Methods of Malaria Diagnosis using Image Processing

Damandeepkaur*, Navpreet Singh Samra** and Prof. Gurjotkaur***
* M.tech ECE 2nd Year, University Rollno.: 1508511, GNDEC, Ludhiana
** MS Electrical Engineering Student id: 107414981, California State University, Northridge
***Assistant Professor, GNDEC, Ludhiana

Abstract: Blood smear exploration is a required part for rapid concealing of malaria parasite. Basic detection of malaria by smear test is inexpensive and highly sensitive. For the testing of blood smear, human power and time can be minimized by using automated computational techniques. These techniques would ease such recognitions that are normally based on morphology and in various cases on detection of colours. In this review paper, we discuss a combined algorithm consisting of morphological operations and colour based pixel discrimination technique to detect malaria parasites from blood smear images of Plasmodium vivax. Using morphological operation partitioning of cells from blood smear image is done and colour based pixel discriminator differentiates malaria cells from segmented image. Mainly the examined method does not require any training set and assumes unattended methodology. It is presuming that the algorithm can enumerate malaria in dirty slides. This makes the algorithm more powerful and robust.

Keywords: Morphology, Blood smears, Plasmodium vivax.

Introduction

Malaria is a mosquito liable disease begins with the parasites of type plasmodium. The people get infected by malaria when malaria parasites are introduced into the circulatory system by infected female anopheles mosquito bites. According to World Health Organisation (WHO) malaria causes one million deaths per year and 250 million people are affected by this disease [1].Charles Louis Alphonse Laveran, a French army surgeon stationed in Constantine, Algeria, was the first who notices parasites in the blood of a patient suffering from malaria. For his discovery, he was awarded the Nobel Prize in 1907. The parasite undergoes a complicated life cycle, inside the human body. During this procedure parasites grows and reproduces themselves. The Red Blood Cells (RBCs) are used as hosts and are destroyed later. The ratio of parasite-infected cells to the total number of red blood cells called parasitaemia. Parasitaemia is used as a measure of infection severity and is an important factor in choosing the proper treatment and drug dosage [2]. Controllingof this disease is a major problem all over the world particularly in tropical areas and low income countries. It becomes the 5th cause of death from infectious diseases worldwide. The detection of malaria is also a challenging problem with less significance. There are four major species of malaria parasites which infects human body namely; Plasmodium falciparum, Plasmodium vivax, Plasmodium ovale and Plasmodium malariae [3].

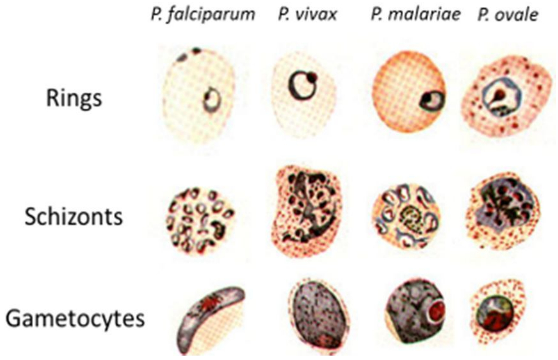


Fig. 1.1 Malaria Parasites Types

Plasmodium vivax is found mostly in tropical and subtropical areas and has a severe clinical manifestation [4].According to WHO, malaria can be detected usingparasite-based diagnostic testing (either microscopy or rapid diagnostic test) before the treatment [5]. In the malaria detection test, microscopy based diagnosis has the central importance for species identification, parasite measurement and management of this disease. This method is more widely used because of its scalability and low running cost.Two types of blood smears, thick and thin, are prepared from the sample blood of patient.The thick smear is used for detecting parasites whereas the thin blood smear is used for identifying malaria species. When the parasite load is low, malaria may be detected about 20 times more rapidly in thick smear than in thin smear [6].The methods based on which image analysis of blood smears have been fall into two classes namely, analysis based on morphology and analysis based on colour and the third method is the combination of the above methods i.e. Combined Algorithm Based Detection, all these methods are discussed in this paper.

