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Computer Automation for Malaria Parasite Detection Using Linear Programming

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ABSTRACT: In this project, we introduce a new approach to represent a mathematical modeling technique by means of linear programming as an efficient tool to solve problems related to medical imaging problems related to Malaria Diagnosis through Microscopy Imaging problems.
Two applications are approached:
(1) Formulation of a linear programming model based on the given data,
(2) Solving and displaying the result using graphical method approach for detecting parasite.

The application mainly consists of developing a linear mathematical model from the collected information and in addition to it, the problem is solved by Graphical approach. By this we mark the region infected with malaria from the original image which leads to identifying parasite. By observation of graph it can be predict whether the blood is infected by parasite or not. The species of parasite infected the erythrocytes can also be classified and parasite can be identified by labeling the infected area.

Keywords: Image Processing, Microscopic Imaging, Malaria Blood Images, Red Blood Cells.

I. INTRODUCTION

Malaria is a mosquito-borne infectious disease of humans and other animals caused by protists of the genus *Plasmodium*. Malaria is a serious infectious disease. According to the World Health Organization (WHO), it causes more than 1 million deaths arising from approximately 300– 500 million infections every year [1]. Despite of newer techniques, manual microscopy for the examination of blood smears is the most common scenario for malaria diagnosis. Diagnosis using a microscope requires special training and considerable expertise. It has been shown in several field studies that manual microscopy is not a reliable screening method when performed by non experts due to lack of training especially in the rural areas where malaria is endemic. This method adds a drawback of delays too.

An automated system aims at performing this task without human intervention and to provide an objective, reliable, and efficient tool to do so. But this work had done by other authors [2].

Microscopy diagnosis of malaria parasites is performed by manual visual examination of blood smears [10]. The whole process requires an ability to differentiate between non parasitic clean stained components (e.g. red blood cells, white blood cells, platelets etc.,) and the malarial parasites using visual information. If the blood sample is diagnosed as positive (i.e. parasites present) an additional capability of differentiating species and life-stages of that species in blood (i.e. identification) is required to specify the infection. On light microscopic examination of the blood film the Morphological stage of the parasites can be reported (Fig.1.1).

In order to perform diagnosis on peripheral blood samples, the system must be capable of differentiating between parasitic and healthy blood components. The majority of existing malaria-related image analysis studies doesn't address these requirements. Study of malaria parasite, its species and life-cycle stages plays an important role in designing of the system. It is provided in the next section.

(a) (b)

Figure 1.1: examples of infected red blood cells with distinct shapes

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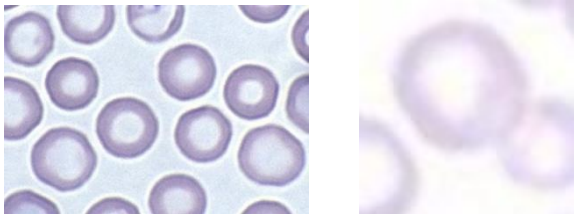

(a) (b)

Figure 1.2: Non-infected malaria blood through microscope imaging

A. Malaria Parasite

The vast majority of deaths are caused by *P. falciparum* and *P. vivax*, while *P. ovale*, and *P. malariae* (where p. stands for *Plasmodium*.) cause a generally milder form of malaria that is rarely fatal. These are the four main types of parasites. The zoonotic species *P. knowlesi*, prevalent in Southeast Asia, causes malaria in macaques.

The WHO practical microscopy guide [7] for malaria provides detailed procedures for laboratory practitioners. Diagnosis initially requires determining the presence/absence of malarial parasites in the examined specimen. Then, if parasites are present two more tasks must be performed: identification of the species, life-cycle stages causing the infection and calculation of the degree of infection. However, these tasks are not necessarily performed separately.

A specimen for manual microscopy diagnosis can be prepared (on a glass slide) in two different forms: first one is a *thick blood film (*figure 2) enables examination of a larger volume of blood, hence it is more sensitive to detect parasites. However, the thick film preparation process destroys RBCs and thus makes identification of species difficult.

Figure 2: examples of Giemsa-stained (a) thin and (b) thick blood film smear images, (c) a concentrated (thick) field of a thin blood film smear [5]

B. Problem Definition

1. Representation of mathematical modeling technique by linear programming to solve problems related to Malaria Diagnosis through Microscopy Imaging problems.
2. The project will hence include identification, detection and classification of parasites in the input image using the designed model.
3. By this, the project will mainly focus at minimizing the size of the software system designed.

C. Problem Output

The system is supposed to offer output in the form of affected image with region marked in it. The clean blood smear will thus not result in any such marked region. Another form of output the system gives is the graphical one. In this, the co-ordinates found to be infected are displayed in the graph using X-Y axes, a horizontal line representing clean blood.

