Colour Component Analysis Approach for Malaria Parasites Detection Based on Thick Blood Smear Images

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Colour Component Analysis Approach for Malaria Parasites Detection Based on Thick Blood Smear Images

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Abstract. Malaria is a plasmodium parasite disease that affects millions of people in the world every year. Hence, early detection tests are needed to prevent the malaria parasites spread throughout the body. For centuries, manual microscopic blood test remains as the most common method that still being used for malaria detection. However, this procedure contains the probability of miscalculation of parasites due to human error. Computerized system is recognized as a quick and easy ways to analyze a lot of blood samples images by providing direct visualization on the computer screen without the need to examine under the microscope. Therefore, this paper aims to analyze different colour components for improving the parasites counting performance based on thick blood smear images. In this study, five different colour spaces namely YCbCr, RGB, CMY, HSV and HSL have been analyzed and eight colour components which are Y, Cb, R, G, C, M, S and L have been extracted in order to determine which colour component is the best for malaria parasites counting. Overall, experimental results indicate that segmentation using Y component of YCbCr proved to be the best with average counting accuracy of 98.48% for 100 images of malaria thick blood smear.

1. Introduction

Malaria is one of the severe global contagious diseases caused by plasmodium parasites that transmitted through infected female Anopheles mosquito. In 2016, based on statistic by World Health Organization (WHO), there was a total of 216 million of malaria cases worldwide which causes 445 000 deaths [1]. Over time, malaria parasites can distort normal blood cells and normally, one to two weeks after a person is infected, the first symptoms of malaria appear such as fever, headache and vomiting. Microscopy blood test is well-known as the most common method used for malaria detection and consists of thick and thin blood smears test [2]. The thick blood smear test is used to find the level density of malaria parasites infection.

Digital image processing has been applied on medical field as it is not only the most efficient method, but also the cheapest. One of the examples is in application of image segmentation for malaria detection. The quality of segmentation is the importance element for the success of image analysis process. A number of researchers have proposed variety of image segmentation approach to improve malaria detection [3]. For example using the watershed distance transform [4], enhance *k*-means

clustering [5], cascaded enhanced *k*-means and fuzzy *c*-means clustering [6], Poisson distribution thresholding [7], Otsu's thresholding [8] and mathematical morphology [9].

Arco *et al*. [10] worked on thick blood smear images and suggested adaptive thresholding method for classification based on pixel size. The system will classify either the pixel belongs to the background or to the parasites and white blood cells. Furthermore, it is only established the pixels around it and analyzed its neighbourhood. Then, morphological methods are applied to evaluate the area of connected components, labelling and counting the parasites. May *et al*. [11] worked on counting infected red blood cells in thin blood smears for malaria detection. First, the images were converted to CIELAB colour space. Next, Otsu's thresholding was used for conversion into binary image by calculated threshold value for each image. Dilation and erosion were performed for noise removal. Based on the previous studies, segmentation plays a major role in improving counting performance for malaria detection. Therefore, this study will utilize the potential of various colour components for segmentation process in order to improve counting performance of malaria parasites.

2. Methodology

In this study several image processing techniques have been implemented to obtain the segmented malaria parasites on thick blood smear images. The proposed procedures are summarized as follows:

Step 1 : Capture the malaria thick blood smear images.
Step 2 : Apply image enhancement technique namely modified global contrast stretching.
Step 3 : Apply colour conversion on enhanced images using YCbCr (luma, blue-difference chroma, red-difference chroma), RGB (red, green, blue), CMY (cyan, magenta, yellow), HSV (hue, saturation, value) and HSL (hue, saturation, luminance) colour spaces.
Step 4 : Apply Otsu's thresholding on Y, Cb, R, G, C, M, S and L component.
Step 5 : Apply watershed segmentation to separate the clumping parasites.
Step 6 : Apply noise removal to remove smaller and larger pixels than malaria parasites pixels.

