THE CLASSIFICATION OF CORNEAL ARCUS IMAGES BY USING IMPROVED CONVOLUTIONAL NEURAL NETWORK

NUR FARAHIN BINTI ABDUL HALIM

MASTER OF SCIENCE IN ELECTRONIC ENGINEERING

2024

Faculty of Electronics and Computer Technology and Engineering

THE CLASSIFICATION OF CORNEAL ARCUS IMAGES BY USING IMPROVED CONVOLUTIONAL NEURAL NETWORK

Nur Farahin Binti Abdul Halim

Master of Science in Electronic Engineering

2024

THE CLASSIFICATION OF CORNEAL ARCUS IMAGES BY USING IMPROVED CONVOLUTIONAL NEURAL NETWORK

NUR FARAHIN BINTI ABDUL HALIM

A dissertation submitted
in partial fulfillment of the requirements for the degree of
Master of Science in Electronic Engineering.

Faculty of Electronics and Computer Technology and Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2024

DEDICATION

All praises to Allah, the Most Gracious and the Most Merciful. To my beloved husband, family, friends and my supervisor Ir. Dr. Ridza Azri Bin Ramlee. This accomplishment is not just my own, but a testament to the collective efforts of all those who have supported me. I dedicate this achievement to them, with a heart full of gratitude. Thank you very much.

ABSTRACT

Corneal arcus (CA), also known as arcus senilis or simply arcus, refers to a condition characterized by the accumulation of lipids, particularly cholesterol, in the cornea of the eye. The presence of CA may be an indicator of underlying systemic conditions such as high cholesterol in human body. When CA is detected during an eye examination, it may prompt further investigation into the patient's lipid profile and overall cardiovascular health. Individuals with CA may be advised to undergo blood tests to measure cholesterol and triglyceride levels. The most common test is known as a lipid panel or a cholesterol blood test. Therefore, leveraging image processing offers a non-invasive and painless alternative to traditional blood tests for detecting corneal arcus. This research is about the implementation of convolutional neural network (CNN) in detecting cholesterols presence by classifying normal and CA images. A dataset of 459 images comprising 237 for normal and 222 for CA images were formed. There are three different CNN models were proposed for feature extraction and classifying the normal and CA images which are CNN, Resnet-50 and VGG-19. From the parameter evaluation, it can be concluded that batch size of 20 and learning rate of 0.0001 suit with Resnet-50 and CNN model, while VGG-19 suit with batch size of 10 and learning rate of 0.00001 to classify with the normal and CA dataset. The best result was exhibited by Resnet-50 with 10-fold cross-validation producing high average detection in terms of sensitivity, specificity, and accuracy of 100%. Thus, deeper networks implementation is recommended in the future to further improve CA localisation in cholesterol detection.

KLASIFIKASI IMEJ ARKUS KORNEA DENGAN MENGGUNAKAN RANGKAIAN NEURAL PELINGKARAN YANG DIPERBAIKI

ABSTRAK

Kornea Arkus (KA), juga dikenali sebagai arkus senilis atau ringkasnya arkus, merujuk kepada keadaan yang dicirikan oleh pengumpulan lipid, terutamanya kolesterol, dalam kornea mata. Kehadiran KA boleh menjadi penunjuk keadaan di mana kolesterol tinggi dalam badan manusia. Apabila KA dikesan semasa pemeriksaan mata, pakar perubatan akan menasihati pesakit untuk membuat pemeriksaan kesihatan yang lanjut ke atas profil lipid pesakit dan kesihatan kardiovaskular secara keseluruhan. Individu yang mempunyai KA akan dinasihatkan untuk menjalani ujian darah untuk mengukur paras kolesterol dan trigliserida. Ujian darah yang dikenali sebagai lipid panel atau ujian darah kolesterol akan mengukur pelbagai jenis kolesterol dan trigliserida dalam darah. Penyelidikan ini adalah mengenai pelaksanaan Rangkaian Neural Pelingkaran (CNN) dalam mengesan kehadiran kolesterol dengan mengklasifikasikan imej normal dan KA. Oleh itu, set data 459 imej yang terdiri daripada 237 untuk imej biasa dan 222 untuk imej KA telah dibentuk. Terdapat tiga model CNN berbeza telah digunakan untuk mengelaskan imej biasa dan KA iaitu CNN, Resnet-50 dan VGG-19. Daripada penilaian parameter, dapat disimpulkan bahawa kumpulan saiz 20 dan kadar pembelajaran 0.0001 sesuai dengan model Resnet-50 dan CNN, manakala VGG-19 sesuai dengan kumpulan saiz 10 dan kadar pembelajaran 0.00001 untuk mengklasifikasikan dengan normal dan CA dataset. Ringkasnya, hasil terbaik dipamerkan oleh Resnet-50 dengan pengesahan silang 10 kali ganda menghasilkan pengesanan purata tinggi dari segi kepekaan, kekhususan dan ketepatan 100%. Oleh itu, pelaksanaan rangkaian yang lebih mendalam disyorkan pada masa hadapan untuk menambah baik pengelasan KA dalam pengesanan kolesterol.

