AUTOMATIC DETECTION OF HIGH MYOPIA AND PATHOLOGICAL MYOPIA USING FUNDUS IMAGE

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Abstract

Abstract—Myopia is one of the common eye defects, however it is on the increase among all global users, especially youths. Early detection and treatment are the main requirements to avoid vision loss and other complications. Pathological and high myopia detection from fundus images with the precision of "How to Develop an Automated System with Convolutional Neural Networks" is sought through this research. The proposed system in particular contains the following steps: image preprocessing, feature extraction to identify significant myopia-related features, and classification using a CNN model to classify images as either normal, pathological myopia, or high myopia. Deep learning techniques would be leveraged by the system to reach high accuracy with sensitivity in detecting myopia so as to aid healthcare professionals in the early diagnosis and timely intervention of myopia patients. This automated system would allow for a huge reduction in the screening time of myopia, particularly in a resource-poor setup.

Keywords: Pathological Myopia, High Myopia, Convolutional Neural Network

1. INTRODUCTION

The most common refractive error is myopia, where nearsightedness is caused by blurred vision for distant objects. Within the last few decades, there has been a sharp rise in myopia, mostly within the younger generation. It is often termed a "myopia epidemic" and now tends to be associated with increasing serious risks of ocular complications, such as retinal detachment, glaucoma, and myopic macular degeneration.

Specially feared is pathological myopia, abbreviated as PM. The association with such myopia is considerable elongation of the eyeball resulting in structural alterations in the retina and choroid. With proper early diagnosis and treatment, advancement of PM together with accompanying visual deterioration is averted. Common tests applied for diagnosing myopia include subjective refraction and auto-refraction, which are time-consuming and subjective and will fail in many instances to detect even a slightest alteration in the eye structure.

The limitation has been overcome with the help of researchers focusing more on automated systems that can accurately and efficiently detect myopia with advanced image processing and machine learning. Fundus images provide the most detailed pictures of the retina possible, and from there, valuable diagnostic information regarding the health of the eyes or any conditions such as myopia can be achieved. The analysis of such images by automated systems could lead to possibly identifying myopia with considerable accuracy and efficiency.

This literature review focuses on the latest progress made in automatically detecting myopia using deep learning techniques on fundus images. Based on various approaches proposed by different researchers, primarily focusing on CNNs, transfer learning, and other novel techniques that have been recently developed. We also consider the current challenges and limitations and maybe some future directions of research in this area.


(a) normal fundus (b) high myopia (c) pathological myopia

Figure No. 1

2. LITERATURE REVIEW

Over the last few years, myopia and cataract-related eye diseases have been found highly increasing. A scenario calls for developing automatic diagnostic systems for early detection and treatment of diseases. In this literature survey, six recent studies based on deep learning techniques are discussed and applied to automatically diagnose pathological conditions, myopia and cataract, from fundus images.

Advances in deep learning and CNNs have recently emerged as a high-powered tool for the automatic classification of various ocular diseases. Indeed, results based on using transfer learning with pre-trained models, such as ResNet-18 and ResNet-50, have been promising and even offered superior accuracy rates. For example, in a paper, a classification accuracy of 98.9% was achieved by using the ResNet-18 and 97.8% by the ResNet-50 of cataract and myopia in fundus images [1]. In another paper, it is shown that an AI-based automated fundus screening system is highly efficient for pathological myopia with an accuracy of 99.7% [2]. This differentiation between PM and HM is important because their clinical presentations are almost identical. With this focus, a two-branch network architecture was proposed in [3] to classify normal, abnormal, PM, and HM using a combination of Binary Cross-Entropy loss and Triplet loss. The accuracy was achieved at 81.82%, and precision/sensitivity were obtained at 83.61% and 83.52%, respectively. This makes it clear that loss functions particularly constructed for certain scenarios have a great potential in improving the model's ability to classify even in very similar classes. These studies have sometimes varied their datasets in terms of size and source, sometimes numbering in the thousands for fundus images.

As an illustration, a study by using a dataset of 3,398 fundus images, spanning three classes: cataract, myopia, and normal [1]. Another study had utilized a more comprehensive set of 3,796 color fundus photographs in creating a PM screening system [2]. Preprocessing techniques include resizing, normalization, and data augmentation, which are essential to make the models robust. For example, images were resized into a standard size for balancing the computational efficiency and feature complexity, such as 512x512 pixels [3]. The performance of the developed models will be assessed by different performance metrics: accuracy, sensitivity, specificity, precision, and F1 score. For instance, the accuracy of up to 99.8% with a specificity of 100% in the automated PM screening system has also been observed [4]. However, the method classification between PM and HM has resulted in an accuracy of 81.82% [3]. Such metrics show light toward the prospective clinical applications with respect to the diagnosticians' ability of the models [4]. Although automatic diagnosis has seen a marked improvement in its efficacy, there remains a significant gap in the differentiation of closely related conditions such as PM and HM. There is also a requirement for increasing larger and more diverse datasets, owing to which many datasets may not depict the entire range of ocular pathologies [5]. Several studies have focused on automating the screening of pathological myopia using deep learning techniques. Early approaches relied on hand-crafted features (e.g., texture, shape, and intensity) extracted from fundus images. Traditional machine learning models like Support Vector Machines (SVM) and Random Forests were applied for classification. However, these approaches required manual preprocessing and lacked robustness.