Related Work

Arco et al. [1] in his paper stated that malaria is an infectious disease and causes serious health problems; half of the world's population, particularly in the developing countries are at risk of malaria. The diagnosis of the malaria is still performed manually especially in developing countries. The advantage of this microscopy is, it gives sensitive and specific results but the main disadvantage of this approach is that it requires extensive human intervention during the diagnosis process which lead to late and sometimes erroneous diagnosis. So, the microscopist requires extensive training to gain experience in the diagnosis, and because the large volume of samples that are analysed, the method is not consistent and is dependent upon blood smear and stain quality, microscope quality and the experienced microscopist. So, the technique digital image analysis is developed. In this the images were pre-processed first and then using morphological operations parasites were detected. The main aim of this method is to develop a digital method to achieve malaria parasites containing less number of errors in the blood films

Diaz and Romero [6] stated that the digital image analysis process improves the performance of parasite density quantification which decreases the time required for the parasite counting and avoids human errors. This technique was proposed for quantifying parasites in stained thin blood films. In this method the image was corrected from luminance differences and the RGB colour space is used for categorising pixels as erythrocyte or background. Then the classification process identifies infected erythrocytes, using a trained bank of classifiers.

Alexander and Drakely [7] gives the drawback of the digital image analysis process in their theory, that it needs user intervention, which consumes more time and large inter and intra-observer variabilities. In this method the limits of acceptable agreement are defined in a way which allows for the natural increase in variability with parasite density. This includes defining the levels of between-reader variability, which are consistent with random variation disagreements within these limits should not trigger additional readings. This approach merits investigation in other settings, in order to determine both the extent of its applicability, and appropriate numerical values for limits of agreement.

Makkapati and Rao [8] presented a scheme based on HSV colour space model. This method is based on detecting hue range and saturation threshold value. The eminent colour in this kind of image is representative of the background, so the hue range is divided into 360 degree in which each segment is of 60 degrees. These segments are used to find the number of pixels in a particular hue segment. Optimal saturation thresholds were identified by using the method proposed.

Guo, Vala and Yang [9-10-11] stated that the optimal saturation thresholding method is widely used in classic image segmentation applications which is based on selecting the discriminant criterion, so that the separability of the resulting classes in gray levels is maximized.

Khatri et al. [12] stated that the optimal saturation thresholding method was found to give an optimal threshold for bimodal distributions but did not work well for unimodal distributions. This method gives the unimodal distribution because most of the pixels belong to the background and only few pixels belong to the parasites which give the big and wide peaks of histogram. In further studies, granulometric estimation and morphological technique gives satisfying results.

Di Ruberto et al. [13] discussed a method which describes a morphological approach for segmenting the cells. This method gives more accurate results as compared to the classical watershed-based algorithm. In this method a hemispherical disk-shaped structuring element is used to enhance the roundness and the compactness of the red blood cells, while a disk-shaped flat structuring element was used to separate over-lapping cells. Regarding the classification step, two different methods were used, one based on morphological operator and another one based on colour histogram similarity. Despite the brilliant solutions presented by these approaches, these kinds of techniques were very sensitive to the image quality. Besides, the fact that it is necessary to analyse both the hue and the saturation images makes the process slow. They proposed an algorithm which focussed on low time consumption, obtained good results independently of the variability of the images.

Various Methods of Detecting Malaria

1. Detection using Morphological operations.
2. Using Colour Based Detection.
3. Combined Algorithm based detection

Microscopic Detection: This detection method is the traditional method. In this method blood specemen is collected from the affected person and the patient is spread on the thick or thin smears. These smears are stained using various staining agents. After that these blood smear are tested under highly advanced microscopes and using visual ability the parasites are detected and classified according to their types. Due to the simplicity of this method, it is considered as Gold standard. This microscopic detection method can detect densities as low as 5-10 parasites per µl of blood. But the main disadvantage of this method is that it is labour-intensive and time consuming, at least it requires 60 minutes from collecting samples to detection results. This method also depends upon good reagents, microscopes and well trained and well supervised technicians. But sometimes these conditions are often not met, particularly at more peripheral levels of health care systems. So the advanced techniques are proposed i.e. Digital image analysis detection.

