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Detection of Malaria Parasite in Thin Blood Smears by using Artificial Neural Network

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Abstract— The paper presented is a part of research work related to computerization of malaria diagnosis, based on processing of digital images of thin blood smear. In this study, an artificial neural network based approach is proposed for detecting Plasmodium parasite in thin blood smear images. Artificial neural network is used as a classifier to differentiate between parasite infected and healthy (non-infected) red blood cells (Erythrocytes). Feedforward neural network trained with RGB color, HSV color space and texture features, extracted from individual red blood cells are studied and evaluated. Our result demonstrates that the network trained with RGB color features is most accurate for detecting Plasmodia parasite and a sensitivity of 97.43 % and specificity of 98.4 % is reported by evaluation of the method.

Keywords*- Neural network, Malaria, thin blood smear, Red blood cell*

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I. Introduction

Malaria is one of the major public health problems and is on the rise in all the endemic regions of the world, including the Indian subcontinent, where about 1.5 million cases are reported every year. Malaria presents a diagnostic challenge to the medical community worldwide [1]. Correct and fast diagnosis is the first step to control the spread of the disease. Microscopy is most accurate and is a gold standard [3], but it is time consuming and not suitable for mass blood screening and or in remote field areas, where 40% of the cases occur [2]. Hence, it is essential to develop fast, accurate, reproducible and human expert independent malaria analysis system, to identify infected and non-infected RBCs in blood smear image.

Several approaches to the computer based detection of malaria in blood images have been proposed in recent few years. In this evolution of automated malaria diagnosis, improved techniques and tools are used for malaria detection. Tek et al. [4] proposed two stage parasite detection system with two consecutive classification algorithms, Bayesian and K-nearest neighbor using four different features based on color histograms, Hu moments, shape and color auto-correlogram with sensitivity of 74%. Ross et al.[5] used backpropagation feedforward neural network to identify & classify malaria parasites present in thin blood films by extracting image features from segmented cells. The algorithm designed is much similar to the manual method using microscopy. Seman et al[6] used MLP network to classify malaria parasites based on six different features achieved an accuracy of 89%. Kshirpa Charpe et al. [7] proposed an approach using color, shape, size, intensity and texture features to detect and classify the parasites using SVM as a classifier reported 90% accuracy.

II. PROPOSED METHODOLOGY

The objective of the proposed work is to develop a system for detecting malaria parasite in RBC stained images.RBC images are acquired from Centre for Disease Control (CDC) website [9].The acquired images are first preprocessed for resizing, color normalization and noise reduction. In second stage, the image is partitioned into meaningful regions, separating foreground from RBC image background by thresholding. In next stage, features based on RGB, HSV color space and texture are extracted from individual red blood cell images. Each individual feature vector as well as their concatenated forms are used to train the ANN classifier. Figure 1 shows the complete flow diagram of the model developed.

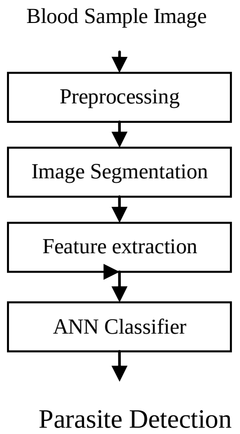

Fig 1. Block diagram of proposed system

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A Preprocessing

The RGB blood cell image is resized, filtered and normalized in color. Resizing is necessary to standardize the spatial resolution for the images obtained from various sources with varying magnification levels. Color normalization is essential to reduce the effect of different light sources and or sensor characteristics. The gray world normalization method [8] is adapted which assumes that there is a constant gray value of image which does not change among different conditions. In order to reduce the effect of noise, 5x5 median filter is used.

B. Segmentation

This stage is important as main objective of image recognition and classification depends solely on this stage. In this stage, the image is partitioned into meaningful regions, separating foreground, from RBC image background by using Otsu's algorithm for thresholding. Histogram provides the frequency distribution of the intensity values in an image. Equation 1 refers to image histogram h(i),

$$h(i)=p(i)/p \qquad (1)$$

i = image pixel intensity level , 0 to L,

p = Summation of all the number of pixels in an image,

p(i)= Summation of the number of pixels with same gray level value i, $0 < i < L$

C. Histogram Based Segmentation

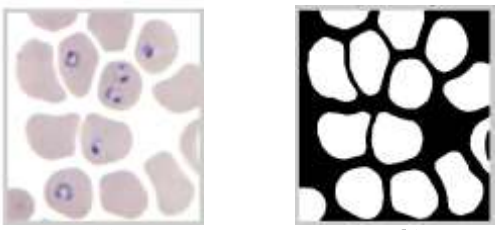
The approach aims to convert a gray scale image into binary image, separating image background from its foreground by means of a non linear operation, called thresholding. The value of threshold T is calculated using Otsu's method. All pixels having intensity values less than T belongs to background and pixels with intensity values greater than T are categorized as foreground. This results to a segmented image where pixels with intensity values less than T are set to 0 and belongs to background, whereas pixels with intensity values greater than T are set to 255 and represents the foreground. Mathematical morphology is further used to separate Erythrocytes from other foreground objects. Watershed algorithm separates the connected blood cells.

