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Portable Malaria Rapid Diagnostic Device

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Abstract

Malaria is a life threatening disease caused by protozoan parasites of the genus Plasmodium. As it poses a serious global health problem, the project proposes to develop a device to detect malaria parasite accurately with the hope of reducing death rate due to malaria. In this device, a digital microscope camera is used to obtain color images from giemsa stained blood films. Digital image processing techniques are applied to these images to detect malarial parasites. Processing of the image is done on a Raspberry pi platform. The aim of the project is to create a fully portable and automated device that can be used with minimum training to detect malarial infection with a high degree of accuracy. The proposed malaria diagnostic device will be helpful when lab technicians who are trained in microscopic analysis of blood samples are not available. It will also limit human error in the detection of the presence of parasites in the blood sample. Automated diagnostic techniques can also notably decrease the time needed for diagnosis of the disease. This device will result in early onset of treatment saving many lives.
Keyword- Malaria, Raspberry Pi, Digital Image Processing

I. INTRODUCTION

Malaria is a life threatening disease caused by protozoan parasites of the genus Plasmodium, transmitted via female Anopheles mosquito. During the life cycle of the parasite, the red blood cell (RBCs) are used as hosts and destroyed afterwards. World Health Organization estimates that in 2015 (http://www.who.int/en/), 212 million clinical cases of malaria occurred, and 429,000 people died of malaria, most of them children in Africa. According to WHO, the disease acts as a dampener on national economies and as many countries with malaria are already among the poorer nations it is difficult for them to break the vicious cycle of disease and poverty. Re-emergence of malaria in various eradicated regions in Kerala has been reported and its mainly due to the impact of immigrants from malaria-endemic regions.

Kerala State Health Department has launched a Malaria Prevention Campaign which aims to make Kerala malaria free by 2020. The Central government based on a call by WHO has made a National Strategic Plan for malaria eradication in India by 2030[1]. Malaria is caused by mainly four types of plasmodium species called Plasmodium falciparum, Plasmodium vivax, Plasmodium ovule, Plasmodium malaria. Among these Plasmodium falciparum causes most of the reported malaria cases. After collecting blood samples, diagnosis of malaria infection is done by searching for parasites in blood slides through a microscope by experts. Recognition and detection of parasite in blood sample is facilitated by applying a chemical process called (Giemsa) staining. This process slightly colors the red blood cell (RBC) and plasmodium parasites. This project proposes to develop a fully portable and automated device to detect malaria parasite accurately, eliminating human error and the need for trained technicians.

II. LITERATURE REVIEW

A. Malaria

Malaria is a mosquito borne disease which is widely spread all over the world. It is one of the predominant tropical Vector borne diseases in the world causing wide spread suffering and number of deaths in the developing countries like India. The World Health Organization (WHO) estimates 300-500 million malaria infected cases and more than one million deaths per year [1]. Malaria statistics report given by National Vector Borne Disease Control Program (NVDCP), Directorate General of Health Services, Ministry of Health and Family Welfare, Delhi, for the year 2013 presents that around 9 lakh people from India are the victims of malaria in the year 2013. It occurs due to the infected female Anopheles mosquito. Female Anopheles mosquito is the only species of mosquito in which the malarial parasites can survive, it is called as host.

B. Existing Method

1) Rapid Diagnostic Tests - Detection of Parasite Antigens.

Rapid diagnostic tests (RDTs) are a type of point-of-care diagnostic, meaning that these assays are intended to provide diagnostic results conveniently and immediately to the patient while still at the health facility, screening site, or other health care provider. Receiving diagnosis at an early stage reduces the need for multiple visits to receive diagnostic results, thus improving specificity of diagnosis and the chances the patient will receive treatment, reducing dependence on presumptuous treatment, and reducing the

risk that the patient will get sicker before a correct diagnosis is made. Rapid tests are used in a variety of point-of care-settings - from homes to primary care clinics or emergency rooms - and many require little to no laboratory equipment or medical training [2].