Digital image analysis detection: In this detection method digital techniques are used i.e. image pre-processing, filtering, thresholding and morphological operations. In this method the images are pro-processed using various methods and soft computing algorithms. The main idea in this detection is firstly the digital images are pre-processed, followed by image filtering and thresholding morphological operations are performed. The main techniques used under this method are:

1. Digital detection using Morphological operations.
2. Colour based detection.
3. Combined Algorithm based detection.
4. Detection using Soft Computing Algorithms.

Detection using Morphological Operations: Current approaches for malaria parasite detection needs image acquisition from thick smear. All images were generated from thick blood smear slides of human blood. Each slide is stained and examined under light microscope with 10X100 magnifications by expert. There is no loss of parasite during staining in thick blood smear; artefacts and parasites are observed in their natural location.

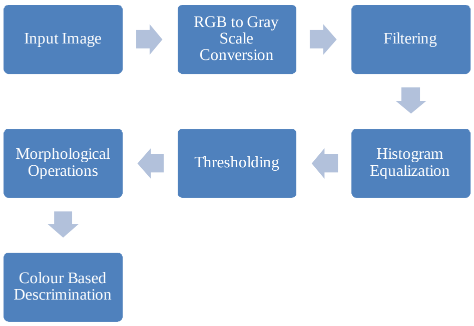


Fig. 3.1.1 Image Processing Steps

Firstly, the input images were converted into gray level image. After the gray scaling, filtering is done on the output image. The filtering is done using Gausian filter, which smoothen the image, removes image noise and reduce detail. By using Adaptive histogram equalization technique the dynamic range of the histogram of filtered image is enhanced. After the pre-processing process thresholding is done on the particular image. In this stage, Adaptivethresholding [2] method is used. On this stage, for each pixel in the image, a threshold has to be calculated. If the pixel value is below the threshold it is set to the background value, otherwise it assumes the foreground value.After the image thresholding the morphological operations are done on the output. Morphological operation closing [2] is performed on the resultant binary image. In closing at first dilation and then erosion is performed, in which all elements of the matrix is 1. Next, from the gray scale image, most of unwanted components are removedwhich are based on area of the components. After removing the unwanted components, mask is produced. The holes filling brings the intensity values of dark areas that are surrounded by lighter area up to the same intensity level as surrounding pixels.

Colour based detection: In this method, the first step is image pre-processing. Here the image pre-processing is done using various colour models like RGB(Red, Green, Blue), HSV (Hue, Saturation, Value), etc. In this HSV [9] (Hue, Saturation, Value) is a colour space Model is used. These models give the knowledge about the colours perceived by human eyes.The HSV colour space model describes colours (hue or tint) in terms of their shade (saturation or amount of grey) and their brightness value. Hue is an attribute by which humans recognize the colours like Red, Green, Blue, Yellow, Magenta, and Cyan or Purple etc. Hue is expressed as a number from 0 to 360 degrees representing hues of red (which start at 0), yellow (starting at 60), green (starting at 120), cyan (starting at 180), blue (starting at 240) and magenta (starting at 300). Saturation is the amount of grey level from 0% to 100% in the colour and value gives the knowledge about brightness of any image.This colour model is represented by cone and the value of cone varies from 0 to 1 on vertical axis. In this step firstly the RGB coloured image is collected and ten these images were converted from RGB to HSV colour model.From the HSV colour space image S (Saturation) components are extracted. After that the histogram is obtained and thenthe standard deviation of the image is calculated in S value and storing the value in TS. The threshold intensity value is calculated as a product of standard deviation with the predefined constant value H.The threshold intensity value is added with an offset value obtained through rigorous experimentation and fixed to a value of 0.25. The sum of this value with obtained dynamic thresholding value is used in this procedure to get the binary image. After that the segmentation is done on the output image and then Morphological closing and holes filling are done. All the obtained contour shapes are filled with pseudo colours.