$$y(m,n) = \begin{cases} 0, & for\ x(m,n) < \\ 255, & otherwise \end{cases} \qquad (2)$$

x(m,n) = input grayscale image,

y(m,n) = binary image,

T = threshold value



(a) (b)

Fig. 2 a) Preprocessed RBC image, b) Image after thresholding,

D. Feature extraction

Image features are needed to discriminate the erythrocytes between the two classes, infected and non infected. Image attributes based on RGB, HSV and texture of individual erythrocyte are extracted to form a feature vector for further processing by classification stage. The final performance of the classifier stage depends on the success of the feature generation stage.

Color and Texture based features are calculated from image histogram. Mean,Standard deviation, Skewness and Entropy are calculated by using "(3) – (6)" respectively.

$$\mu = \sum_{i=1}^{N} z_i \,.\, p(z_i) \qquad (3)$$

$$\sigma = \sqrt{\sum_{i=1}^{N} (z_i - \mu)^2} .\ p(z_i) \qquad (4)$$

$$\mu_3 = \sqrt{\sum_{i=1}^{N} (z_i - \mu)^3} . p(z_i) \qquad (5)$$

$$H = -\sum_{i=1}^{N} p(z_i) \,.\, log_2\, p(z_i) \qquad (6)$$

where $p(z_i)$ = image histogram,

z_i = image intensity variable,

i = intensity levels in image

E. Classification

Artificial Neural Network is used as a classifier [10] to classify the erythrocytes into infected and non infected category, on the basis of features extracted by segmenting thin blood images. To determine the applicability of the network as malaria infection detection tool, the network is trained and tested on 100 images for evaluation of the performance.are preferred. Please embed symbol fonts, as well, for math, etc.

III .RESULTS AND DISCUSSION

The performance and accuracy of the algorithm is evaluated by measuring two parameters: sensitivity and specificity.

Sensitivity=TP/(TP+FN) (7)

Specificity=TN/(TN+FP) (8)

where, TP = True positives

FN = False negatives

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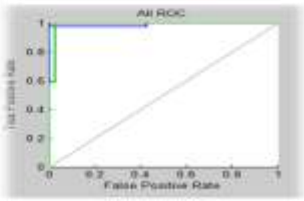
FP = False positive

TN=True Negatives

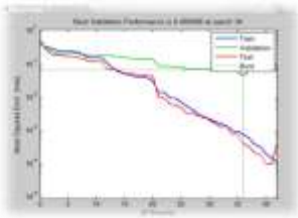
Our result demonstrates that the network trained with RGB color features is most accurate for detecting Plasmodia parasite. Sensitivity of 97.43% and specificity of 98.4% is reported by evaluation of the method with an overall performance of 98%.

Table1: Performance of ANN Classifier

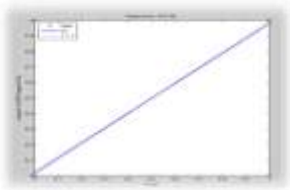
ANN Input Feature Vector attribute	**ANN Performance**			
	Training Performance	***Validation Performance***	***Testing Performance***	***Overall Performance***
RGB Color	100%	90%	100%	98%
HSV Color	96.7%	80%	70%	88%
Texture	100%	95%	80%	95%



(a)



(b)



(c)

Figure1 Results of ANN Classifier (a).ROC Curve,(b) Performance, (c) Regression

The training data set used to train the neural network had 100 images, including both parasites infected and non infected images. After the training, the network was tested with a selected set of different images belonging to both classes and it was found that the network was able to classify and categorize accordingly. The receiver operating characteristics (ROC) shows an area under curve (AUC) nearly equal to unity, indicating good classification accuracy

IV. CONCLUSION

The result shows that the artificial intelligent based approach using ANN classifier as a tool, suits for detecting malaria infection. Among the different rapid methods, the proposed automated parasite detection algorithm has many advantages, viz. fast, accurate, low cost per test, not species specific, temperature insensitive [2] and needs only thin blood smear images to detect malaria infection and classify the parasite species.

We expect that there is a scope in further reduction of number of false positive detections by acquiring larger training and testing data sets for higher performance and robustness of our approach.

V. FUTURE ENHANCEMENTS

The work carried out has a future scope and it is aimed to train the ANN further, to classify the species of Plasmodium parasite using thin blood smear images. Moreover, the methodology can be used for diagnosis of other hematological problems by properly choosing the image attributes and parameters to extract the image features.

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