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Detection of Malaria Parasites through Medical Image Segmentation Using ANN Algorithm

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Abstract: ***Malaria is the leading cause of mortality and morbidity in tropical and subtropical countries. Fast and accurate diagnosis of the disease is key toits effective treatment and management. In the diagnosis of disease conventional microscopy is the gold standard. Another diagnosis technique which yields superior results is quite costly and hence inaccessible for developing countries where the disease is prevailing. Therefore in this work, an accurate, speedy and reasonable system of malaria detection using stained thin blood smear images was developed. The method uses Artificial Neural Network (ANN) to investigation for the existence of plasmodium parasites in thin blood smear images. Images of infected and non-infected erythrocytes were extracted, image segmentation, pre-processed, relevant features extracted from them. Some image processing algorithms to automate the diagnosis of malaria on thin blood smears were developed. With respect to results obtained by expert microscopists, the classification accuracy of 95.0% in detection of infected erythrocyte was achieved. The study revealed that artificial neural network (ANN) classifiers trained with colour features of infected stained thin blood smear images are suitable for detection.***

Keywords: ANN, PCR, THG, RDT

I. INTRODUCTION

Fundamental problem in image processing is image enhancement and restoration in a noisy environment. Generally Information are present in the image. Anything that deteriorates that information is called noise. Denoising of that image is very necessary for retrieval of that information. For noise removal various techniques are used Such as FFT (Fast Fourier Transform), WT (Wavelet Transform), DWT (Discrete Wavelet Transform), Fuzzy Logic, ANN (Artificial Neural Network) etc.

In medical field for various applications such as diagnosis, research, and treatment image technology is used. Noise cancellation from an image is a very important for several disciplines such as medical, biology and engineering. Filters are the conventional solutions for denoising of images. There are specific filters for each types of noise. For example, for salt and pepper noise, median filter is mostly used. In case of gaussian noise mean filter or Weiner filter is used. When data is acquire or transmitted in a channel, noise gets added in the image which varies from time to time and also it changes in a fraction of second. A human expert can't take decision to choose a filter at that small time. To avoid different limitations of fixed filters, adaptive filters are designed.

The work in this paper includes the use of ANN (Artificial Neural Network) for denoising of a medical image followed by the suitable filter classification. Neural Network gives the excellent performance in identifying the noise as well as its removal.

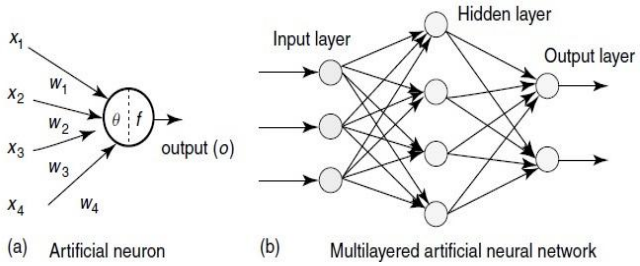
Image denoising is used to calculate the original image from a noisy image with some assumptions or knowledge of the image reduction process. An image denoising procedure takes a noisy image as input and produces the outputs image in which the noise has been reduced. Medical imaging technology is becoming an important component of large number of applications i.e. diagnosis, research, and treatment. The main aim of image restoration techniques is to restore the original image from a noisy observation of it. In digital image processing research and applications, image denoising is a challenging task. This makes it imperative to find a robust method to comply that task.

Malaria is a common but serious protozoan disease caused by peripheral blood, spleen or liver parasites of the genus Plasmodium.For diagnosis of malaria several methods exist. These methods can be classified into two, based on their cost and performance. These are the high cost methods and low cost methods. Polymerase Chain Reaction (PCR) based techniques that detect specific nucleic acid sequences and Third Harmonic Generation (THG) imaging of emission from the Hemozoin using infrared ultrafast pulsed laser excitation, belong to the class of high cost methods. From the studies it has been seen that these techniques can yield high sensitivity and specificity to malaria diagnosis. However, they are rarely used in developing countries where the disease is endemic because of the high cost, specialized infrastructure needs and handling difficulties. RDTs are relatively fast in malaria diagnosis and can be administered by unskilled personnel. However, their results were unreliable. Besides, commercially available RDT kits are specific to single species of plasmodium parasites and in cases where mixed infection is suspected, all the four kits should be used. This makes the technique relatively expensive. The gold standard method of malaria diagnosis is conventional microscopy. The limitation of this technique is that it is time taking and results obtained are difficult to reproduce.

II. ARTIFICIAL NEURAL NETWORKS (ANN)

In generalizations of mathematical models of biological nervous systems artificial neural networks (ANN) has been developed. In conditions where statistical properties of pattern class are not known, classification of a decision theoretic problem is best handled by methods that yield the required decision functions directly via training. Neural network is one such approach. It is made of inter-connections of nonlinear computing elements organized as networks reminiscent of the way neurons are believed to be interconnected in the brain. Basic processing elements of neural networks are called artificial neurons, or simply neurons or nodes.

