Lecture Notes in Networks and Systems 958

Rabindra Nath Shaw · Sanjoy Das ·
Marcin Paprzycki · Ankush Ghosh ·
Monica Bianchini *Editors*

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Preface

This book features selected high-quality papers presented at The 3rd International Conference on Advanced Computing and Intelligent Technologies (ICACIT-2023), was organized by Indira Gandhi National Tribal University, Regional Campus Manipur (IGNTU-RCM) during December 8–9, 2023, through online mode. The conference got an overwhelming response and received more than 200 papers from all around the world. All submitted papers have gone through a single blind review process on an average three reviews per paper. The acceptance rate is less than 25%. The presented papers published in this book chapter.

The book focuses on current development in the fields of computing and intelligent technologies. This book covers most of the latest computer science topics including AI and machine learning, data mining and warehousing web mining, computational intelligence, big data analytics, IoT architectures and protocol, image and pattern recognition, natural language processing, speech and signal processing, biomedical informatics, network performance analysis, wireless sensor networks, cryptography and data security, and smart city applications. The book is beneficial for readers from both academia and industry background.

We are thankful to all the authors that have submitted papers for keeping the quality of ICACIT 2023 at high levels. The editors of this book would like to acknowledge all the authors for their contributions and the reviewers. We also acknowledge the invaluable help received from the members of the International Program Committee and the chairs responsible for different aspects of the conference. We appreciate the role of special sessions organizers. Thanks to all of them, we were able to collect many papers on interesting topics, and during the conference, we had very interesting presentations and stimulating discussions.

We hope that this book will offer valuable information to professors, researchers, and graduate students in the fields of Computer Science Engineering, Communication Engineering, and related fields. We hope that you will find this collection of papers

inspiring, informative, and helpful. We look forward to seeing you at the next ICACIT event.

Chandigarh, India — Rabindra Nath Shaw
Imphal, India — Sanjoy Das
Warsaw, Poland — Marcin Paprzycki
Chandigarh, India — Ankush Ghosh
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Dr. Monica Bianchini received the Laurea cum laude in Mathematics and the Ph.D. degree in Computer Science from the University of Florence, Italy, in 1989 and 1995, respectively. After receiving the Laurea, for two years, she was involved in a joint project of Bull HN Italia and the Department of Mathematics (University of Florence), aimed at designing parallel software for solving differential equations. From 1992 to 1998, she was Ph.D. Student and Postdoc Fellow with the Computer Science Department of the University of Florence. Since 1999, she has been with the University of Siena, where she is currently Associate Professor at the Information Engineering and Mathematics Department. Her main research interests are in the field of artificial intelligence and applications, machine learning, with emphasis on neural networks for structured data and deep learning, approximation theory, information retrieval, bioinformatics, and image processing. She has authored more than seventy papers and has been Editor of books and special issues on international journals in her research field. She has been a participant in many research projects focused on machine learning and pattern recognition, founded by both Italian Ministry of Education (MIUR) and University of Siena (PAR scheme), and she has been involved in the organization of several scientific events, including the NATO Advanced Workshop on Limitations and Future Trends in Neural Computation (2001), the 8th AI*IA

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Development of CNN-Based Feature Extraction and Multi-layer Perceptron for Eye Disease Detection

Antara Malakar, Ankur Ganguly, and Swarnendu Kumar Chakraborty

Abstract Identification of multiple eye disorders utilizing a multi-label categorization methodology is an effective way. The crucial merit of this technique is that it can identify the disorders in earlier times. Ocular disease affects millions of people worldwide, and early detection and treatment of these abnormalities are crucial in preventing avoidable blindness. Diagnosing eye illnesses accurately necessitates the analysis of a diverse array of visually discernible symptoms associated with these conditions. The wide range of symptoms exhibited by various eye illnesses emphasizes the importance of a comprehensive assessment for an accurate diagnosis. Because of the moderate progression, the disorder gives several indications in the initial times, so creating disorder detection is a complex work. To achieve an effective identification system, architecture for a machine learning-assisted method is suggested. Initially, the required eye images are gathered from the standard online data sources. It is then followed by Convolution Neural Network (CNN)-based feature extraction, where the features are extracted by Visual Geometry Group 16 (VGG16). Finally, the attained features are subjected to the Multi-Layer Perceptron (MLP) for detecting the different eye disorders. The performance analysis is conducted contrast with other conventional models to prove the developed model efficacy.