ACKNOWLEDGEMENTS

ALLAH SWT is the best planner. I am decided to continue my study on the year of COVID-19. The beginning was so hard for me to keep on doing the research from home because I do not have a suitable source to run my project. It takes time almost 1 year after the lockdown for me to access the facility provided by the faculty for me to run the project. As time goes by, I managed to run this project using the facility provided in Research Lab 3 (MLSP). Despite, many difficulties and constraints I had faced, there are many people I would like to thank you for giving me support and encouragement to complete this research and without whom I would not have made it through my master degree! First of all, I would like to express my sincere gratitude to my supervisor, Ir. Dr. Ridza Azri Bin Ramlee whose insight and knowledge into the subject matter steered me through this research. My colleagues for giving me consistent support and had to put up with my stresses and moans for the past three years of study! and my biggest appreciation to my husband, Muhammad Irshad Bin M. Abu Zaki, my parent and family for all the support you have shown me and always pray for my continued success in no matter what it takes or how long it takes to complete this research even though my mom always ask me to complete the master as quickly as possible. Next, thank you to all that directly or indirectly include in the completion of this master research.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

Acc	Accuracy
AG	Angiography
AHE	Adaptive Histogram Equalization
AI	Artificial Intelligence
BG	Biorthogonal
BPN	Backpropagation Neural Network
BR	Bayesian Regulation
CA	Corneal Arcus
CASIA	Chinese Academy of Science
CDF	Cumulative Distribution Function
CDR	Cholesterol Detection Regression
CHD	Coronary Heart Disease
CL	Connected Layer
CLAHE	Contrast Limited Adaptive Histogram Equalization
CLHE	Contrast Limited Histogram Equalization
CNN/ConvNet	Convolutional Neural Network
COCO	Common Objects in Context
COVID	Corona Virus
CPU	Central Processing Unit
DA	Data Augmentation
DB	Daubechies
dB	Decibels

DL	Deep Learning
FCL	Fully Connected Layer
FFT	Fast Fourier Transform
FN	False Negative
FP	False Positive
GHz	Gigahertz
GLCM	Gray Level Co-Occurrence Metrics
GLM	Gray Level Mean
HDL	High Density Lipoprotein
HE	Histogram Equalization
HEF	High-Frequency Emphasis Filtering
ICE	Iris Challenge Evaluation
ILSVRC	Imagenet Large Scale Visual Recognition Challenge
IT	Information Technology
LDL	Low Density Lipoprotein
min	Minutes
ML	Machine Learning
MLP	Multilayer Perceptron
MLP-BP	Multilayer Perceptron
MMU	Multimedia University
MNF	Minimum Noise Function Transformation
MPL	Max-Pooling Layer
MSE	Mean Squared Error
NHANES	National Health and Nutrition Examination
NIR	Near Infrared

NM	Not Mention
NPV	Negative Predictive Value
P	Precision
PSNR	Peak Signal to Noise Ratio
RAM	Random Access Memory
RBF	Radial Basis Function
ReLU	Rectified Linear Regularization Unit
ResNet	Residual Network
RGB	Red-Green-Blue
s	Seconds
Sn	Sensitivity
Sp	Specificity
SVM	Support Vector Machine
SYM	Symlets
TN	True Negative
TP	True Positive
UBIRIS	University Of Beira Interior
UM	Unsharp Masking
US	United States
VGG	Visual Geometry Group
WV	Wavelets
WVU	West Virginia University

LIST OF PUBLICATIONS

The followings are the list of publications related to the work on this thesis:

Farahin, N., Halim, B. A., Azri, R., Ramlee, B., Zaki, M., Mas'ud, B., and Jamaludin, A., 2022. Enhancement of automatic classification of arcus senilis-nonarcus senilis using convolutional neural network. *Indonesian Journal of Electrical Engineering and Computer Science (IJEECS)*, 28(1), 210–220. https://doi.org/10.11591/ijeecs.v28.i1.pp210-220 (SCOPUS indexed).

AH, N. F., Ramlee, R. A., Mas'ud, M. Z., and Alias, M. A. 2022. A Comparative Study of Deep Learning Parameters for Arcus Senilis Classification. *Journal of Telecommunication, Electronic and Computer Engineering (JTEC)*, 14(4), 21-24.

CHAPTER 1

INTRODUCTION

This chapter mainly will provide an overview of corneal arcus condition as well as the background study of classification technique through deep learning method. The objectives of the project and challenges or problems that led to the development of this project are highlighted and discussed. Overall, this chapter presents the organization of this research study.