2.1. Image acquisition

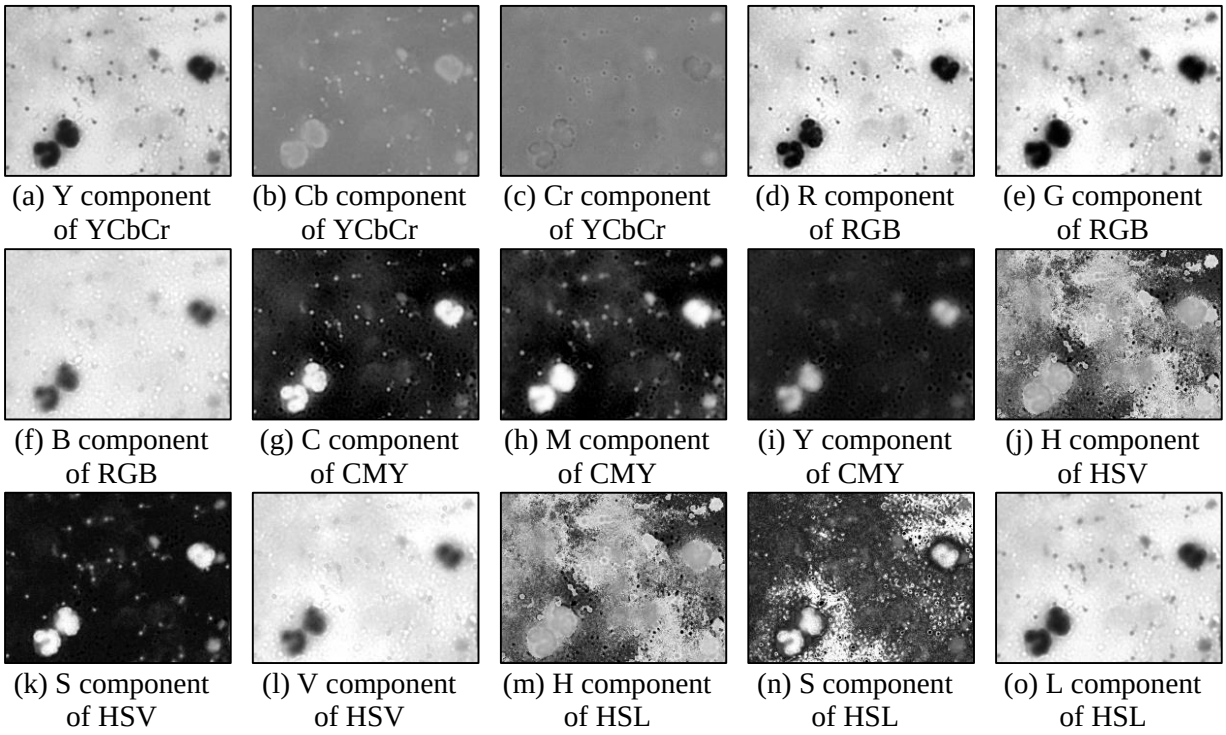
The malaria thick blood smear samples were retrieved from Department of Microbiology and Parasitology, Hospital Universiti Sains Malaysia (HUSM). The blood smear samples have been examined using 100X magnification lens of computerized Leica DLMA microscope. In this study, 100 malaria images were captured with 800 x 600 resolutions and saved in bitmap (*.bmp) format.

2.2. Contrast enhancement technique using modified global contrast stretching (MGCS)

In this study, the images are captured under low light condition, which is resulted as a low quality images. Therefore, image enhancement is needed to improve the quality of images for visual awareness. The images are enhanced by using MGCS technique to emphasize and sharpen the images quality. This technique use particular minimum and maximum values that lie in a specified percentage of pixels from the total number of pixels in the RGB image. The enhancement of malaria images depends directly on the minimum and maximum values that will be used during the contrast stretching process. Detail descriptions of the MGCS enhancement method can be found in [12].

2.3. Colour conversion on enhanced image using YCbCr, RGB, CMY, HSV and HSL colour spaces

The malaria thick blood smear images are captured in RGB which are difficult for the segmentation process. Therefore, colour conversion is applied on enhanced images for easing the segmentation process and also as they can describe colour equivalent as how the human eye interpreted colour. The enhanced images are converted into five colour spaces namely YCbCr, RGB, CMY, HSV and HSL. Figure 1 shows the conversion of colour spaces into colour component.



(a) Y component of YCbCr (b) Cb component of YCbCr (c) Cr component of YCbCr (d) R component of RGB (e) G component of RGB

(f) B component of RGB (g) C component of CMY (h) M component of CMY (i) Y component of CMY (j) H component of HSV

(k) S component of HSV (l) V component of HSV (m) H component of HSL (n) S component of HSL (o) L component of HSL

Figure 1. Conversion of YCbCr, RGB, CMY, HSV and HSL colour spaces into colour component

