CHAPTER 5 – CONCLUSIONS AND FUTURE WORKS

5.1 Conclusions

The purpose of this study is to develop an automated image processing and classification algorithm to detect erythrocyte from malaria thin blood smears image. Thin blood smears image was prepared by experts from Eijkman Institute of Molecular Biology. There are a lot of blood sample from different species, different live cycle. In this study, infected blood smears by Plasmodium falciparum in ring stage was selected as the input image for testing the algorithm.

The proposed algorithm begins with image pre-processing step. In image pre-processing, RGB image was converted to grayscale image by using Irfanview. After the grayscale image generated, the grayscale image was converted to binary image using Otsu method to obtain the binary mask of the image. Then 3x3 median filtering was applied to remove the noise in the image and followed by hole filling to fill the hole that founded in objects after thresholding. To prepare the image for classification, Otsu Dual Thresholding was applied to get an image with three dimensions of colour and followed by holefilling.

The next step is blood cell segmentation stage. The purpose of this stage is to collect each cell at the image by performing Connected Component Extraction at the binary image. After all the cells were collected as single cell, feature extraction was begin. The purpose of feature extraction is to get the characteristic of each blood component. The features that observed in this study were area of cell, range of pixel value, maximum pixel value, minimum pixel value and the standard deviation.

From the feature extraction data, rules for classification step was made for recognize an object as an erythrocyte, leucocyte, thrombocyte or artefacts.

The features that used for the classification were the area of cell and the pixel intensity level. From that features, the rules were :

- Healthy erythrocyte will be determined if there are all the pixels founded in the black pixels.
- Infected erythrocyte will be determined if there are part of pixels founded in the black pixels, part of pixels founded in the grey pixels and the pixel area is below some threshold value.
- Suspected overlapping cell will be determined if there are part of pixels founded in the black pixels, part of pixels founded in the grey pixels and the pixel area is beneath some threshold value.
- Leucocyte will be determined if there are part of pixels founded in the black pixels, part of pixels founded in the grey pixels, more grey pixels founded than black pixels and the pixel area is beneath some threshold value.

Threshold value for minimum area of an erythrocyte is 1000 pixel and smaller than that, the object will be determined as thrombocyte or artefacts. Threshold value for maximum area of an erythrocyte is 7300 and larger than that assigned as overlapping cell or leucocyte.

From 104 images, 276 overlapping cell is detected and to handle the overlapping cell, I used distance transform algorithm and followed by watershed method. From the data that has been collected, these two algorithms can handle overlapping cell. The error appeared when the concavity of the overlapping cell is unclear so the distance transform only detect one cell in the overlapping cell. After separate the overlapping cell, the classification rules applied to each cell. The accuracy of this system to recognize erythrocyte is 99.6%, but the accuracy of this system to recognize infected erythrocyte is 14.5%.

5.2 Future Work

The purpose of this thesis is to identify erythrocyte in infected thin blood smears microphotograph. The blood image is infected with malaria parasite from *Plasmodium falciparum* species. The proposed algorithm produced a good result in identify erythrocyte cell but it is not good enough to identify infected erythrocyte so this proposed algorithm still far from perfect. It needs a lot of improvement. These are some ideas that can be used to improve the system:

- This system designed for distinguish erythrocyte from the other blood components but it is not good enough to be used by microscopist. The proposed system is too general and it can be improved by developing a system to identify infected erythrocyte with malaria parasite.
- The proposed system can handle overlapping cell if the concavity of cell is clear. It needs a further development to handle overlapping cell with unclear concavity.
- There are another species from Plasmodium species. Each species need an algorithm to identify its parasite because each species has different characteristic of parasite.
- In Plasmodium falciparum life cycle, there are other stages beside ring stage like gamete or schizont stage. It is important to develop a system to identify malaria parasite in those stage.