comparison purposes.

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VI. REFERENCES

Aparna, V., Sarath, T. V. and Ramachandran, K. I. (2017) 'Simulation model for anemia detection using RBC counting algorithms and Watershed transform,' *2017 International Conference on Intelligent Computing, Instrumentation and Control Technologies, ICICICT 2017*, pp. 284–291. DOI: 10.1109/ICICICT1.2017.8342575.

Chen, Y. M., Miaou, S. G. and Bian, H. (2016) 'Examining palpebral conjunctiva for anemia assessment with image processing methods,' *Computer Methods and Programs in Biomedicine*. Elsevier Ireland Ltd, 137, pp. 125–135. DOI: 10.1016/j.cmpb.2016.08.025.

Dimauro, G. *et al.* (2018) 'Automatic Segmentation of Relevant Sections of the Conjunctiva for

Non-Invasive Anemia Detection,' *2018 3rd International Conference on Smart and Sustainable Technologies, SpliTech 2018*. University of Split, FESB, pp. 1–5.

Duke, W. W. (1928) 'Palm Color Test : A Simple, Practical Clinical Method For The Diagnosis of Anemia and Plethora', *Archive of Internal Medicine*, 42(4), pp. 533–545.

Sanchez-Carrillo, C. I. *et al.* (1989) 'Test of a non-invasive instrument for measuring hemoglobin concentration,' *International Journal of Technology Assessment in Health Care*, 5(4), pp. 659–667. DOI: 10.1017/S0266462300008527.

Sheth, T. N. *et al.* (1997) 'The relation of conjunctival pallor to the presence of anemia,' *Journal of General Internal Medicine*, 12(2), pp. 102–106. DOI: 10.1046/j.1525-1497.1997.00014.x.

Suner, S. *et al.* (2007) 'Non-Invasive Determination of Hemoglobin by Digital Photography of Palpebral Conjunctiva', *Journal of Emergency Medicine*, 33(2), pp. 105–111. DOI: 10.1016/j.jemermed.2007.02.011.

Tamir, A. *et al.* (2018) 'Detection of anemia from the image of the anterior conjunctiva of the eye by image processing and thresholding,' *5th IEEE Region 10 Humanitarian Technology Conference 2017, R10-HTC 2017*, 2018-Janua, pp. 697–701. DOI: 10.1109/R10-HTC.2017.8289053.

WHO (2012) 'Anaemia Policy Brief,' (6), pp. 1–7. Available at: http://www.who.int//iris/bitstream/10665/148556/1/WHO_NMH_NHD_14.4_eng.pdf.

Yalçin, S. S. *et al.* (2007) 'The validity of pallor as a clinical sign of anemia in cases with beta-thalassemia,' *Turkish Journal of Pediatrics*, 49(4), pp. 408–412.

Zucker, J. R. *et al.* (1997) 'Clinical signs for the recognition of children with moderate or severe anemia in western Kenya,' *Bulletin of the World Health Organization*, 75(SUPPL. 1), pp. 97–102.