A HEURISTIC METHOD FOR MALARIA DETECTION

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ABSTRACT

We have developed a new computer-aided diagnosis system for automated detection of malaria parasites in digital microscopic images. Our work is based on heuristic programming of two stages of processing being applied to the raw images. The first stage consists in searching color value for each pixel in the image. The second step concerns with comparing the pixels values determined in the first stage. Our method was applied to microscopic acquired digital images from real situations. The results, which we obtained, show that our method is effective for malaria parasites detection.

Key words: medical image diagnosis, malaria detection, feature extraction, heuristic programming.

1. INTRODUCTION

Medical image processing is an active and interested area in computer vision paradigm. This field presents a wide area of applications including diagnosis activities such as chest X-ray, cancer detection, melanoma detection, blood disease detection and other medical images that occur in radiology, nuclear magnetic resonance (NMR), ultrasonic scanning and computer tomography. Surgical treatment planning and thereby control are further applications [1]. Digital image processing should support medical personnel by detecting, identifying, and selecting relevant information and editing these visually.

The benefit utilizing image processing in the medical applications depends on many factors such as cost, speed, accuracy, data storage and retrieve, etc… The design aim is to provide high quality and rapid operation at a low cost. Using existing hardware and software reduce the cost significantly and increase the performance. In the field of medical diagnostic using image processing many methods, algorithms and systems have been developed.

In attempt to participate in this field, we developed an approach for malaria disease detection using heuristic programming for color classification.

This paper is organized in five sections. Section 2 presents the motivations of our work and objectives. Section 3 discusses our proposed method for malaria detection. In section 4, the results of applying the proposed method are presented. Section 5 summarizes our work and future work.

2. MOTIVATIONS AND OBJECTIVES

Several motivations make us do this type of research. These motivations are the following:

1. Widespread and seriousness: According to the RBM reports [2], today around 40% of the world's population, mostly those living in the poorest counties, is at risk of malaria. It is spread throughout the tropical and sub-tropical regions of the world and causes more than 300 million acute illnesses and at least one million deaths annually. Malaria kills an African child every 30 seconds.

2. Diagnosis difficulties: Malaria laboratory diagnosis becomes a hard task particularly in its final stages where microscopic specialists make efforts to specify disease stage parasite morphology. In addition, laboratory diagnosis is time consuming; the classical microscopic approaches such

as thick and thin films tests require between up to 60 minutes from collecting, preparing and specifying the parasite type [2].

3. According to our interview with some physicians in Yemen [3], it is common that some diagnoses are not specific where microscopic tests are not accurate due to non-specific malaria symptoms either from clinical or laboratory diagnosis.

As we know, computer is a useful tool in many applications particularly in clinical and technical medical activities. So, it is reasonable to use computer advantages such as speed and accuracy to make malaria diagnosis. Our work objectives are the following:

1. The main objective is to implement an automatic system being capable to detect malaria disease and to specify its stages.
2. The system can allow a satisfactory diagnosis with rapid and accurate results.
3. The system will be a useful tool facilitating for specialists malaria microscopic diagnosis.

3. MALARIA DETECTION

This section deals with malaria detection using image processing algorithms. The section starts by describing the features that help to detect infected blood cells. Then, it gives a description of the method used to detect those infected cells.

3.1. Feature extraction

The main characteristics of malaria parasites can be known according to the malaria type test. Two types of tests can be applied for malaria detection and identification. The first one is called thin film test and from which malaria can be detected and identified. The second one is called thick film test and used only for malaria detection.

By diagnosing blood cells infected by malaria, several features can be observed. Figure 1 shows two images of a thin film test and one image of a thick film tests. From the first two images, we can distinguish the infected cells from those that are not infected and the malaria type can also be identified.

In image (a) salient features of infected cells are numerous fine ring forms, double chromatin dots, marginal forms , red cells' size is not changed. From these features, the malaria type can also be identified. According to the characteristics of four malaria species [4], this type is called P. falciparum. In image (b), we can extract the following characteristics : developing and thick (signet) ring forms and red cells's size is enlarged, so this type is called P. Vivax. [4]. From image (c) malaria type can only be detected.

