# A HYBRID GLCM-CNN MODEL FOR CATARACT DETECTION IN FUNDUS IMAGE

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**BORANG PENGESAHAN STATUS LAPORAN**

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# A HYBRID GLCM-CNN MODEL FOR CATARACT DETECTION IN FUNDUS IMAGE

SYAKIRAH HANIM BINTI ZULKERNAIN



This report is submitted in partial fulfillment of the requirements for the Bachelor of Computer Science (Artificial Intelligence) with Honours.

FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2022/2023

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I hereby declare that this project report entitled

**A HYBRID GLCM-CNN MODEL FOR CATARACT DETECTION IN FUNDUS IMAGE**

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STUDENT : ____________________ Date : 22/09/2023
(SYAKIRAH HANIM BINTI ZULKERNAIN)



I hereby declare that I have read this project report and found this project report is sufficient in term of the scope and quality for the award of Bachelor of Computer Science (Artificial Intelligence) with Honours.

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## DEDICATION

To my beloved parents, En Zulkernain and Pn Rohana, thank you for sacrificing everything for supporting my final year project.

To my beloved sisters and brothers, thank you for understanding me and giving me some space and idea in writing for finishing my proposed project.

To my supervisor, Ts Dr Ngo Hea Choon, thank you for your guidance, your support and your suggestions to improve the quality of my project.

To my friends, thank you because always sharing the idea and showing your support for my project.

Without all these people, it is hard for me to achieve this achievement, completing my final year project successfully.

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Next, I am eternally grateful for having advocating siblings. Much obliged to all of them. Also, many thanks to my friends who have been encouraging me and being a source of strength to reassure me upon this accomplishment.

Finally, I would not be able to conclude this project without the support of an Artificial Intelligence (ChatGPT), who has complemented and added the finishing touch in this assessment. While I stuck and wedged to figured out some problem solving, ChatGPT undeniably assisted me to find an idea to innovate it into something better and untangled those hurdles.

# ABSTRACT

Detection of cataracts based on fundus images is hard to perform due to errors in the image, such as uneven illumination, and some of the fundus images have low quality. The CNN single model can perform the detection of cataracts, but the misclassification is hard to reduce. This project proposes to use GLCM and CNN as feature extractors and DNN as a classifier to increase the accuracy of cataract detection while at the same time reducing the number of misclassifications of cataract and normal classes. The GLCM and CNN feature extraction are combined and become input for DNN for classification in performing cataract detection. The proposed model was built using PyCharm, and the results were visualised using classification reports, graphs, and a confusion matrix. The proposed model is compared with another two models, which are CNN and GLCM-k-NN. The performance results showed that GLCM-CNN can achieve high accuracy, which is 93%, but in terms of precision, sensitivity, and F1 score, they need to be enhanced for future works. The number of misclassifications still couldn't be reduced as minimally as possible. The suggestion was made in this project for future work.

# ABSTRAK

Pengesanan katarak berdasarkan imej fundus sukar dilakukan kerana ralat dalam imej, seperti pencahayaan tidak sekata, dan sesetengah imej fundus mempunyai kualiti yang rendah. Model tunggal CNN boleh melakukan pengesanan katarak, tetapi salah klasifikasi sukar untuk dikurangkan. Projek ini bercadang untuk menggunakan GLCM dan CNN sebagai pengekstrak ciri dan DNN sebagai pengelas untuk meningkatkan ketepatan pengesanan katarak dan pada masa yang sama mengurangkan bilangan salah klasifikasi katarak dan kelas biasa. Pengekstrakan ciri GLCM dan CNN digabungkan dan menjadi input untuk DNN untuk pengelasan dalam melaksanakan pengesanan katarak. Model yang dicadangkan telah dibina menggunakan PyCharm, dan hasilnya divisualisasikan menggunakan laporan pengelasan, graf dan matriks kekeliruan. Model yang dicadangkan dibandingkan dengan dua model lain, iaitu CNN dan GLCM-k-NN. Keputusan prestasi menunjukkan bahawa GLCM-CNN boleh mencapai ketepatan yang tinggi, iaitu 93%, tetapi dari segi ketepatan, kepekaan dan skor F1 perlu dipertingkatkan untuk kerja-kerja masa hadapan. Bilangan salah klasifikasi masih tidak dapat dikurangkan seminimum mungkin. Cadangan telah dibuat dalam projek ini untuk kerja akan datang.