– Can be done in the field with minimum training
– False positives – persistence of antigens for some time even after successful treatment
– False negatives – Mutation of parasites - deletions in the genes encoding the proteins tested using RDTs
– Requires arrangement for storage of test kits

2) Malaria Microscopy- Visual Identification of Parasite.

The microscopic tests involve staining the blood sample and direct visualization of the parasite under the microscope. For over a long period of time, the direct microscopic visualization of the parasite on the thick and/or thin blood smears has been the accepted method for the diagnosis of malaria in most places, from the clinical laboratory to the field surveys. The careful examination of a well-prepared and well-stained blood film presently remains the "gold standard" for malaria diagnosis. The most commonly used microscopic tests include the peripheral smear study and the Quantitative Buffy Coat (QBC) test [3].

– Reliable technique
– Can also be used to determine the severity of the infection
– Requires a lab and trained technicians
– Time consuming, prone to human error

III. METHODOLOGY

The objectives of our device can be summarized as:

1) To develop a portable device for rapid diagnosis of malaria that can be used even in remote areas
2) To minimize the occurrence of false positives and false negatives in diagnosis for effective treatment
3) To reduce the quantum of training required for using the device
4) To remove the need for a technician to visually inspect blood smears to identify the malaria parasite reducing strain and improving accuracy

The image is processed using two segmentation techniques - HSV segmentation and watershed segmentation. The two methods are applied separately so that HSV segmentation detects parasites that were not detected by watershed segmentation and vice versa. The proposed system combines the results of both segmentations so that the count of almost all malaria parasites in a blood smear is obtained, making the output more accurate [4]. The flow chart in Fig. 1 depicts the image processing steps used.

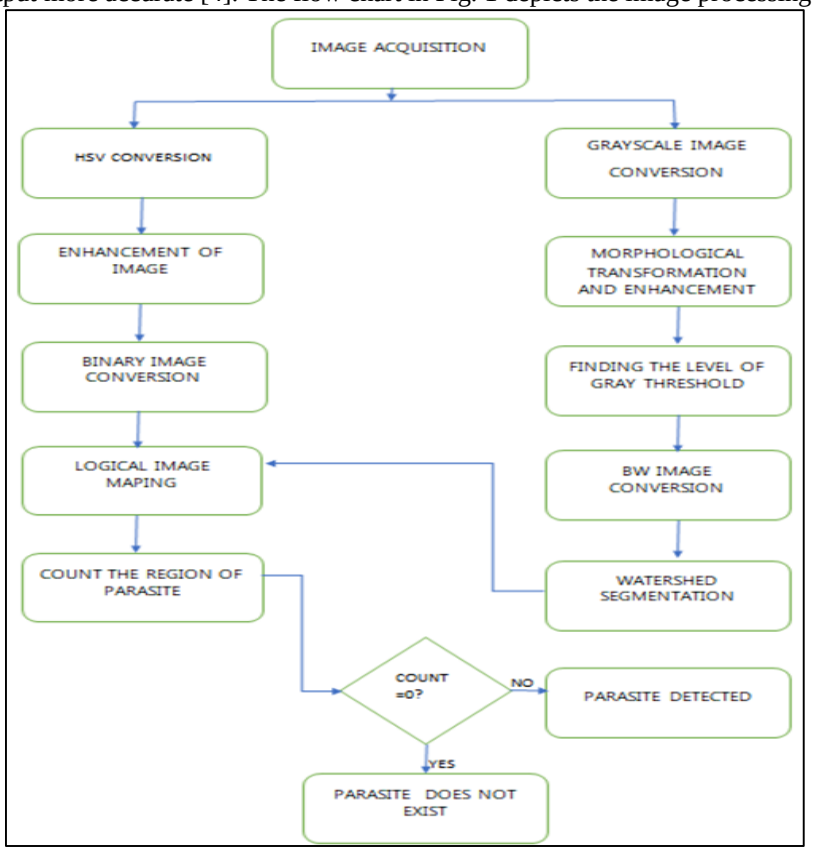

Fig. 1: Flow Chart –Image Processing Steps

A. Image Acquisition

The images are acquired using a compound microscope, by removing the eyepiece and positioning a raspberry pi cam to capture digital images (Fig. 2). This reduces the cost of the image acquisition section of the device.