In a simplified mathematical model of the neuron, the effects of the synapses are represented by connection weights that modulate the effect of the associated input signals, and the nonlinear characteristic exhibited by neurons is represented by a transfer function. The neuron impulse is then computed as the weighted sum of the input signals, transformed by the transfer function. By adjusting the weights in accordance the learning capability of an artificial neuron is achieved to the chosen learning algorithm. A typical artificial neuron and the modeling of a multi-layered neural network are illustrated in figure below.



Architecture of an artificial neuron and a multilayered neural network.

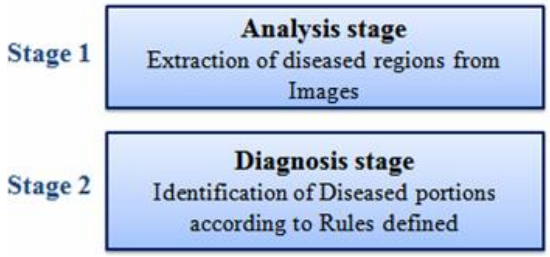
III. METHEDOLOGY

In this work the main emphasis is on the detection of malaria using image processing. For detecting malaria detection of erythrocyte parasites is very important. In thin blood smear images has been highlighted in the process model. Noise reduction was considered to reduce some undesirable effects in the images which often are acquired during the process of sample preparation and image acquisition such a non-uniform illumination, salt and pepper noise and image blurring. This operation served to remove spurious noise present in the images. The images were pre-processed by performing median filtering operation with a filter kernel of 5 by 5 to remove noise. The images were then spatially rescaled to a uniform size. Identification of infected erythrocytes was then done by a trained ANN using erythrocytes RGB feature as its input. This is due to the high correlation of parasite features in different stages and species. Based on this difficulty, neural network classifiers were considered to be the best tools for the job. This is because they would learn to distinguish different stages and species using examples of image features of these parasites used as training set.

IV. COMPUTER AIDED DIAGNOSIS (CAD)

Nowadays, in medical imaging CAD is one of the major research subject. By providing lot of information CAD helps doctors to understand medical images so that the accuracy and consistency of medical diagnosis could be ameliorated, and also the time taken in reading an image by traditional methods could be decreased. CAD algorithms are very essential for early detection of many diseases and also help radiotherapists in their medical decision-making operations. The CAD algorithm is provided with functions that automatically analyses data acquired and provides patient and tissue diagnosis automatically to identify the suspected regions from images. This algorithm consists of mainly two stages i.e ananalysis stage and a diagnosis stage.

1. In the analysis stage, diseased regions are extracted and examine the features of these regions with the help of image processing methods. In this a computer searches for features of disease.
2. In the diagnosis stage, diagnosis rules are determined according the extracted features, and the diseased portion are identified according to defined diagnosis rules. In this a computer evaluates identified features to differentiate between malignant and benign diseased part.



Basic Stages in CAD

ANN Segmentation of Erythrocytes

In this method, a multilayered neural network was trained to divide the image into two regions; erythrocytes region and the image background. To train the network two sets of feature vector were used. One set consist of RGB pixel values

and the other set consist of both RGB and HSI image pixel values. The features were categorized into two classes; erythrocytes and the background pixel values. To train the neural network a total of over 400 feature vectors were used, with 280 feature vectors belonging to the erythrocytes class and 192 feature vectors belonging to the background class.

Process Model

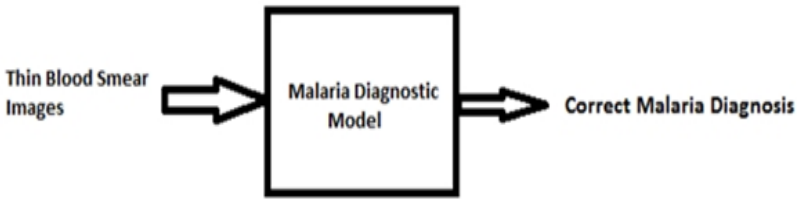


Figure of Malaria Detection

To detect whether you have malaria or not doctors use thick and thin blood smears. If the test is negative and no parasites are found, you will have repeated blood smears every 8 hours for a couple of days to confirm that there is no malaria infection.

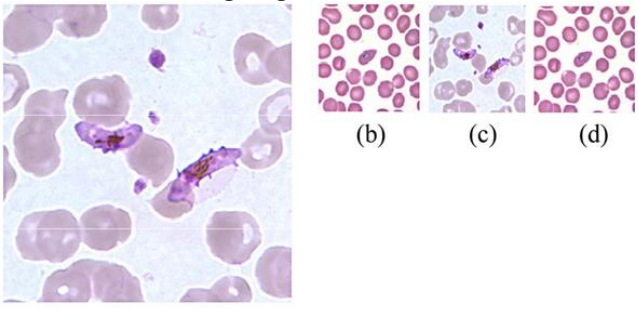
Mostly from a finger prick blood smears were taken. Thick and thin blood smears will let doctors know the percentage of red blood cells that are infected (parasite density) and what type of parasites are present.