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| | |
|---|---|
| **AE** | **Artificial intelligence** |
| **AI** | **Autoencoder** |
| **BPNN** | **Back propagation neural network** |
| **CAD** | **Computer aided diagnosis** |
| **CNN** | **Convolutional neural network** |
| **DNN** | **Deep neural network** |
| **DRL** | **Deep reinforcement learning** |
| **DTL** | **Deep transfer learning** |
| **FN** | **False negative** |
| **FP** | **False positive** |
| **GAN** | **Generative adversarial network** |
| **GLRLM** | **Graphical user interface** |
| **GTSDM** | **Grey level run length method** |
| **GUI** | **Grey-tone spatial dependence matrices** |
| **IOL** | **Intraocular lens** |
| **k-NN** | **k-nearest neighbour** |

| | |
|---|---|
| **ML** | **Machine learning** |
| **MLP** | **Magnetic resonance image** |
| **MRI** | **Multilayer perceptron** |
| **RBM** | **Rectified linear unit** |
| **ReLU** | **Recurrent neural network** |
| **RGB** | **Red, green, blue, alpha** |
| **RGBA** | **Restricted Boltzmann machine** |
| **RNN** | **Recurrent neural network** |
| **SDLC** | **Software development life cycle** |
| **SVM** | **Support vector machine** |
| **TN** | **True negative** |
| **TP** | **True positive** |
| **VGG** | **Visual geometry group** |

# CHAPTER 1: INTRODUCTION

## 1.1 Introduction

Deep learning algorithms are widely used for analysing problems based on medical data. There are few approaches that have been done recently by using deep learning to perform image classification, object detection, segmentation, registration, and other tasks related to medical data. Before deep learning was introduced in the medical field, the analysis method was done with the sequential application of low-level pixel processing and mathematical modelling.

Alex-Net, which is one of the convolutional neural networks (CNN) models, making a big impact in artificial intelligence (AI) field, especially in deep learning. The impact has encouraged the researchers to apply deep learning to analysing medical data and produce more medical analysis papers around 2015 and 2016. Figure 1.1 shows that the popular discipline implements a deep learning model for medical analysis (Litjens et al., 2017). The reason why magnetic resonance image (MRI) is popular compared to others is because the MRI image has invaluable information that attracts clinical routine and computer-aided diagnosis (CAD) attention (Liu et al., 2018).

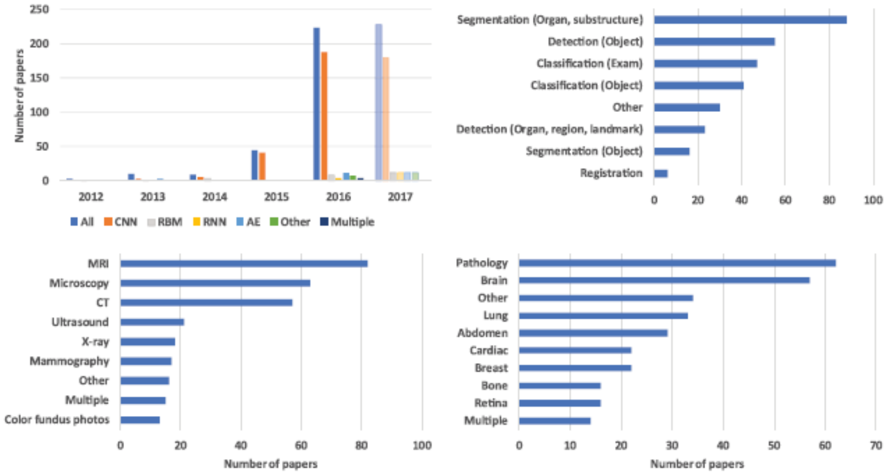


**Figure 1.1: Impact of Deep Learning Based on Number of Papers (Litjens, 2017)**

Since the MRI field has been explored by many researchers, this proposed project has tried to explore another discipline for finding new information and output to improve healthcare diagnosis. Ophthalmology was chosen as a discipline for applying intelligent analysis in this proposed project. This proposed project will be focused on analysing fundus images for cataract detection.

Based on the Australian Institute of Health and Welfare 2023 glossary website, ophthalmology is a branch of medicine that focuses on the diagnosis and treatment of eye disorders. In ophthalmology, there are several conditions that are treated by ophthalmologists, such as partial or complete loss of vision, eye injuries, pain or inflammation, eye conditions, health conditions that can affect the eyes, and poor vision that need specialist care (Common Eye Disorders and Diseases, 2022). One of the conditions that is common in ophthalmology clinics is cataracts.

