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Review on CAD based System for Detection of Disease through Medical Image Processing

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Abstract:

In tropical and subtropical countries malaria is the leading cause of morbidity and mortality. It is observed that use of conventional microscopy in the diagnosis of disease has occasionally proved inefficient because it is time consuming and results are difficult to reproduce .Alternative diagnosis techniques which gives superior results are quite expensive and are not in the reach of developing countries where the disease is endemic.
Image pre-processing reduces the size of the acquired images to speed up processing and median filtering to remove salt and pepper noise. Trained neural network classifiers were used to detect and determine the life stages and species of Plasmodium parasites. To approximate the number of erythrocytes in the images template matching technique was used and hence the degree of infection is estimated (parasitemia).
It is revealed that artificial neural network (ANN) classifiers trained with colour, morphological, and texture features of infected stained thin blood smear images are suitable for detection and classification of Plasmodium parasites into their respective stages and species. It was further found that ANN classifiers can be trained to perform image segmentation. Classification accuracy of 95.0%, 92.7%, 92.0%, and 79.7% for detection of infected erythrocytes, stages determination, species identification, and parasitemia estimation respectively was achieved with respect to results obtained by expert microscopists. It was further found that ANN classifiers can be trained to perform image segmentation. In this review we want to explain about the better method for diagnosis of malaria through image processing.

Key Words: Microscope, Image process, Malaria Diagnosis, LED, Plasmodium.

I. INTRODUCTION

Malaria is a common but serious protozoan disease caused by peripheral blood, spleen or liver parasites of the genus Plasmodium. There are four species of Plasmodium parasites that cause malaria in humans. These are Plasmodium falciparum,Plasmodiumovale,Plasmodiumvivaxand Plasmodium malariae. These species of Plasmodium attack red bloodcells and undergo various life stages namely, early trophozoites, mature trophozoites, gametocytesand schizoites.

Several methods exist for malaria diagnosis. 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 [14] and Third Harmonic Generation (THG) imaging of Hemozoinusing infrared ultrafast pulsed laser excitation, belong to the class of high cost methods. Plasmodium parasites in unstained thin blood smears have been detected using THG imaging microscope [15]. 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 their high cost, specialized infrastructure needs and handling difficulties.Rapid Diagnostic Test (RDT) which detects specific antigens derived from malaria parasites in lysed blood [16] and conventional microscopy [17, 18] belong to the low cost class.While RDT are relatively fast in malaria diagnosis and can be administered by less skilled personnel, their results can be unreliable [18]. Besides, the commercially available RDT kits are specific to single species of Plasmodium parasites and in cases where a patient is infected with multiple species of Plasmodia, different kits should be used, an approach which makes the cost of diagnosis. Here we wants to say that many works were done on diagnosis of malaria but we are trying to diagnos the disease in better way with less time.

Table-I: Age distribution of malaria cases

Age group (Years)	*Number of cases*	*Percentage*
<5	10	6.1
5-9	26	16
10-14	38	23.3
15-19	25	15.3
20-24	14	8.6
25-29	5	3.1
30-34	9	5.5
35-39	6	3.7
>39	30	18.4
Unknown	1	---
Total	164	100

TABLE 4. Number of imported malaria cases among U.S. and foreign residents,* by region of acquisition — United States, 2007

Region of acquisition	U.S. residents		Foreign residents		Total	
	No.	(%)	No.	(%)	No.	(%)
Africa	476	(64.9)	167	(63.5)	643	(64.5)
Asia	143	(19.5)	77	(29.3)	220	(22.1)
Central America and the Caribbean	75	(10.2)	8	(3.0)	83	(8.3)
South America	13	(1.8)	0	(0)	13	(1.3)
North America	5	(0.6)	4	(1.5)	9	(0.9)
Oceania	20	(2.7)	3	(1.2)	23	(2.3)
Unknown†	2	(0.3)	4	(1.5)	6	(0.6)
Total	734	(100)	263	(100)	997	(100)

* Persons for whom U.S. or foreign status is not known are excluded.
† Region of acquisition is unknown.

II. LITERATURE REVIEW

2.1 Overview of Malaria Diagnosis Approaches

Several numbers of confirmatory tests for Plasmodium parasites exist. Depending on their level of detection complexity and cost of installation these techniques are categorized into two classes. These are the low cost, low technology techniques and the high cost, high technology techniques. The conventional microscopy and Rapid Diagnostic Test (RDTs) are low level techniques while the high level techniques includes Polymerase Chain Reaction (PCR) and Third Harmonic Generation (THG) imaging test. A brief description of these techniques is given below.

2.1.1Conventional Microscopy

This is currently the gold standard in malaria diagnosis because of its low cost and allows quantification of parasitemia and determination of Plasmodium parasite life stages and species. However, there are some limitations in this technic, with the most serious being that the method is time taking, especially when parasitemia is low. This is because many microscopic fields of view have to be examined before a decision of the diagnosis is made. Besides, in the case of mixed infections the microscopist has to examine the slides carefully in order to differentiate between different species of Plasmodium present. While after the treatment of disease he/she has to take account of the fact that some parasite stages remain in the blood [19]. Malaria parasite density in the blood affects the sensitivity of this technique [14, 20]. Results are difficult to reproduce and the accuracy of the method depends on the skills and experience of microscopist [1 - 3].