Keywords Multiple eye disease detection · CNN-based feature extraction · Retinal images · Multi-layer perceptron · Performance evaluation

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1 Introduction

Eye disorders are widespread globally, encompassing various types that contribute to visual impairment. Nowadays, a minimum of 2.2 billion people in the globe have visual deterioration [1]. The most common visual deterioration is called as myopia that troubles nearly 130 million people around the world [2]. The visual deterioration has led to a crucial health problem around the globe. Many eye disorders can be efficiently handled by the initial screening and periodical treatment [3]. In the current days, the crucial screening approach is manual screening that is not facing the multi-scale clinical needs. One of the main causes of the blindness is detected as diabetes [4]. Most importantly, one-third of the people with diabetes are assumed to be detected with Diabetic Eye Disease (DED), which is a chronic eye disorder. It creates the everlasting visual deterioration.

Initial detection of retinal disorders is crucial, however, the detection of these disorders employing neural networks needs a significant amount of memory and time. Extra information should provide to improve the precision. Yet this needs huge computational power and a high amount of investment in time [5]. Hence, an analytically pre-trained system can merit the execution as it utilizes the structure to decrease the losses. Transfer Learning (TL) or already trained systems have established and evaluated successful outcomes in the categorization of medical images and identification [6]. These models are time-consuming and tedious to the retina's digital pictures with various image settings [7]. Furthermore, the conventional fundus photography is a tiresome approach that needs more level of patient cooperation and photographic expertise.

The latest developments in the sector of image detection and categorization have faced a shift toward deep learning techniques. These are increasing the computational costs and memory [8]. The most promising deep learning models depend on convolution filters that permit computerized learning and attribute extraction [9]. The strength of deep learning models comes from their capacity to train the hierarchy of the attributes with distinct stages of abstraction from the presented data. In the field of ophthalmology, the deep learning models have been employed for screening the disorders like age-related macular degeneration, glaucoma, retinopathy of prematurity using color fundus images or OCT images, and diabetic retinopathy [10].

The important contribution of the designed model is described as follows.

- To construct the multiple eye disease detection model utilizing the advanced methods that help to detect the disorder in earlier stages and prevent the vision loss of the individuals.
- To extract the features from the original images employed a CNN-aided feature extraction where the features are extracted with the support of VGG16.
- To detect the multiple eye disorder by utilizing the MLP model that creates the classified outcomes with better efficiency.

The framework of the implemented multiple eye disease detection model is explained here. The traditional works of the developed system are shown in Part 2. The methodology of multiple eye disease detection utilizing the advanced techniques is illustrated in Part 3. The feature extraction and MLP model for multiple eye disease detection are described in Part 4. The results and discussions of the suggested model are shown in Part 5. Part 6 offers the conclusion of the implemented model.

2 Existing Works

2.1 Related Works

In 2020, Sarki et al. [11] have focused to generate an automated categorization model taking two criteria: (i) multi-class DED and mild multi-class DED. Experts system experimented on multiple data resources, glossed by the ophthalmologist. The research was conducted utilizing the major two already trained CNN systems on the "ImageNet". Moreover, multiple functionality development models were utilized such as contrast enhancement, optimization, and fine-tuning. A high correctness of 88.3% was attained for the categorization on the VGG16 system and for mild multi-class categorization obtained 85.95%.

In 2022, Puneet et al. [12] have recommended an operation by developing the attention concept; TL with the Deep CNN (DCNN), the system determined a correctness of 95.6 and 97.79% on the testing and training information accordingly. This system efficiently categorized the multiple ocular diseases such as drusen, diabetic macular edema, and choroidal neovascularization from the optical coherence tomography pictures. It might offer a better answer to the medical sector to solve the burden of the ophthalmologist in the Diabetic Retinopathy (DR) screening.

In 2021, Sikkandar [13] has suggested Super Iterative Clustering Algorithm (SICA) to detect the HE, and CWS on the retinal picture. For this approach, the Feature-Based Medical Image Retrieval (FBMIR) data resources were employed. Noise existed in the pictures and the histogram filtering model was utilized to transform the red, green, and blue (RGB) pictures into a quality grayscale picture with the absence of noise. The classification functionality of the Deep Assimilation Learning Algorithm (DALA) method was evaluated with multiple categorization metrics such as F-measure, precision, and recall. At last, the false categorization rates were estimated to contrast the functionality of the trained models. The model might enhance the correctness of the automatic identification and categorization of the eye disorders.

