

**AUTOMATIC STATUS IDENTIFICATION OF MICROSCOPIC
IMAGES OBTAINED FROM MALARIA THIN BLOOD SMEARS**

By

Dian Anggraini

A Bachelor's Thesis
submitted to the Faculty of

LIFE SCIENCE

Department of
BIOMEDICAL ENGINEERING

In Partial Fulfillment of the
Requirements for the Degree of

BACHELOR OF SCIENCE
WITH MAJOR IN BIOMEDICAL ENGINEERING

Swiss German University
EduTown BSDCity
Tangerang 15339
INDONESIA

Telp. +62 21 3045 0045
Fax. +62 21 3045 0001
E-mail: info@sgu.ac.id
www.sgu.ac.id

July 2011

Revision after thesis defense on 28 July, 2011

STATEMENT BY THE AUTHOR

I hereby declare that this submission is my own work and to the best of my knowledge, contains no material previously published or written by another person, nor material which to a substantial extent has been accepted for the award of any other degree or diploma at any educational institution, except where due acknowledgement is made in the thesis.

Dian Anggraini

Date

Approved by:

Dr. Anto Satriyo Nugroho, M.Eng (Advisor)

Date

Aulia Arif Iskandar, MT (Co-advisor)

Date

Chairman of the Examination Steering Committee

Date

Dian Anggraini

ABSTRACT

Automatic Status Identification of Microscopic Images
Obtained from malaria Thin Blood Smears

By

Dian Anggraini

SWISS GERMAN UNIVERISTY

Bumi Serpong Damai

Dr. Anto Satriyo Nugroho, M.Eng, Major Lecturer

Development of an accurate laboratory diagnostic tool, as recommended by WHO, is the key step to overcome the serious global health burden caused by malaria. This study aims to explore the possibility of computerized diagnosis of malaria and to develop a novel image processing algorithm to reliably detect the presence of malaria parasite from *Plasmodium falciparum* species in thin smears of Giemsa stained peripheral blood sample. The algorithm was designed as an expert system based on the method used by medical practitioner performing microscopy diagnosis of malaria. Digital images were acquired using a digital camera connected to a light microscope. Prior to processing, the images were subjected to gray-scale conversion to decrease color variability. Global thresholding was implemented to obtain erythrocyte and other blood cell components in each image. The segmented images were further processed to obtain informative features that were further used in classification stage. Two-stage classification using selected features was built based on Bayesian Decision Theory. Malaria samples, prepared and provided by Eijkman Institute of Molecular Biology Indonesia, were used to build and test the proposed algorithm.

Keywords— malaria, thin blood smears, image segmentation, thresholding

DEDICATION

I dedicate this thesis to, first and foremost, Jesus Christ who makes my life amazing. In addition, to my life mentor Ir. Poerwanto Pratikno, my life coach Ms. Sanny Djohan, Irene “Jo” with whom I share similar ambition, and my family who sometimes do not understand me but always loves me unconditionally.



ACKNOWLEDGMENTS

My 92 days of this thesis work have been a rewarding experience. Therefore, please allow me to begin this thesis report by addressing my deepest gratitude to those who have made my learning process exhilarating.

First and foremost, I would like to thank Dr. Anto Satriyo Nugroho, M.Eng for giving me the opportunity to develop an exceptional skill through this thesis work. He has been a transformative presence in all aspects of my education, and despite my apparent stubbornness and ambition, I really appreciate his gentle encouragement. I am so thankful for his guidance, patience, advice, and above all for the new perspective on engineering, science, and on life that I would otherwise not have.

Furthermore, many thanks are due to Mr. Aulia A. Iskandar, MT, Mr. James Hunt, Mr. Michael Early, Mrs. Intje Kreefft, as well as Ms Mina Arsitha and her Examination Office team (for answering my never ending questions) not only for their professionalism, but also for their kindness and patience.

This project is also supported by Center for Information and Communication Technology - Agency for the Assessment & Application of Technology (PTIK-BPPT) and Eijkman Institute of Molecular Biology. Therefore, thank you to every member of CAD Malaria team for their guidance, advice, and support. I can never thank them enough for going above and beyond in sharing knowledge about practical aspects of this work.

In addition, I would like to thank Andree Ang Surya, Christian Pratama, Mr. Ismail Ekoprayitno Rozi, Harvey Kurniawan, Ninon, Yuni, Miranti, Agung, and Pak Made. I have learned a great deal from working with this superlative group of people who gave survival advice, scholarly inputs, and friendship.