2.1.2 Rapid Diagnostic Tests (RDTs)

It is an alternative method of malaria diagnosis recommended by W.H.O. for use in areas where microscopy is not available [18]. In this method antigens derived from malaria parasites were detected. This technique is faster than the conventional microscopy with a single diagnosis taking an average time of 30 minutes [4]. Besides, the techniques can be handled by a non-skilled technician. Some of these methods include Parasite-F [16], ICT Malaria pf/pv [5], and optiMAL [6]. There are some limitations of this method including: low sensitivity over microscopy [7], and prevalence of false positives particularly after treatment [8].

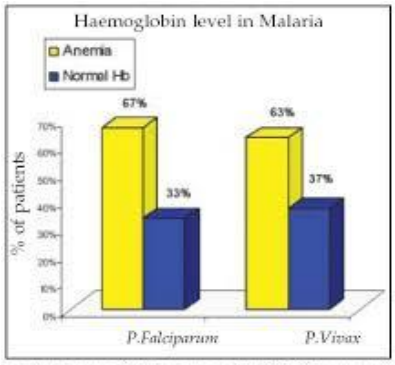

Fig-1: Haemoglobin changes in *P.Falciparum* and *P.Vivax*.

2.1.3 Third Harmonic Generation (THG) Imaging

Third Harmonic Generation (THG) imaging with femtosecond laser excitation can be used to detect malaria pigment (Hemozoin) [15, 36]. Due to its high cost of installation and its demand for highly skilled manpower this technique has not so far been adopted in malaria endemic zones.

2.1.4 Polymerase Chain Reaction (PCR)

Being a sophisticated technique it requires advanced infrastructure. PCR is used to amplify a single or a few copies of DNA sequence to several orders of magnitude. It is used in medical and research laboratories for several applications including diagnosis of malaria [2 - 4, 30 - 32] and requires several components and reagents [33].

Differential Diagnosis	Number of cases n = 324	Percentage
Acute respiratory tract infection	138	42.6
Acute gastroenteritis	55	17.1
Sepsis	30	9.2
Urinary tract infection	25	7.8
Anemia	15	4.7
Sickle cell anemia	11	3.3
Otitis media	9	2.7
Febrile convulsion	8	2.5
Failure to Thrive	7	2.1
Conjunctivitis	6	1.9
Bronchopneumonia	5	1.5
Retro Viral Disease	4	1.2
Others*	11	3.3
Total	324	100

*: Meningitis, Congenital heart diseases, Mumps, Scabies

Symptom	Number of patients (n=47)	Percent
Fever	47	100
Vomiting	9	19.14
Headache	7	14.89
Unconscious	4	8.5
Convulsion	4	8.5
Breathlessness	5	10.63
Hypoglycemia	3	6.38
Jaundice	29	61.70
Pallor	20	42.55
Hypotension	4	8.5
Oliguria	6	12.76
Breathlessness	5	10.63
Bleeding tendency	1	2.12
Hepatomegaly	25	53.19
Splenomegaly	27	57.44

Use of PCR for malaria diagnosis, has several advantages including, high sensitivity even in low parasite load [2, 33 - 35], and ability to distinguish different species of Plasmodium parasites. However, this technique suffers from some limitations such as: high cost of installing its infrastructure, inability to quantify parasitemia and long diagnosis duration with a single case taking up to 8 hours [4].

III. RELATED WORK

In past a number of studies on the possibility of automating conventional microscopy have been done.
In this section a number of these studies are reviewed.

Zoueuet al. (2008), [37] proposed a method of diagnosing malaria without labelling the parasites using a light microscope with LEDs emitting in the range of UV to IR replacing the classic white light. To capture images formed at the eye piece a digital camera was fitted with microscope. It was reported that parasite images having the best contrast were recorded for blue light. This study failed to address the effects of chromatic aberration which are common in multispectral imaging using classical optics. Chromatic aberration causes images of specimen in a light microscope to be formed in different focal points for different wavelengths of light used to illuminate the specimen. This would therefore pose a challenge in automating the detection and classification of Plasmodium parasites because adjustment of focal point would be required for every wavelength used for illumination. This technique was also dependent of a human operator for switching between LEDs and making the diagnosis.

Brydegaardet. al.(2011), [38], proposed an improved version of multispectral microscope based on light emitting diodes (LEDs). The LEDS emitted lights in 13 spectral bands ranging from ultraviolet (UV) to near infra-red (IR). The dispersive optical components of the instrument were made of quartz to reduce achromatic aberration and lens fluorescence in illumination profiles towards the ultraviolent region. The device was also fitted with an imager for capturing images in the 13 spectral range of the LEDs. The instrument was interfaced to a computer and switching of LEDs and image capturing was done using LAB-VIEW software. It was reported that the instrument could detect Plasmodium parasites in non-stained thin blood smear images. However, species and stages differentiation of Plasmodium parasites was not addressed.