In 2023, Sengar et al. [14] have constructed a computerized deep learning-assisted non-invasive structure to detect the eye disorders employing the color fundus pictures. A multi-class eye disorder RFMiD data resource was utilized to build an effective diagnostic structure. The multi-class fundus pictures were drawn out from the multi-label data resource and then multiple augmentation methodologies were adopted

to create the structure robustly in the present time. The power of the EyeDeep-Net was estimated by employing the various statistical measures and the functionality of the suggested system was detected to be higher than the various traditional systems. The comparison of the recommended model to the latest models confirmed its effectiveness regarding categorization and disorder detection via digital fundus pictures.

In 2022, Wang et al. [15] have given the problems of manual screening and constructed an initial screening model employing the Ultra-Wide Field (UWF) fundus pictures to detect the various eye disorders. The model utilized a CNN-aided structure including two factors such as attribute extractor and classifier. The attribute extractor has drawn out the general attributes of four sub-pictures of the raw UWF fundus pictures that were joined and then given to the classifier to assume its class. The functionality of the model was very reliable and confirmed by the ophthalmologists.

2.2 Research Gaps and Challenges

A disorder which troubles the vision of the human eye is called eye disease. Most of the eye disorders are very silent and not noticeable at the early stages. So, diagnosing the eye disease is very important. It reduces the damage to the eyes. Periodical eye examinations are necessary which enhance the quality of the life. Multiple systems have been implemented and the challenges and the features are given in Table 1. CNN [11] is easy to store and secure the image. It enhances the quality of the image for the human interpretation. However, it consumes more time to process the image. It is very costly depending on the particular system. Transfer learning [12] gives efficient results for the models. It helps to analyze the data. But, it reduces the accuracy because of the negative transfer. Histogram filtering [13] is a straightforward method and it is very strong. It can identify the unusual outliers. Yet, it doesn't allow identifying the related values. It is very hard to contrast the distributions. Convolutional neural networks [14] can perform the weight sharing. It is very accurate. But, it fails to encode the place and the orientation of the objects. It is a very slower method. Feature extraction [15] decreases the redundant information. It is very efficient on the computer resources. However, it is less accurate because of the random value creation. To tackle these issues, a new system has been developed to identify the multiple eye diseases using deep learning.

Table 1 Features and challenges of existing various eye disease detection models

Author [citation]	Methodology	Features	Challenges
Sarki et al. [11]	CNN	• It is easy to store and secure the image • It enhances the quality of the image for the human interpretation	• It consumes more time to process the image • It is very costly depending on the particular system
Puneet et al. [12]	Transfer learning	• It gives efficient results for the models • It helps to analyze the data	• It reduces the accuracy because of the negative transfer
Sikkandar [13]	Histogram filtering	• It is a straightforward method and it is very strong • It can identify the unusual outliers	• It doesn't allow identifying the related values • It is very hard to contrast the distributions
Sengar et al. [14]	CNN	• It can perform the weight sharing • It is very accurate	• It fails to encode the place and the orientation of the objects • It is a very slower method
Wang et al. [15]	Feature extraction	• It decreases the redundant information • It is very efficient on the computer resources	• It is less accurate because of the random value creation

3 Methodology of Multiple Eye Disease Detection Technique

3.1 Proposed Detection System for Multiple Eye Disorder

The eye is a very crucial and sensory part of the human body. Eye disorder is a general health problem all over the globe. Two kinds of eye disorders such as conjunctivitis and cataract. The cataract creates some kind of clouding in the eye lens and causing to minimal vision. If it is not treated for a long time, it will create the permanent vision loss. On the other side, conjunctivitis also known as pink eye is a situation, here the eye conjunctiva is affected by an allergic or an infection reaction. It can trouble the single of both eyes and causes to discharge or redness. Viral and bacterial conductivities can be very dangerous. One of the important reasons for doing the eye test is to detect eye disorders or reduce the damage to the eyes. The initial treatment can safeguard the eyes against the permanent blindness. Numerous models have been implemented to detect the eye disorders but those systems are time-consuming and inaccurate. Figure 1 depicts the overall structure of the developed multiple eye disease detection model.