Apparently eight colour components have been chosen to be segmented, which are Y and Cb components from YCbCr colour spaces, R and G components from RGB colour spaces, C and M components from CMY colour spaces, S component from HSV colour spaces and L component from HSL colour spaces. These colour components are chosen as they shows better contrast between foreground and the background as can be seen in figure 1. The conversion from RGB images to five different colour spaces will be interpreted as the following equation [13]:

$$Y = 0.299R + 0.587G + 0.114B \quad (1)$$

$$Cb = 128 - 0.169R - 0.331G + 0.511B \quad (2)$$

$$C = 1 - R \quad (3)$$

$$M = 1 - G \quad (4)$$

$$S = 1 - \frac{3}{R+G+B}\min(R,G,B) \quad (5)$$

$$L = \frac{(max_{(R,G,B)} + min_{(R,G,B)})}{2} \quad (6)$$

2.4. Otsu's thresholding on Y, Cb, R, G, C, M, S and L colour component

After applying the colour conversion on enhanced images, Otsu's thresholding method is proceeding on the eight selected colour components. Otsu's thresholding is used to conceive a binary image from the grey level image by finding the maximum variance between the classes [14]. Basic principle of Otsu's thresholding is to split the image into two classes in term of foreground and background is called as bi-level thresholding (BT). However, Otsu's thresholding can also split the images into more than two classes, and it is called as multilevel thresholding (MT). Multilevel thresholding segments a gray level image pixel into several distinct classes [14]. In this study, Y, Cb, R, G, C and M component are segmented into three classes, which are for malaria parasites, white blood cells (WBCs) and the background regions. Meanwhile, S and L component are segmented into two classes, which are for malaria parasites and the background regions. Nonetheless, the thresholding value is differs due to different colour component is applied.

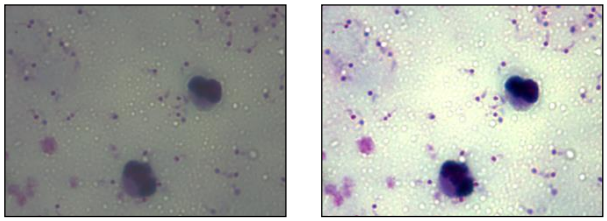
2.5. Separation of clumping parasites by using watershed segmentation with distance transform
The malaria parasites are close to each other and some of them are overlapping. These overlapping malaria parasites might affect the performance of accuracy counting. Therefore watershed with distance transform is used to separate the clumped parasites. Euclidean distance transform calculates the difference between the pixel and the nearest non-zero pixel to separate each connected parasites. The detail descriptions of this method can be found in [15].

2.6. Removing the lesser and greater pixels than malaria parasites pixels size
After the segmentation process is done, some noise appears on the image. An arithmetic operation namely area opening is used to remove the noise. This operation allows the eliminating of the unwanted object that is smaller and larger than the structuring element of the desired object. Thus, any regions which are lesser or greater than malaria parasites pixels are considered as non-malarias and will be get rid from the image through area opening process. After all, the size of malaria parasites pixels also differ due to different colour component is used.

2.7. Evaluation of malaria parasites counting
Next, malaria parasites counting process is carried out to verify the accuracy of counting performance by using difference colour component. The parasite counting is performed by using the region growing algorithm. This algorithm labels the malaria parasites according to their order in the malaria image and then determines the total number of the parasites based on the labelled image. The accuracy of the counted malaria parasites is determined based on the average counting percentage in order to evaluate the performance of each colour component to produce a good counting analysis by using the following equation:

$$Accuracy = \left(1 - \frac{Manual\_Count - System\_Count}{Manual\_Count}\right) x100\% \quad (7)$$