Cataract, also known as the stern curtain, is a cloudy area in the lens of the eyes. The cloudy area forms when the proteins in the lens of the eyes clump together. In general, a normal eye condition can give clear vision by allowing all the light passing through it to form an image on the retina. But in cataractous conditions, the light isn't easily passed through the lens due to clumps of proteins inside the lens, making the vision blurred or hazy, or in rare cases, causing ghosting distortion. Cataract is usually not painful, but it can cause discomfort in the patient's vision (Nizami, 2022).

To conduct a retinal exam for assessing cataracts, the ophthalmologist will put drops in the eyes of patients to make them dilate. The ophthalmologists will use a special device called a fundus camera to focus more on the fundus of the eyes. The fundus image will be created once the ophthalmologist snaps the image (The Eye Examination, n.d.). The generated image will show the structure of the back of the eyes, which are the optic nerves, retinal vessels, and optic disc (What is a Retinal Eye Exam, 2022).

The fundus image gives a small conclusion in a cataract diagnosis. In a normal condition, it will show that the optic disc and large and small vessels can be clearly seen. While for the mild stage, almost the same as in the normal, the blood vessels become less detailed to see. For the moderate stage, only the large blood vessels and optic disc can be seen in the fundus image. For the severe stage, there is nothing to see from the fundus image (Xu et al., 2020). Detecting the cataract from the fundus image is not easy for ophthalmologists, especially for normal and moderate stages, because the images almost look the same. Thus, it is important to produce an intelligent programme that can perform cataract detection very well to reduce the risk that patients will face in the future.



## 1.2 Problem Statement

The detection of cataracts is quite challenging in fundus image observation. Some cataract images can be misclassified as normal, and some normal images can be misclassified as cataractous due to the moderate stage of the cataract, which almost looks like a normal condition. The misclassification that needs to be tried to reduce is predicted as normal, but the real output is cataract. This kind of misclassification is dangerous for patients since they don't know the signs of cataracts until it affects their eye structure, especially the lens and retina.

Many studies have proposed single models, and some of them have proposed hybrid models based on machine learning (ML) methods only. Almost every single model has been proposed to use a neural network, most often a CNN model, which can give a good outcome in terms of accuracy. The main functions of CNN are image recognition, object classification, and pattern recognition. In CNN architecture, the filters will try to identify unique features that are present in the image.

To detect cataracts based on fundus images, it is not just based on pattern only but need to consider the texture of the fundus image based on every structure inside the retina. The way CNN performs cataract detection is not clear based on the fundus image since most of the research papers did not define which part is important for analysis.

To improve the ability of the CNN model, it needs to perform feature extraction with another statistical model separately for analysing fundus images texture. The classification will be performed using the deep neural network (DNN) after the texture analysis process.



## 1.3 Objectives

1. To extract information from each fundus image by using five features of Grey-level Co-Occurrence Matrix (GLCM), which are correlation, energy, homogeneity, dissimilarity, and contrast.

2. To improve the ability of the CNN model for detection by combining it with GLCM.

3. To evaluate the performance of the hybrid GLCM-CNN model with CNN and hybrid GLCM with k-Nearest Neighbour (k-NN).

## 1.4 Scope

The scope for this proposed project is based on the result of detection of cataract on fundus image by using combination of two algorithms which are two feature extraction algorithms and a deep learning algorithm. The fundus images that will be used to process in Python are normal fundus images and cataract fundus images. To set up a framework to design and implement texture analysis is by using scikit-learn library to enable the GLCM attribute and the Keras TensorFlow model for the CNN and DNN model. The performance will be evaluated using accuracy, sensitivity, precision and F1 score.

## 1.5 Project Significance

The proposed project is important in diagnosing early stages of cataract. Diagnosing in the early stages is very important to reduce the burden on the healthcare system and improve the quality of life for patients. Diagnosing in the early stages can allow the ophthalmologist to identify the patient who needs to be more careful with cataract development. Thus, this can save many people from becoming blind for life.



## 1.6 Expected Output

The expected output for this project is that the hybrid model can improve the detection of cataracts by using GLCM-CNN model. The accuracy might be high, and the false negative might be lower compared to research papers published on the website.

## 1.7 Conclusion

Integrating cataract detection with an intelligent system is most important nowadays for preventing blindness in the future due to the growth of protein clumps inside the lens. The system will perform texture analysis of the fundus image and classify it with a deep learning algorithm. Early detection can prevent the life quality of a patient from getting worse.