Fig. 2: Compound Microscope

B. Image Segmentation

For detecting the parasite two segmentation procedures - HSV Segmentation and Watershed segmentation, have been combined. The procedure is described below:

1) HSV Segmentation

HSV stands for Hue, Saturation and Value. By this segmentation method we can calculate the parasite hue, saturation and value component and using this, the parasite position in RBC can be identified. This procedure is divided into several steps which are described below.

a) Converting the image into HSV format and calculate the indices of the parasite:

First we convert the image into HSV format. Then the hue, saturation and the value are calculated. For the malaria parasite, the hue components lie between 0.3 and 0.9 and the value components are less than 0.8. This value is calculated from the RGB value of the parasite and using the blue pixels. The original and HSV images are presented in figures 3 and 4.

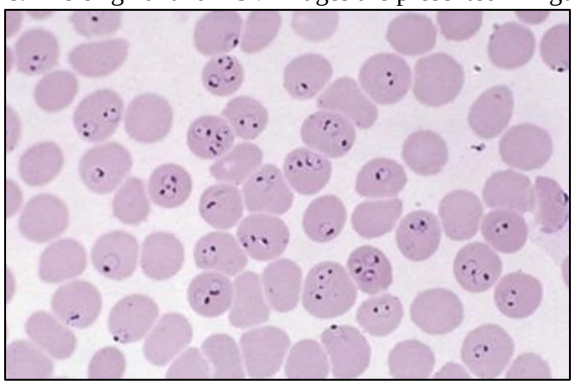

Fig. 3: RGB image

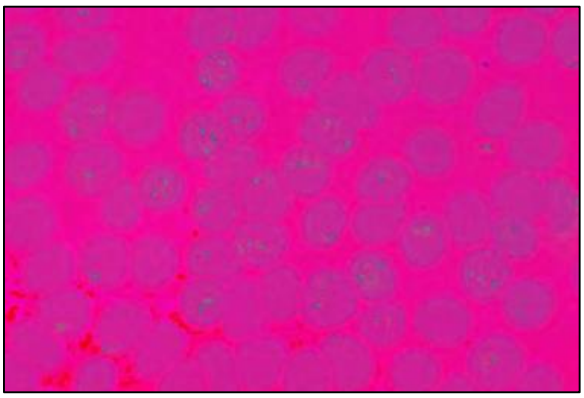

Fig. 4: HSV image

b) Binary Image Conversion

Fig. 5: Binary Image

The HSV image is then converted into a binary image. As a result, the parasite positions in the RBC are identified. The binary image is shown in fig. 5. It is seen that the regions of interest - the parasites are white which is used in the next step.

2) Watershed Segmentation

Using HSV segmentation, all the parasites cannot be detected because of possible color distortions in the input image. So another segmentation procedure - watershed segmentation is applied, for the detection of the parasite which may have missed detection in the previous segmentation procedure. Before applying this segmentation, some pre-processing steps are applied which are described below with the explanation of watershed segmentation.

a) Grayscale Conversion

The RGB image is converted into grayscale image and the contrast of the grayscale image is enhanced using local histogram equalization to enhance the visibility of the parasite in the image. The grayscale image is given in fig. 6.

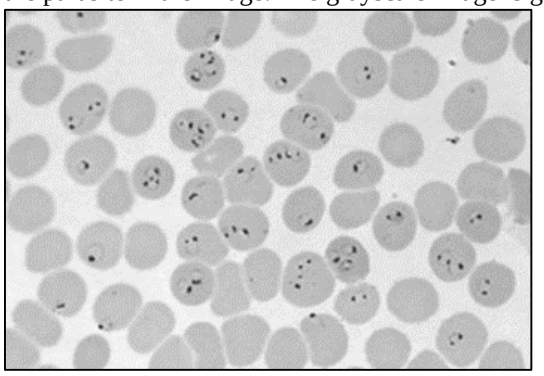

Fig. 6: Grayscale image

b) Morphological Transformation

After converting into grayscale image, morphological transformation is applied on the grayscale image. Morphological erosion method is used. The purpose of morphological transformation is to remove the noise from the image which is lesser than the structuring element. Erosion highlights the parasite in the blood sample. The resultant image after applying morphological transformation is shown in fig. 7.