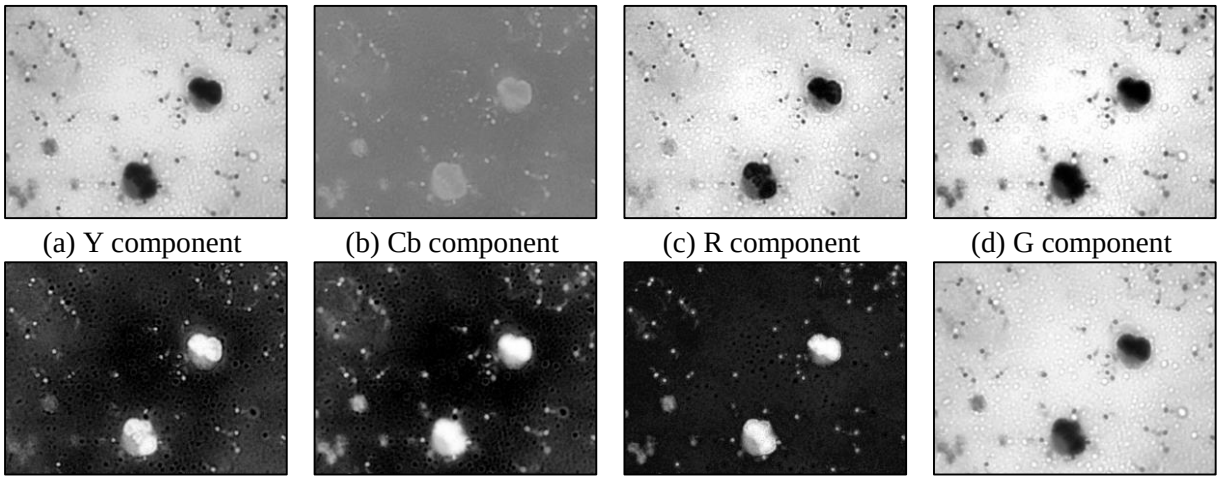
3. Result and Discussions
In this study, the proposed image processing procedure have been employed and analyzed on 100 malaria thick blood smear images. Firstly, the malaria images are enhanced by using MGCS since they are low quality images. Figure 2 shows the original malaria images and the enhanced images after applying the MGCS technique.



(a) Original image (b) Enhanced image

Figure 2. Original images of malaria thick blood smear and enhanced images after applying MGCS technique.

From the enhanced image, colour conversion has been applied using YCbCr, RGB, CMY, HSV and HSL colour spaces for easing segmentation process. Y, Cb, R, G, C, M, S and L colour component have been selected to be segment since its shows a good distinct between malaria parasites on foreground and the background of the images. Figure 3 shows the differences between colour components.

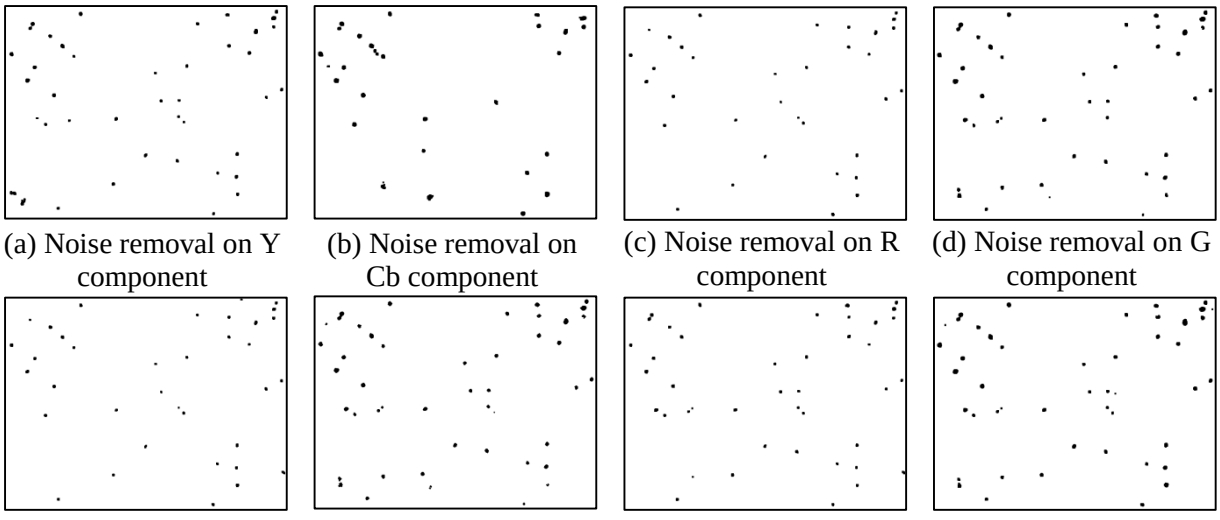


(a) Y component (b) Cb component (c) R component (d) G component

(e) C component (f) M component (g) S component (h) L component

Figure 3. The differences between colour components.

Next, Otsu's thresholding has been applied to segment the malaria parasites from the background region. The clumping malaria parasites have been separated by using watershed segmentation with euclidean distance transform to obtain accurate result during counting process. Finally, the smaller and larger pixels that lie in between malaria parasite pixels have been removed through area opening technique from arithmetic operation and noise removal of image border has been done to obtain a clean segmented image and improve counting accuracy. The final results obtain after performing Otsu's thresholding, watershed segmentation, and noise removal process are presented in figure 4.