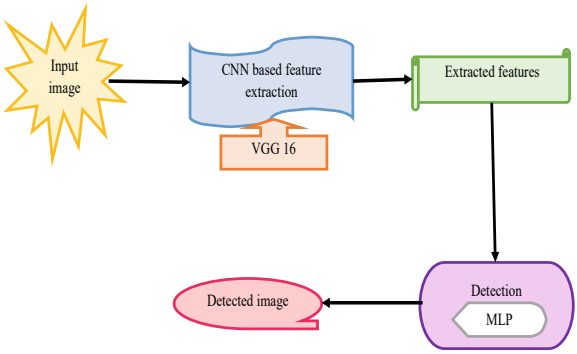

Fig. 1 Representation of the developed multiple eye disease detection model

The developed multiple eye disease detection model helps to detect the various disorders in the eye effectively. At first, the necessary images are collected from the classical data sets. Then it is given to the CNN-assisted feature extraction. Here, the attributes are extracted with the support of the VGG16 model. At last, the obtained attributes are fed into the MLP approach for identifying the distinct eye problems. Numerous experiments are conducted contrast with conventional classifiers to prove the effectiveness of the developed model.

3.2 Details of Eye Image Collection

The implemented multiple eye disease detection model collects the images from four datasets such as "Ocular Disease Recognition, Retinal Fundus Multi-Disease Image Dataset (RFMiD), Eye Disease Dataset, Bajwa Hospital (Multi Eye Disease Dataset)" accordingly. The details about the mentioned data resources are given below.

Dataset 1("Ocular Disease Recognition"): The required images are attained from the link through "https://www.kaggle.com/datasets/andrewmvd/ocular-disease-recognition-odir5k: access data: 2023-05-13". This data resource is a structured ophthalmic data resource of 5000 sick people with their color fundus photos from right and left eyes, doctor's diagnostic keywords, and ages. This data resource contains the real-life sick person data.

Dataset 2("RFMiD"): The necessary images are gathered from the link via: "https://www.mdpi.com/2306-5729/6/2/14: access date: 2023-05-13". This data resource includes 3200 fundus pictures taken from the three distinct cameras with 46 scenarios. It contains large types of disorders presented in the routine clinical frames. This data resource helps to develop the generalizable systems for the retinal screening.

Dataset 3("Eye Disease Dataset"): The important images are collected from the link "https://www.kaggle.com/datasets/kondwani/eye-disease-dataset: access

date: 2023-05-13". This resource includes five kinds of disorders such as Uveitis, Glaucoma, Crossed eyes, Cataracts, and Bulging eyes. This data resource utilizes the A-I predictive models for the estimation of the eye disorders.
Dataset 4(Bajwa Hospital (Multi Eye Disease Dataset)): The images are acquired from the link "https://data.mendeley.com/datasets/rgwpd4m785: access date: 2023-05-13". This data resource is constructed utilizing the image sources of the three distinct eye modalities. It includes four various classifications like retinal disease, glaucoma, cataract, and normal. Also, it includes 100 fundus images.

Figure 2 provides the sample images of the multiple eye diseases with various classes for all the datasets.

4 Feature Extraction and Multi-layer Perceptron Model for Multiple Eye Disease Detection

4.1 CNN-Based Feature Extraction

To extract the features in the developed model, the CNN assisted feature extraction method is utilized. The feature extraction approach supports to decrease the redundant data from the data resources and increases the speed of learning. In this developed model, the original image is given as the input, where the features are extracted via the VGG16 technique. The VGG16 [16] model includes more convolutional layers. The initial and next convolutional layers consist of 64 attribute kernel filters and the filter size is 3×3. The given picture is given into the initial and next convolutional layer, and then the dimension varies to $224 \times 224 \times 64$. The resultant image is given to the max-pooling layers with 2 strides. Next, the fourth and third convolution layers are includes 124 attribute kernel size and 3×3 filter size. The resultant image is then passed to the fifth, sixth, and seventh convolutional layers with 256 attribute maps and 3×3 kernel sizes. Besides, the eighth to thirteen layers are forming as a two sets of convolution with the 3×3 kernel size and 512 kernel filters. These are accompanied with a max-pooling layer with 1 stride. The fourteen and fifteen layers are entirely linked hidden layers of units 4096 accompanied with 1000 units of softmax resultant layer. The feature-extracted images are collected and utilized for the detection process.

4.2 Multi-layer Perceptron for Classification

Nowadays the MLP technique is widely accepted for the disease detection models. The developed model utilizes the MPL approach to obtain the classified results. Here, the feature-extracted image E_d^{FE} is forwarded to this technique. MLP [17] is