A thick blood smear is a drop of blood on a glass slide. Thick blood smears are most useful for detecting the presence of parasites, because they examine a larger sample of blood. Thin blood smears help doctors to discover what species of malaria is causing the infection.To date, microscopic examination of thick and thin blood smears is the easiest and most reliable test for malaria.

V. RESULT

The normalization of two images from CDC and KEMRI before and after scaling is shown below. Figure (a) is an image from CDC whose size is 1600 by 1600 pixels while Figure (b) is an image captured from KEMRI blood samples. Figures (c) and (d) give the resultant images after image rescaling operation.

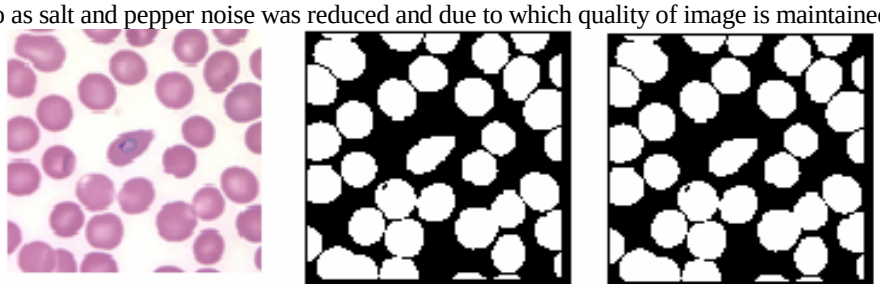
CDC image size reduced to 300 by 300 pixels after image rescaling and it is also needed to maintain its useful features such as erythrocytes, parasites and background regions which have been conserved. After rescaling there is no change in the KEMRI image size. Thus it is can be said that the image rescaling algorithm has produced the desired results of rescaling images from both KEMRI and CDC. For making the computation very fast at various stages of image processing image rescaling is very necessary i.e., feature extraction, image segmentation.



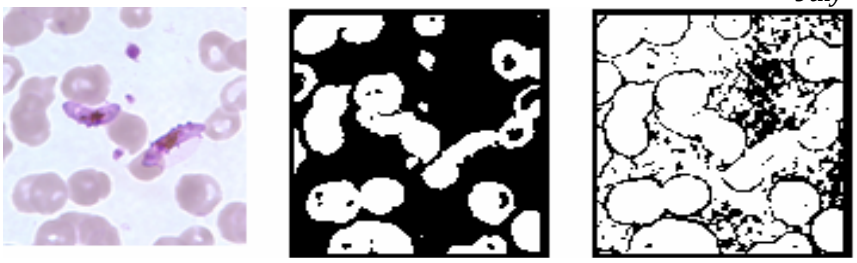
Results of image rescaling (a) CDC image (b) KEMRI image (c) and (d) rescaled CDC and KEMRI images respectively

Test Results for Noise Reduction

Figures (a) and (d) shows the rescaled KEMRI and CDC images respectively. Filtering is done using the median filter and before and after filtering erythrocytes of these images is segmented. For KEMRI image it can be seen from the results that the difference between two binary images is nothing, but for CDC image segmenting after the filtering the image is resulted to a notable improvement of the binary image quality. This is due to noise which means CDC images have been degraded by noise; which can be corrected by median filtering. Some of the possible sources of such noise include unbalanced illumination of the sample in the microscope, sample degradation or apoor sample preparation. By performing median filtering random noise also referred to as salt and pepper noise was reduced and due to which quality of image is maintained.



(a) (b) (c)



(d) (e) (f)

Effect of image filtering, (a) and (d) pre-processed KEMRI and CDC images, (b) and (e) binary images obtained from the pre-processed images, (c) and (f) binary images obtained from raw images from KEMRI and CDC respectively

VI. CONCLUSION

In this paper it is concluded that the green colour component of RGB image is the most suitable for segmentation when histogram segmentation techniques is used. This is because of the quantum efficiency of the camera being optimum at the green wavelength. Here the method of thresholding is applied.

Artificial Neural Network Algorithm provides the excellent results i.e above 90%. However, on comparing the network trained only with RGB features performed marginally better than the one trained with both RGB and HSI features. By this we come to a conclusion that the neural network classification accuracy decreases with the increasing number of features and sample size is held constant. It can be concluded that RGB features are adequate to distinguish erythrocytes from the rest of the thin blood smear image using an ANN.

From these images it can be observed that the ANN managed to capture the erythrocyte regions well in both CDC and KEMRI images.

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