Future studies should include an increase in datasets, optimization in model architecture, and examination of additional features that may further enhance the performance of the diagnostic tool [5]. The potential for this area is promising in improving clinical outcomes with the advent of deep learning techniques being incorporated into automatic diagnosis techniques pertaining to myopia and cataract. The studies reviewed here reveal some promising developments in being able to achieve high accuracy in classification processes regarding ocular diseases as seen in fundus images, thus requiring further research into this space. As technology improves with time, the automation systems formulated and implemented in clinical practice can result in interventions to such patients who have myopia and cataract even more timely and effectively [6].

3. SYSTEM ARCHITECTURE

The automated detection system for high myopia and pathological myopia of the eye based on critical fundus images utilizes the identification of eye conditions by Convolutional Neural Networks (CNNs) founded on key retinal features. Users input fundus images through an intuitive Graphical User Interface. These images contain critical retinal information, which are forwarded to the system where preprocessing and analysis are carried out. It cleans the data in the preprocessing stage by removing noise, standardizing pixel intensities, and resizing all images to make them roughly uniform. The procedures of data augmentation, such as rotation, zoom, and flip, increase the variety of the training set, thus lowering the danger of overfitting the model and improving its generalization.

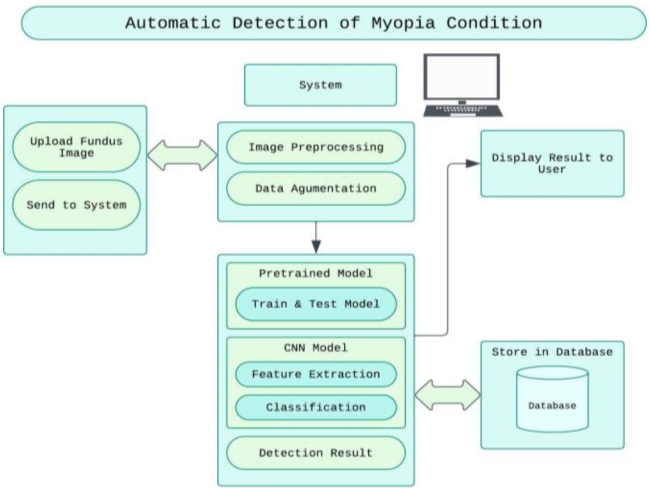

Figure No. 2

In the feature extraction phase, the system automatically finds critical parameters such as optic disc characters, retinal thickness, and blood vessel patterns—all features that could be used to diagnose and differentiate high myopia from pathological myopia. Convolutional layers with spatial feature mapping within the retina are part of the CNN model architecture, and ReLU activation functions enable non-linear learning, while the pooling layers down-sample feature maps and retain only the most important information. Three fully connected layers classify the final outputs. The CNN model classifies the given input images into three classes: normal fundus, high myopia, and pathological myopia. After the process of classification, the outcome is fed back to the user through the designed GUI for better understanding of the condition. Moreover, the system presents quantitative measurements of myopia severities, such as retinal thickness or optic disc abnormalities, to help ophthalmologists in making decisions during treatment. The classification outcome along with numerical values are safely archived in a database that allows for long-term monitoring and follow-up on each patient's disease progression. Information of users and image metadata is also kept in the database, thus allowing longitudinal analysis as well as inter-patient comparisons. The CNN is trained upon a large labeled fundus images set. This would obviously enhance the ability of the model in distinguishing between high myopia and pathological myopia. Updating weights by means of the Adam optimizer takes place during training. It helps achieve efficient convergence and better accuracy of the model.

This system architecture, with efficient preprocessing, automated feature extraction, and strong classification using CNNs, provides a reliable and efficient diagnostic tool to detect myopia-related conditions. The system is scalable for various clinical settings while being user friendly with secure data storage, allowing healthcare providers to improve accessibility and make an early intervention in managing myopia-related eye health issues.

4. CONCLUSION

The proposed system for the detection of high myopia and pathological myopia using fundus images takes an innovative approach towards early diagnosis and interventions in conditions linked with myopia. Convolutional Neural Networks in the classification of fundus images permit a system to segregate with high accuracy between normal fundus images, high myopia, and pathological myopia. With an automatic approach, the manual screening process usually labor-intensive, and the tendency is error-prone, further dictated by the availability of professionals only, which does not need to be taken care of.

The quality of the images improves, and the extraction of more features from an image becomes more reliable by leveraging preprocessing techniques such as noise removal, data cleaning, and image normalization. This would include optic disc parameters, retinal thickness, and blood vessel patterns that are being picked up and analyzed by the CNN model that is optimized through the training process on diverse and augmented datasets. The multi-step process improves on the robustness of the system in the accurate classification of the change in myopia.

With the increasingly rising prevalence of myopia, this project seeks to identify it as early as possible, especially among the younger population due to increased screen time and indoors, increasing its trend. The early diagnosis is very critical to the treatment of patients with high and pathological myopia. If undiagnosed, it would lead to severe complications such as retinal detachment and vision loss. This system supports the health professional using friendly user interface to display results, store diagnostic data, and monitor in the long term, enhancing the process of decision-making through timely interventions and treatment plans. In general, the system would introduce a scalable and accessible solution to the challenges of myopia detection challenges and hence offers an opportunity to leverage on the diagnosis accuracy with AI and efficient access to healthcare, improving the outcome of at-risk populations.

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