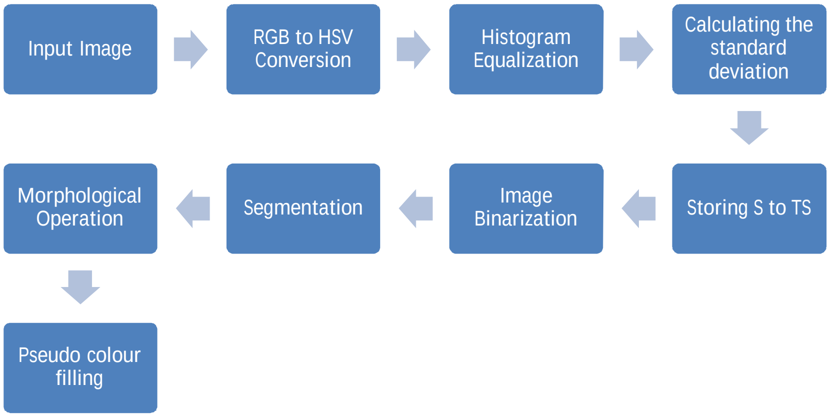


Fig. 3.2.1 Block Diagram of Colour based Detection

Combined algorithm based detection: In this approach the above two methods are combined. Here firstly input images are converted into grey scale. After that DIS (Difference in Strength) for each pixel is calculated and after this procedure the DIS image is obtained. More the DIS value, more pixels are located at the edge. In next step image binarization is done using Adaptivethresholding and morphological closing is done using 3x3 square matrix. Using morphological closing, first screening is done using the Euler number function. With the help of these steps the background is washed and it will generate the ROI (Region of Interest).On the back ground image, the colour based screening technique is used. Before doing this the image is converted into HSV plane.The malaria parasites are detected using HUE value from the processed image. Again the Euler number is extracted from the intermediate image. The block diagram of this method is described below:

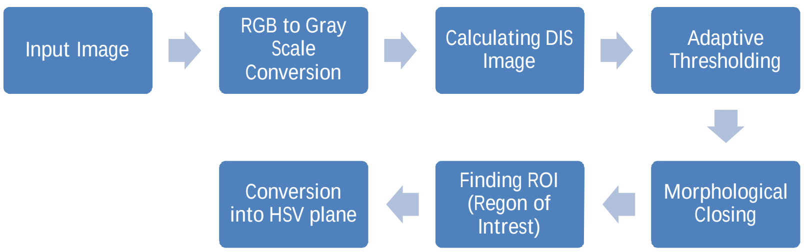
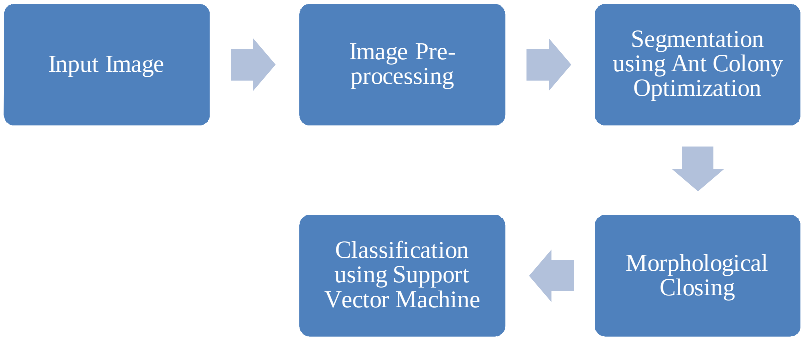


Fig. 3.3.1 Block Diagram of Combined Algorithm Based Detection

Detection using Soft Computing Algorithms: In this method various soft computing algorithms are used like Genetic Algorithm, Neural Networks and various optimization techniques are also used. These algorithms are used for classification and segmentation and morphological operations. In soft computing two different categories of algorithms are used i.e. classification and in the second type out of many outputs the best output or the optimized result is considered. In this paper

Ant Colony optimization is used for segmentation and Support Vector Machine is used for classification. The block diagram of this method is shown below:



Conclusion

For classifying the malaria affected cells and the healthy cells True Positive (TP), True Negative (TN), False Positive (FP) and False Negative (FN) methods are used. From these parameters the True Positive Rate (TPR) and False Positive Rate (FPR) is calculated. It is very interesting that when the binarization technique, Morphological operations and colour based discrimination methods are combined the percentage of malaria detection is improved. So the combined algorithm gives the satisfactory results as compares to the individual algorithm because this method gives the larger value of FPR. One more importance of combined algorithm is that, this algorithm give more accurate results even the blood smear slides are not very clean.

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