DEVELOPMENT OF AN AUTOMATED MALARIA DETECTION SYSTEM USING DEEP LEARNING MODELS

ADEGOKE, FAITH OMOLARA
(21PBF02258)
B.Sc (SLT) in Biological Sciences/Biotechnology, Ekiti State University

AUGUST, 2023

DEVELOPMENT OF AN AUTOMATED MALARIA DETECTION SYSTEM USING DEEP LEARNING MODELS

BY

ADEGOKE, FAITH OMOLARA
(21PBF02258)
B.Sc (SLT) in Biological Sciences/Biotechnology, Ekiti State University

A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE MASTER OF SCIENCE (M.Sc) DEGREE IN BIOINFORMATICS IN THE DEPARTMENT OF COMPUTER AND INFORMATION SCIENCES, COLLEGE OF SCIENCE AND TECHNOLOGY, COVENANT UNIVERSITY, OTA, OGUN STATE, NIGERIA

AUGUST, 2023

ACCEPTANCE

This is to attest that this dissertation has been accepted in partial fulfilment of the requirements for the award of the degree of Master of Science in Bioinformatics in the Department of Computer and Information Sciences, College of Science and Technology, Covenant University, Ota, Nigeria.

Miss Adefunke F. Oyinloye
(Secretary, School of Postgraduate Studies) **Signature and Date**

Prof. Akan B. Williams
(Dean, School of Postgraduate Studies) **Signature and Date**

DECLARATION

I, **ADEGOKE, FAITH OMOLARA (21PBF02258)** declare that this dissertation is a representation of my work and is written and implemented by me under the supervision of Professor Jelili O. Oyelade of the Department of Computer and Information Sciences, Covenant University, Ota, Nigeria. I attest that this dissertation has in no way been submitted either wholly or partially to any other university or institution of higher learning for the award of a master's degree. All information cited from published and unpublished literature has been duly referenced.

ADEGOKE, FAITH OMOLARA

Signature and Date

CERTIFICATION

This is to certify that the research work titled **"DEVELOPMENT OF AN AUTOMATED MALARIA DETECTION SYSTEM USING DEEP LEARNING MODELS"** is an original research work carried out by **ADEGOKE, FAITH OMOLARA, (21PBF02258)** meets the requirements and regulations governing the award of Master of Science (M.Sc.) degree in Bioinformatics from the Department of Computer and Information Sciences, College of Science and Technology, Covenant University, Ota, and is approved for its contribution to knowledge and literary presentation.

Prof. Jelili O. Oyelade
(Supervisor) **Signature and Date**

Prof. Olufunke O. Oladipupo
(Head of Department) **Signature and Date**

Prof. Olufunke R. Vincent
(External Examiner) **Signature and Date**

Prof. Akan B. Williams
(Dean, School of Postgraduate Studies) **Signature and Date**

DEDICATION

This research work is dedicated to God Almighty, the custodian of all wisdom, knowledge, and understanding, for His grace and favour throughout the execution of this research.

ACKNOWLEDGEMENTS

I am sincerely grateful to God Almighty for the grace given to me to be where I am today. My profound gratitude goes to the Chancellor of Covenant University, Dr David O. Oyedepo whose life is a testament that once a goal is set in mind, it can be done, I want to thank him for instilling the "nothing is impossible" mindset in me. I also want to thank the Vice-Chancellor of this university for all work done for the progress of this school. My sincere appreciation goes to the dean of the School of Postgraduate Studies, Prof Akan B. Williams, and the head of the Department of Computer and Information Sciences, Prof. Olufunke O. Oladipupo for their tireless labour in seeing to the progress of the students and the school at large.

My profound gratitude to my supervisor Prof. Jelili O. Oyelade for his guidance, advice, and support during this project. I would also like to appreciate the PG coordinator of the department, Dr Itunuoluwa Isewon whose tireless efforts are a source of inspiration and motivation to always aim for the best. To all the faculty and staff of the department, thank you for all you do. I want to thank the Covenant Applied Informatics and Communication – Africa Center of Excellence (CApIC-ACE) domiciled at Covenant University for sponsoring my education.

I sincerely appreciate Prof. Segun Okeniyi and Mrs Okeniyi for being a family here. To my mentor and his wife, Pastor Olanrewaju and Mrs Bisola Kolawole, thank you for the gestures of love shown to me. I am grateful to Mr Sanni Bolarinwa for his kind gesture towards me at the beginning of my study.

I also want to appreciate my friends who were a source of encouragement at various times; Jumoke Adeyemi, Samuel Owusu-Ansah, Stephen Binaansim, Paul Owolabi, Chioma Onyido, Erika Baiguerel, Mariam Kanonte, Emmanuel Alagbe, Favour Folorunsho, Praise Agbetuyi-tayo, Precious Adebola, Tobi George, Abednego Shekari, Oni Olaiya, Mercy Tebamifor, all PG fellowship executives for 2022/2023 session, bible study unit members and others whom space will fail me to mention.

Lastly, my heartfelt appreciation goes to my dear parents, Pastor Olusola and Pastor Funmilayo Adegoke who have been a pillar of support all through my life. I am blessed to be your daughter and I do not take it for granted. To my siblings, Hope and Grace Adegoke, I love you. Thanks for your immense support.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Malaria remains a public health concern, prompting intensive research into computer-aided diagnosis using machine learning models. However, the effectiveness of these models is hindered by the presence of variabilities in clinical practices, especially in medical imaging. These issues, such as demographic differences among patients, diverse staining methods, and variations in devices, coupled with the absence of standardized medical protocols, present considerable obstacles in achieving optimal model performance. This study aims to develop a malaria detection system using deep learning models. Existing malaria image datasets were curated by doing a systematic literature review of papers published in this domain from 2015-2023. Thirteen (13) datasets were retrieved following this process. The key artifacts classified are the infection status, parasite species, type of stain, type of smear, and optical train. Python programming was used in implementing the deep learning models for the classification of the identified artifacts. Getting this information about an image dataset will ensure standardized approaches to diagnosis and research, leading to more reliable and comparable data across different settings and studies. The performance evaluation metrics used include recall (sensitivity), accuracy, precision, and F1-score. A ten-fold cross validation was also done. The models were evaluated on single set and combined sets (to increase statistical power) to compare their performance. The best performing model for infection status is VGG19 on the single set, RESNET50 performed best on the single set for Species classification, for classifying smears, VGG19 performed best on the combined set, RESNET50 performed best on the single set for classifying stains and for classifying optical train, VGG19 had the best performance on the combined set. A prototype web application for the prediction of these artifacts was developed using the Python Flask micro-framework. The best performing models were loaded to the web application. When deployed, it will provide a user-friendly platform for medical professionals and researchers alike.

Keywords: Malaria, Image classification, Deep Learning, Computer-aided Diagnosis, Blood Smear Images