Anandet. al.,(2012)[24]investigated detection of Plasmodium infected erythrocytes using a technique called holography. A digital holographic microscope was set up to capture holograms of erythrocytes. A mathematical reconstruction algorithm was then applied to the holograms to recover the object wave. To differentiate between a health cell and an infected cell, a correlation operation was performed using thickness profiles of the reconstructed image with the thickness profile of a known health erythrocyte. Detection probabilities of 84% and 11% as true positive rates and false positive rates were reported. This technique does not involve staining of erythrocyte before detection. However, setting up the digital holographic microscope demands thorough alignment of the optics involved which would require skilled personnel.

Omucheniet. al. (2012), [39] developed a technique of detecting Plasmodia infected erythrocytes by imaging unstained thin blood smear blood samples using a multispectral imaging microscope developed by Bryegaard[38]. Multivariate chemometric techniques such as Principal of
Components Analysis (PCA), Hierarchical Cluster Analysis (HCA) and Artificial Neural Network (ANN) were used to process the multispectral images obtained in order to discriminate infected erythrocytes from the non-infected. Plasmodium parasites stages and species identification was not addressed.

Diazet. al.(2009), [22] developed a technique for detection, quantification of parasitemia and parasite life stages. Pixel colour features were extracted and used to train classifiers for detection and determination of parasite life stages. Clustered erythrocytes were resolved by use of template matching before parasitemia was estimated. The study reported a sensitivity of 94% for detection of infected erythrocytes and 79% for stages identification. The technique was not fully automatic as it called for human intervention during training of the classifier every time diagnosis had to be made. Besides being semi-automatic, the process of erythrocyte identification and stage determination were computationally expensive as features for classification were extracted from every single pixel in the image.

Ross et. al.(2006), [40] proposed a technique for automating malaria diagnosis using optical microscopy. A light microscope fitted with a digital camera was used to capture images of Giemsa stained blood slides. After images were captured they were loaded to a Personal Computer (PC) for processing.Image processing techniques and neural network classifiers were used. Infected erythrocytes were positively identified with a sensitivity of 81% while the sensitivity for species determination was 73%. The study did not address the quantification of parasitemia and determination of parasite species. Morphological image processing techniques used for erythrocyte segmentation could not produce satisfactory results as erythrocytes were heavily clustered [21]. The sizes of erythrocytes were determined using granulometry with circular structuring element (SE). The assumption was erythrocyte shapes are circular. This is not always the case. Sometimes erythrocytes shapes are deformed especially if they are infected with diseases such as sickle cell or if they appear in clusters [21].

Di Rubertoet. al.(2002), [23] proposed a technique of automatically detecting and quantifying malaria parasites infection in blood images of patients. The method employed a modified watershed algorithm to segment erythrocytes. There were two alternatives proposed for classifying

parasite stages. One was the use of morphological thinning, where skeletons of parasites images were used to categorize parasitesinto their respective stages of infection. The second option was use of colour histograms similarity. The study did not propose a technique of differentiating species of Plasmodium parasites. The efficiency of the segmentation algorithm proposed reduces with the degree of clustering of erythrocytes. Similarly the accuracy of colour histogram similarity for classification of parasites would depend on the imaging parameters and illumination conditions under which the image being probed is taken. The detection accuracy of parasitemia reported was relatively low at 50%.

In summary, it is seen that no study has been done so far that comprehensively addresses malaria diagnosis from detection of Plasmodium parasites to determine the life stages and species of the parasites as well as parasitemia estimation. Most of the techniques proposed in the previous works provide over simplified methods which are not realistic. For instance some studies have not addressed the distinction of Plasmodium parasites from the rest of stained objects (artefacts) in the blood sample [21].

In this work, most of the limitations of the previous works have been addressed. For instance, a novel method of segmenting erythrocytes and Plasmodium parasites using artificial neural networks (ANN) has been developed. This technique has overcome the problem of distinguishing between the Plasmodium parasites and other stained objects (artefacts) in images of thin blood smears. Identification of erythrocytes is performed by ANN classifier. The classifier is trained to recognize erythrocytes with varied features. Because of this the technique is more robust than granulometry which has been used extensively in previous studies in erythrocyte recognition [22, 23].Template matching technique has been implemented for the segmentation of clustered erythrocytes with different possible shapes of erythrocytes used as templates. This has improved the accuracy of determining parasitemia.

IV. CONCLUSION

Most of the malaria diagnosis techniques usually require human intervention as an aid in interpretation of their results. Attempts to automate conventional microscopy which is the gold standard method of malaria diagnosis has shown little success as the degree of accuracy for parasitemia estimation and species differentiation reported remains low. From the above review we have concluded that ANN method is the better one from the listed work.

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