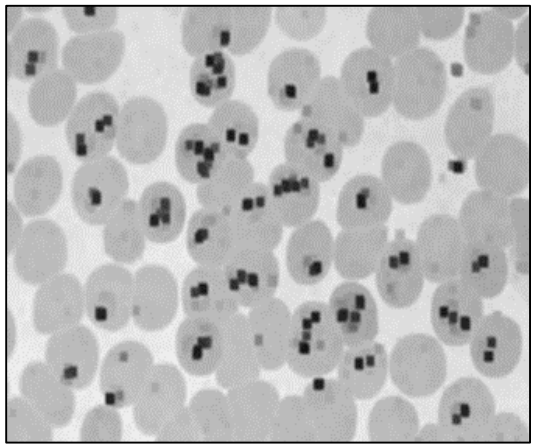

Fig. 7: Morphological transformation

c) Converting into black & white image

The level of gray threshold is determined and using this gray threshold value the system converts the image into black and white image.

d) Watershed Segmentation

The watershed transformation treats the image it operates upon as a topographic map, with the brightness of each point representing its height, and finds the lines that run along the tops of ridges.

C. Parasite Detection

To detect the parasite, the system converts HSV and watershed segmented images into logical images. The white pixels of the logical image mean that parasites exist in the acquired image. If the number of white pixels identified is not zero, then parasites have been detected. If this property is zero it means the RBCs in the smear are not infected by the malaria parasite.

D. Hardware

The aim is to develop a portable device for rapid diagnosis of malaria even in remote areas. The hardware used are a microscope and digital camera with magnification range 40x to 1000x and a resolution of 8 megapixel, to obtain an image which will be given to Raspberry pi 3 B+ development board in which Opencv image processing software is installed. The output is displayed on a led display (Fig. 8).

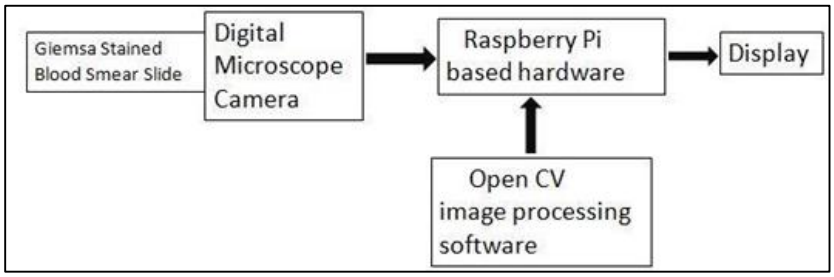

Fig. 8: Basic block diagram

IV. RESULTS

The PMRDD implementation was tested with a set of 30 images of blood infected with the malaria - malaria positive and 30 uninfected blood smears (malaria negative) the result is presented in the table 1. The incorrect results are due to differences in the lighting conditions used to obtain the various images [5]. The proposed device will ensure that the lighting of the blood smear will be controlled within the device.

BLOOD SAMPLE/ DATA	Malaria positive	Malaria negative
TOTAL NO: OF IMAGES	30	30
IMAGES WITH CORRECT RESULT	28	29
Accuracy of result	93.33%	96.67%
Accuracy of the device	95%	

Table 1: PMRDD - Implementation Results

V. CONCLUSION

The existing methods of malaria parasite detection have disadvantages such as time consumption, false negative and false positive results, and requirement of laboratory facilities and trained technicians. A portable, automated device that overcomes these problems to detect the presence of malaria parasite in blood sample using image processing is developed. The results of testing of the device shows that with proper control of lighting, the accuracy of the device will be optimum. This device can be further extended for diagnosis of other hematological disorders like leukemia, sickle- cell anemia and filariasis. The proposed device can also be provided with a solar cell, which can be used to charge the device battery.

ACKNOWLEDGMENT

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