From computer vision and digital image processing perspective, three main features ; color, form and size characterize malaria parasites. In addition, each type of malaria and its stage can be identified using these features. These characteristics can be used to detect and identify using computer facilities. While color is used to detect malaria, form and size are useful to identify malaria type and stage. In our present work we only try to detect malaria infection using color as token. As known diagnostically, the infected cells appear with dark blue color, so the proposed method is based in this feature for only malaria detection in both types of tests; thick and thin.

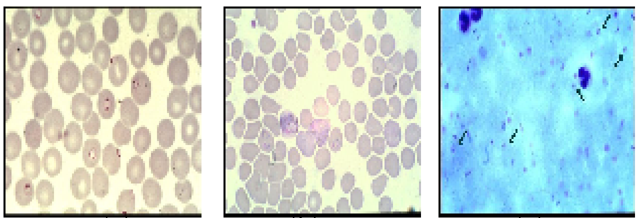

(a) (b) (c)

Figure 1: images of microscopic streams. (a) and (b) are thin film images of *P. falciparum* and *P. Vivax* malaria respectively, (c) is thin film image [5].

3.2. Detection method

In order to detect malaria parasites, we adopted a heuristic-based search. The heuristic methods are widely used in artificial intelligent applications such as decision support systems and intelligent systems [6]. Also, heuristic search (programming) is used in image enhancement and segmentation [7]. In our work, the heuristic process consists of two steps:

First step: this steps is based on determining the pixel value for each color from the three essential color; red, green, and blue. After several searches, we noticed that the blue color takes the largest value followed by red and green in the infected cells. Also, we found that the blue color has a percentage between 35-40 in the infected cells. So, in our algorithm we fix this percentage to 37.

Second step: in this step, we read the values of the three basic colors for several pixels in the same time and compare them according to the following condition: the largest value is for the blue should be in the range determined in the first step.

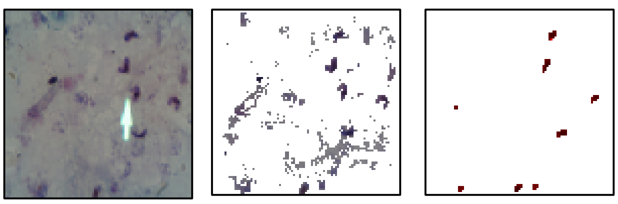
The results of applying the proposed method and its evaluation are presented in the next section.

4. RESULTS AND DISCUSSION

The proposed method is applied to several images for both thick and thin tests as indicated in the figures given bellow. Part (a) of figures 2 and 3 shows a raw image for a thick film. The results of the processing of both steps are given in parts (b) and (c). Similarly, part (a) of figures 4 and 5 shows the raw images of the two types of malaria for a thin film and the results are given in parts (b) and (c). We can notice that the result of these tests is positive where the algorithm detects the infected cells.

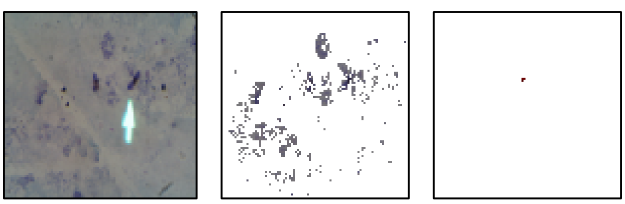
In order to evaluate the performance of our method we apply it to some uninfected images. Figure 6 and 7 show the result of testing uninfected blood cells. In these figures, the result is satisfactory where the system indicated that the cell in not infected, i.e. negative test. However, in some cases, the system indicated that the result is positive while the cell is not infected as indicted in figure 8. In fact, these erroneous results can be caused due to the following:

1- density of chemical added substances or,
2- white blood cells,
3- other impurities which carry the same color as malaria parasites.