Furthermore, please allow me to deliver a special gratitude to my best friend Teresa Vania Tjahja who always stands beside me in bad time and good time (24/7, literally!!). I can never thank her enough for all her supports, jokes, patience, as well as all her comments on my facebook's wall. She never stops to encourage me to learn more and develop more C-codes. Despite her reluctance to Biology, skirts, and high heels, I really appreciate all the time we shared talking about our ambitions and future plans. She is one of a kind.

Equally important, I would not have made it without the support from every member of the "Kapputt Family as well as Mr. Reggio N. Hartono, Mr. Kho I Eng, Mr. James Purnama, Mrs. Rachmawati, Mr. Michael, Mr. Randy Anthony, and Ms. Elizabeth Prabawati. Thank you, not only for all the help, but also for the jokes and kindness. You have made a time consuming work enjoyable and I am so glad to know that I could always have you all in my corner, supporting me along the way.

Last but not least, I would like to thank my parents and my little sisters. From them I have learned the importance of having passion for and pride in my work. From an early age my father has instilled me the importance of scientific method and logic as well as time management, which have proven to be invaluable tools throughout this thesis work. Finally, I cannot thank my mother enough for her prayers and her willingness to drive me to perfection.

TABLE OF CONTENTS

STATEMENT BY THE AUTHOR.....	2
ABSTRACT.....	3
DEDICATION.....	4
ACKNOWLEDGMENTS.....	5
CHAPTER 1 – INTRODUCTION.....	13
1.1 Background.....	13
1.2 Research Objectives and Scope.....	16
1.3 Research Problems.....	16
1.4 Benefits of Research.....	17
1.5 Organization of Thesis.....	17
CHAPTER 2 – LITERATURE REVIEW FROM MEDICAL PERSPECTIVE.....	19
2.1 Malaria.....	19
2.2 Prevalence of Malaria in Indonesia.....	21
2.3 Diagnosis of Malaria.....	22
2.3.1 Clinical Diagnosis.....	22
2.3.2 Microscopy Diagnosis.....	23
2.3.3 Nucleic-acid based Malaria Diagnosis.....	23
2.3.4 Detection of <i>Plasmodium falciparum</i> antigen.....	24
2.3.5 Immunological Method.....	24
2.4 Malaria Diagnostic through Microscopy.....	25
2.4.1 Peripheral Blood Smears for Malaria Diagnosis.....	25
2.4.2 Examining Blood Film.....	27
2.4.3 Examining Blood Film for Malaria Parasite.....	29

CHAPTER 3 – LITERATURE REVIEW FROM IMAGE PROCESSING

PERSPECTIVE.....	35
3.1 Algorithm Development of Automated Malaria diagnosis.....	35
3.2 Image Pre-Processing.....	36
3.3 Segmentation of Blood Cell Constituents.....	37
3.4 Feature Extraction.....	39
3.5 Classification.....	40
3.5.1 Previously Proposed Method.....	40
3.5.2 Bayesian Model for Classification.....	42
CHAPTER 4 – METHODOLOGY.....	44
4.1 Materials and Method.....	44
4.2 Image Acquisition.....	45
4.3 Development of Dataset.....	46
4.4 Algorithm Development based on manual Microscopy.....	47
4.5 Proposed System.....	50
4.5.1 Image Pre-Processing.....	51
4.5.2 Blood cell Component Segmentation.....	52
4.5.3 Feature Extraction.....	56
4.5.4 Classification.....	59
CHAPTER 5 – RESEARCH FINDINGS.....	61
5.1 Dataset of Blood Smear Images.....	61
5.1.1 Structure and Properties.....	61
5.1.2 Dataset Content.....	62
5.2 Experimental Environment.....	65
5.3 Image Pre-Processing.....	65
5.4 Blood Cell Component Segmentation.....	68
5.4.1 Initial Algorithm.....	68
5.4.2 Proposed Algorithm.....	70
5.5 Feature Extraction.....	74

5.5.1 First Set of Features.....	75
5.5.2 Second Set of Features	77
5.6 Classification.....	82
5.6.1 Initial Classification Model	83
5.6.2 Final Classification Model	92
CHAPTER 6 – CONCLUSION AND RECOMMENDATION.....	101
6.1 Conclusion	101
6.2 Future Work	103
GLOSSARY	105
REFERENCES	111
APPENDICES	114
Appendix 1: Paper for International Conference	114
Appendix 2: Media Coverage	121
CURRICULUM VITAE.....	128



SWISS GERMAN UNIVERSITY