(a) Noise removal on Y component (b) Noise removal on Cb component (c) Noise removal on R component (d) Noise removal on G component

(e) Noise removal on C component (f) Noise removal on M component (g) Noise removal on S component (h) Noise removal on L component

Figure 4. Final results obtain after performing Otsu's thresholding, watershed segmentation, and noise removal processes.

The counting process of malaria parasite has been carried on to certify the performance of different colour component. Based on average of malaria parasites count obtained from table 1, the Y component of YCbCr colour spaces has provide a better counting performance with average accuracy of 98.48% for 100 malaria images as compared to the other colour components.

Table 1. Average malaria parasites count for 100 images.

Details	Manual Counting	YCbCr [Y]	YCbCr [Cb]	RGB [R]	RGB [G]	CMY [C]	CMY [M]	HSV [S]	HSL [L]
Total Parasites	3936	3876	3761	4199	3674	4243	3997	4112	3751
Accuracy (%)	-	**98.48**	95.55	93.32	93.34	92.20	98.45	95.53	95.30

4. Conclusion

In this paper, the results of average counting of malaria parasites by applying eight types of colour components have been displayed. Comparisons between Y, Cb, R, G, C, M, S and L colour components extracted from YCbCr, RGB, CMY, HSV and HSL colour spaces have been operated as input images to Otsu's thresholding in order to identify the best colour component for segmentation of malaria image for counting of malaria parasites process. The proposed segmentation techniques have been applied on 100 malaria thick blood smear images. Based on the quantitative findings, the results indicate that segmentation using Y component of YCbCr colour spaces has proven to be the best colour component for segmenting malaria image with average counting of 98.48%.

5. References

[1] World Health Organization 2017 World Malaria Report 2017
[2] Mathison B A and Pritt B S 2017. Update on malaria diagnostics and test utilization *Journal of clinical microbiology* **55**
[3] Poostchi M, Silamut K, Maude R, Jaeger S and Thoma 2018 Image analysis and machine learning for detecting malaria *Translational Research* **194**
[4] Salamah U, Sarno R, Arifin A Z, Sarimuddin S, Nugroho A S, Rozi I E and Asih P B S 2018 Segmentation of Malaria Parasite Candidate from Thickblood Smear Microscopic Images using Watershed and Adaptive Thresholding *Journal of Telecommunication, Electronic and Computer Engineering (JTEC)* **10**
[5] Nasir A S A, Mashor M Y and Mohamed Z 2018 Enhanced k-means clustering algorithm for malaria image segmentation *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences* **42**
[6] Abdul Nasir A S, Jaafar H, Wan Mustafa W A and Mohamed Z The Cascaded 2018 Enhanced k-Means and Fuzzy c-Means Clustering Algorithms for Automated Segmentation of Malaria Parasites *MATEC Web of Conferences* **150**
[7] Suryawanshi M S, Dixit V 2013 Improved technique for detection of malaria parasites within the blood cell images *Int J Sci Eng Res* **4**
[8] Sulur K M, Nasir A S A, Mustafa W A, Jaafar H and Mohamed Z 2017 Analysis of Colour Constancy Algorithms for Improving Segmentation of Malaria Images *Journal of Telecommunication, Electronic and Computer Engineering* **10**
[9] Loddo A, Di Ruberto C and Kocher M (2018) Recent advances of malaria parasites detection systems based on mathematical morphology *Sensors* **18**
[10] Arco J, Gorriz J, Ramirez J, Alvarez I and Puntonet C 2014 Digital image analysis for automatic enumeration of malaria parasites using morphological operations *Expert Syst Appl* **42**
[11] May Z, Aziz S A M and Salamat R A 2013 Automated Quantification and Classification of Malaria Parasites in Thin Blood Smears *International Conference on Signal and Image Processing Applications (ICSIPA)*
[12] Abdul-Nasir A S, Mashor M Y and Mohamed Z 2012 Modified global and modified linear contrast stretching algorithms: New colour contrast enhancement techniques for microscopic analysis of malaria slide images *Computational and Mathematical Methods in Medicine*

[13] Nishad P M 2013 Various colour spaces and colour space conversion *Journal of Global Research in Computer Science* **4**
[14] Kotte S, Kumar P R and Injeti S K 2016 An efficient approach for optimal multilevel thresholding selection for gray scale images based on improved differential search algorithm *Ain Shams Engineering Journal*
[15] Aris T A, Nasir A S A and Mustafa W A 2017 Analysis of Distance Transforms for Watershed Segmentation on Chronic Leukaemia Images *Journal of Telecommunication, Electronic and Computer Engineering* **10**

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