1.1 Project Overview

A healthy lifestyle means physical and mental health in a person. In many cases, the physical and mental are closely related to each other. Cholesterol, a fundamental lipid molecule, plays a pivotal role in the physiology of living organisms, serving as an indispensable component of cell membranes and a precursor for vital bioactive molecules. While essential for various physiological processes, an imbalance in cholesterol levels can lead to profound health implications, notably cardiovascular diseases, stroke, diabetes, high blood pressure and many more. High and low cholesterol in the blood vessels is one of the physical health issues that we must consider.

There are two types of cholesterol in lipoprotein transporters which are low density lipoproteins (LDL) and high-density lipoproteins (HDL). LDL is considered bad cholesterol that carries cholesterol particles throughout the body and cholesterol will accumulate in the wall of the arteries. HDL considered as good cholesterol, it will pick up the excess cholesterol and take it to liver. Figure 1.1 below shows the illustration of LDL and HDL in human body. Usually, people that will be associated from high risk of developing high cholesterol are those who are living with obesity, consuming a lot of saturated and trans-fat like fast food, have a limited physical activity, smoking, having a family history of high cholesterol or having diabetes, kidney failure or hypothyroidism.

A report from the American Heart Association 2021 stated that according to National Health and Nutrition Examination Survey (NHANES) in 2015 to 2018, among US adults ≥20 years of age, the age-adjusted prevalence of obesity was 39.9% in males and 41.1% in females; the prevalence of extreme obesity was 6.2% in males and 10.5% in females; the overall prevalence of obesity among youth 2 to 19 years of age was 19.0% (Virani et al., 2021). Apart from this risk factor, it is wise to keep in mind that people all of ages, genders and ethnicities can have high cholesterol. This disease happened when the plaque (extra cholesterol that build up at the arteries) became hardened and narrowed at the wall of arteries which will block the flow of blood into heart. This condition is known as atherosclerosis which is a serious condition of that can limit the blood flow through the arteries and raise a risk of developing dangerous blood clot (Rafieian-Kopaei et al., 2014). Without any treatment or medication, hence, it will lead to many life-threatening complications like stroke, heart attack, chest pain or angina, high blood pressure peripheral vascular disease and chronic kidney disease.

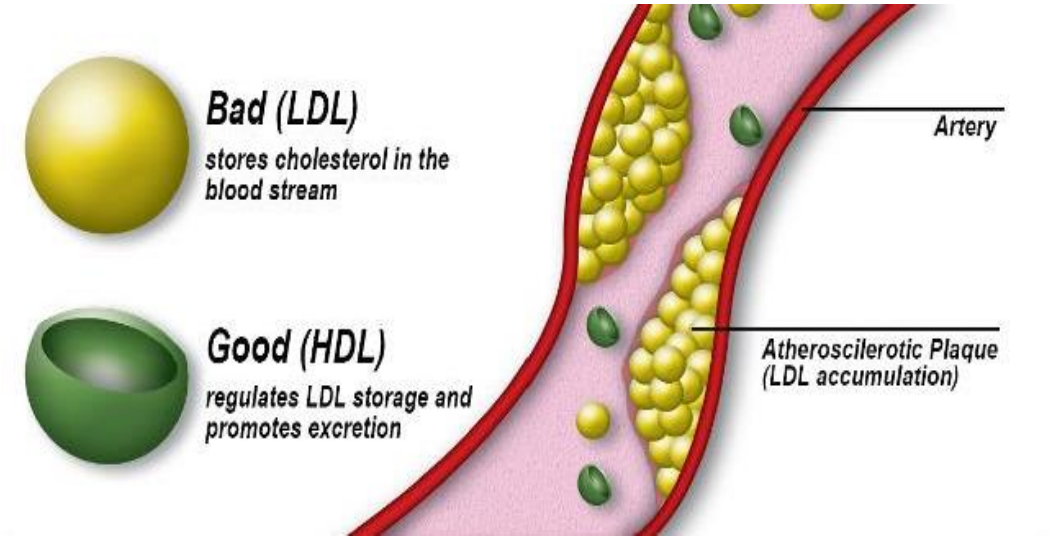

Figure 1.1: The illustration of type of cholesterols (Hosur, 2022).

Essentially, the focus of this research is to suggest non-intrusive way in detecting the cholesterol. Currently, there are a few ways in detecting level of cholesterol in blood vessel for instance lipid panel test. The test required patient to fast at least 10 hours fasting and if the patient suffered from heart attack, surgery, infection, or pregnancy they need to wait 2 months before having the test. A blood test will be performed using a syringe to extract the blood from the vein at the arm or finger prick in order to gain a blood sample to be test out the level of cholesterol. Sometime, there is a people that have a fear to needle also called needle phobia or trypanophobia. People who suffer from this phobia at times debilitating condition usually will experience symptoms like hypertension, rapid heart rate, fainting or loss consciousness, besides, they even fear associated with doctors and nurses. This will prevent them from seeking treatment when facing from any serious ailments for instances high cholesterol in body.

In conclusion, high cholesterol can be one of the root causes in triggering other disease to attract so, it is a must to have a preliminary detection on detecting cholesterol.