II. METHODS

A. Describing linear programming methods

Linear Programming (LP or linear optimization) is a mathematical method for determining a way to achieve the best outcome (such as maximum profit or lowest cost) in a given mathematical model for some list of requirements represented as linear relationships.

Maximize $c^T X$
Subject to Ax <= B
and x > 0

Where, **x** represents the vector of variables (to be determined), **c** and **b** are vectors of (known) coefficients, *A* is a (known) matrix of coefficients, and $(\cdot)^{\mathbf{T}}$ is the matrix transpose. The expression to be maximized or minimized is called the *objective function* ($\mathbf{c}^T\mathbf{x}$ in this case). The inequalities $A\mathbf{x} \leq \mathbf{b}$ are the constraints which specify a convex polytope over which the objective function is to be optimized. [9]. We have referred a model (fig.3) composed of an objective function, restrictions, decision-making variables and parameters [8] and mapped our new model on this.

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Eg.

$a_1h_1 + b_1s_1 >= 80$ ..say
$a_2h_2 + b_2s_2 < 80$ ..say

Here, h= totalH / block
s= totalS / block
a,b= % of h,s ie. 100/(size of block)

The objective function:

$A_1H_1 + A_2H_2 >= X$ ----------(1)

It is subject to restrictions:

a1 h1+ b1s2 = A ----------(2)
a2h1 +b2s2 = B ----------(3)
a3 h1+b3s2 = C ----------(4)
a4s1 +b4s4 = D ----------(5)

With:

$h_i, s_i \geq 0$ (i = 1,2) ----------(6)

Where:

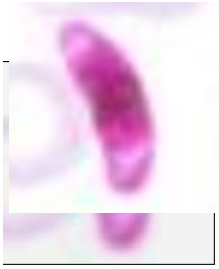
(1) The objective function for the problem (X) in linear programming, this function must be linear.

III. FRAMEWORK

Diagram below shows the block schematic of the proposed system. The steps performed from image acquisition to graph generation include all such modules shown here. Image processing required might include Blurring, RGB-to-HSV conversion etc. The linear model can be then designed using these HSV values.

IV. EXPERIMENTAL RESULTS

ORIGINAL IMAGE



OBJECT DETECTION

The figure 4 shows that the original image along with parasite detection image and infected region is labeled. So we can say that directly the person infected with malaria.

The microscopic image in fig.5 depicts the image not infected with malaria so there is no line vertically in X-axis and no region is labeled because there is no infected region.

ORIGINAL IMAGE

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GRAPHICAL RESULT

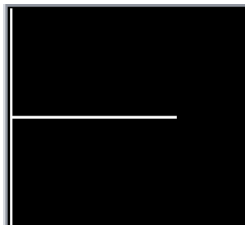

Figure 5

If we find some of red blood cells infected with parasite and some of the blood cells not infected with parasite then the resultant graph by using this method is shown in figure 6. In this case we say that the blood is infected with malaria. Also we can see the labeling of infected region as shown in figure 6.

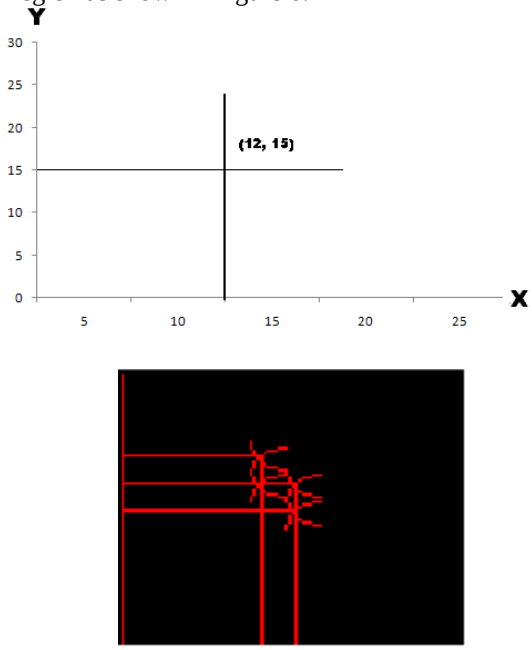

Figure 6

IV. CONCLUSION

In this article we have considered parasite images to be bigger and clearer enough. The block of image where we find infected parasite are marked to make them noticeable; when compared with region not infected with malaria parasite. In addition, the difference between the infected and non-infected different parasite species results is emphasized. The complete automation techniques are designed to reduce the size of the system.

V. DISCUSSION

Throughout this paper we have consider all species of parasite as different entities to make the classification process simpler to understand and develop.

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