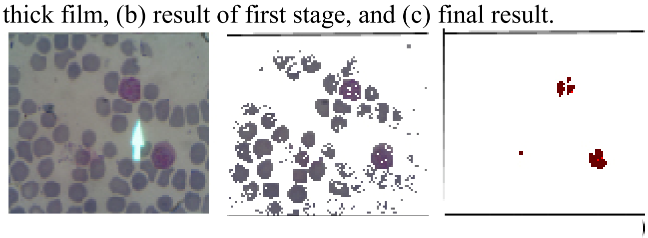
(a) (b) (c)

Figure 2 : Positive malaria test . (a) original image of a thick film, (b) result of first stage, and (c) final result.



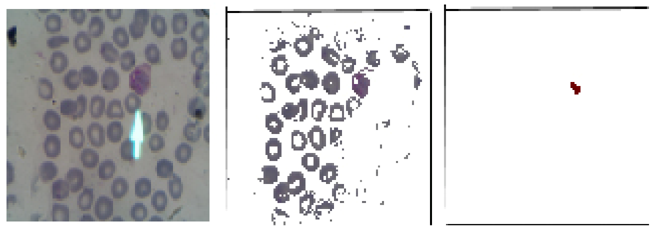
(a) (b) (c)

Figure 3 : Positive malaria test. (a) original image of a thick film, (b) result of first stage, and (c) final result.



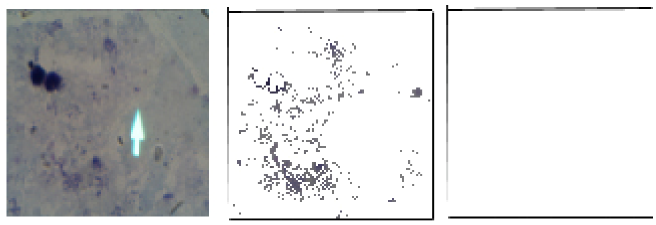
(a) (b) (c)

Figure 4 : Positive test. (a) original image of a thin film, (b) result of first stage, and (c) final result.



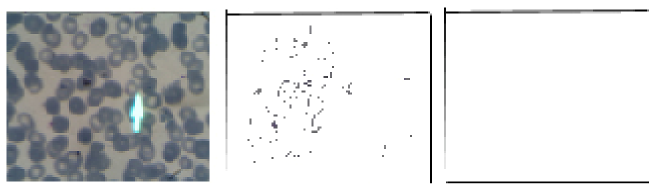
(a) (b) (c)

Figure 5: Positive malaria test. (a) original image of a thin film, (b) result of first stage, and (c) final result.



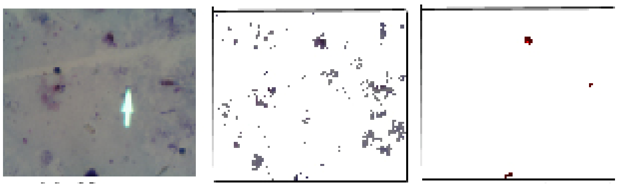
(a) (b) (c)

Figure 6: Uninfected cell. (a) original image of a thick film, (b) result of first stage, and (c) final result.



(a) (b) (c)

Figure 7: Uninfected cell. (a) original image of a thin film, (b) result of first stage, and (c) final result.



(a) (b) (c)

Figure 8 : Uninfected cell. (a) original image of a thick film, (b) result of first stage, and (c) final result.

5. CONCLUSIONS AND FUTURE WORKS

The diagnostic analysis is a prompt area for image processing application. With the proposed system we achieved the possibility of malaria detection using heuristic approach. The results obtained by applying our method encourage us to continue our research to implement a complete and robust system for detecting and identifying malaria disease, its types, and parasite stage.

At present, we work to improve the performance of our system by implementing a mathematical model. To achieve our objectives, the future work will deal with the analysis of malaria parasites using other characteristics such as size or form. Also, We will try to implement an integrated hardware system permitting the processes of image acquisition, processing, analysis and recognition.

6. REFERENCES

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