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A Comprehensive Survey of Diabetic Retinopathy Detection in Retina Images through Deep Learning Techniques

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A B S T R A C T

Diabetic retinopathy (DR) is a prevalent and potentially sight-threatening complication of diabetes mellitus. This condition ranks among the primary causes of blindness. Recently, we have seen an increase in interest in the use of advanced deep-learning methods in the analysis of medical images. Fundus photo with problems such as low contrast, noise, and uneven lighting. At the forefront of deep learning in image analysis are convolutional neural networks (CNNs), which show remarkable accuracy for distinguishing and categorizing severity levels of diabetic retinopathy in fundus images. Among these architectures, ResNet (Residual Network) CNN is effective. Validation of this approach is done through rigorous experimental evaluation and model training using established datasets such as EyePACS and MESSIDOR. These evaluations underline the potential of these models in the classification of diabetic retinopathy. The strategic alliance between medical expertise and cutting-edge technology is embodied by the integration of artificial intelligence models into cutting-edge devices, exemplified by smartphones. This integration facilitates real-time processing, leading to accelerated diagnosis and timely interventions. Such a combination of capabilities fits seamlessly into the Internet of Medical Things (IoMT) domain.

Keywords: Deep Learning, Image Analysis, CNN, Diabetic retinopathy, Healthcare

Introduction

Diabetic retinopathy (DR) is a formidable global health problem in which the complex blood vessels in the eyes are damaged, often leading to irreversible blindness. The worldwide increasing prevalence of diabetes, with both type 1 and type 2 diabetes reaching epidemic proportions, emphasizes the urgency of addressing the multifaceted impact of this metabolic disorder. In addition to direct eye impacts, diabetes is a pervasive threat to overall health, contributing to heart problems, vascular complications in the legs, and increased susceptibility to stroke. In this landscape, fundus color imaging is emerging as a mainstay in ophthalmology, offering a non-invasive means of identifying the spectrum of eye diseases. The integration of digital fundus imaging with computer-aided diagnosis (CAD) systems represents a transformative advance that provides ophthalmologists with sophisticated tools for effective disease detection and classification, with particular emphasis on the nuanced stages of diabetic retinopathy.

Central to the diagnostic challenge that DR presents is its different stages – proliferative DR, denoting an advanced stage characterized by aberrant blood vessel formation with serious consequences, and non-proliferative DR, denoting an early stage with weakened vessels. Obtaining high-quality fundus images is essential to increase diagnostic accuracy and reveal the complexity of DR-related characteristics. As the field of ophthalmology continues to embrace technological innovation, the collaborative synergy between advanced imaging modalities and evolving CAD systems holds promise for improving the detection and treatment of diabetic retinopathy, ultimately contributing to improved patient outcomes and vision health worldwide.

Literature Review

[1] There have been numerous papers published that introduce and compare various solutions for image Analysis in Diabetic Retinopathy. S. H. Abbood discusses the importance of early diagnosis and care for diabetic retinopathy (DR) to minimize the chance of vision loss. It highlights the use of retinal image analysis as a popular approach for disease diagnosis in modern ophthalmology. The algorithm for improving the quality of fundus images by reducing noise and improving contrast. It mentions the use of two standard datasets, EyePACS and MESSIDOR, to evaluate the experimental results. It aims to fill the research gap by applying circular retinal cropping and evaluating it from a classification perspective. It highlights the importance of early detection of eye diseases such as diabetic retinopathy, glaucoma, retinal neoplasms, and macular degeneration.

[2] In Selvachandran's recent review, the author delves into the evolving landscape of automated Diabetic Retinopathy (DR) detection, with a particular focus on advancements since 2015. The review extensively explores the properties and architectures of Convolutional Neural Network (CNN) models, offering profound insights into their efficacy in detecting DR from fundus images. Notably, the analysis categorizes and scrutinizes various machine

learning models, including CNNs, Artificial Neural Networks (ANNs), and Support Vector Machines (SVMs), based on their types and specific roles in DR detection tasks. While the review serves as a valuable resource for researchers in the field, providing a comprehensive snapshot of recent developments, there is an opportunity for further enhancement. Future iterations could benefit from addressing practical implementation challenges encountered in real-world scenarios, as well as considering broader technological and ethical aspects. This expansion would contribute to a more holistic understanding of the landscape and pave the way for more robust and ethically sound advancements in automated DR detection.

[3] In a critical review by Dolly Das, the imperative of early recognition and diagnosis in preventing the progression of diabetic retinopathy (DR) and subsequent blindness is prioritized. Das carefully explores the landscape of machine learning (ML) and deep learning (DL) models designed for automated DR detection and highlights their transformative impact on the diagnostic process. The review casts a wide net on various ML and DL models, including support vector machines (SVMs), decision trees, convolutional neural networks (CNNs), and deep convolutional neural networks (DCNNs), elucidating their potential in facilitating the early detection of DR. Importantly, the paper addresses the challenges inherent in fundus image analysis and classification for the diagnosis of DR and illuminates the complexity of the field. As a result, Das's work not only provides valuable insights into the critical problem of diabetic retinopathy, but also highlights the paramount importance of early detection in mitigating its serious consequences. In the future, a deeper exploration of the limitations and potential ways to overcome the challenges in applying ML and DL models to real-world clinical settings could further enrich the discussion and guide future research in this key area of health technology.

Methodology

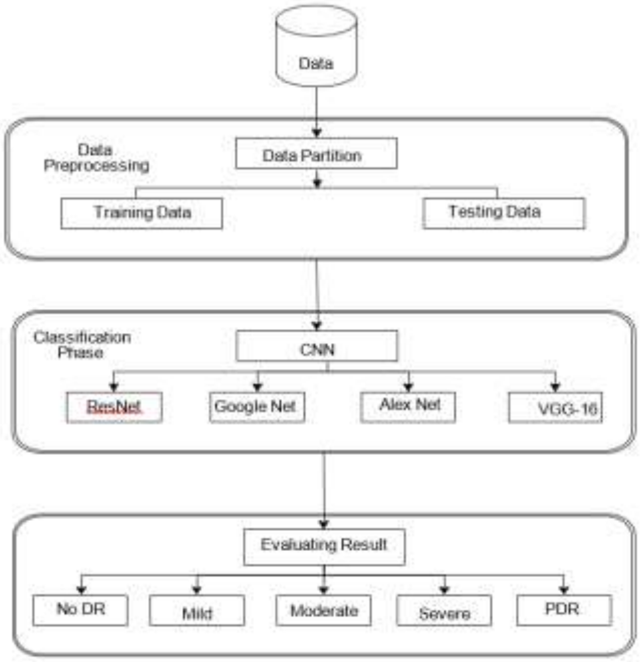

Fig: Generalized Steps for DR Detection

Data Preprocessing: This is the first step in the algorithm and involves preparing the data for training and testing. Converting images to a format suitable for a deep learning model. This can include resizing images, normalizing intensity values, and converting them to grayscale.

Data augmentation: This can help improve model accuracy by artificially increasing the amount of data available for training. Common data augmentation techniques include rotating, flipping, and cropping images.

Image segmentation: This involves identifying and isolating regions of interest (ROIs) in images, such as blood vessels in the retina.

Data partition: After preprocessing, the data is divided into two partitions: training data and test data. The training data is used to train the deep learning model, while the test data is used to evaluate the performance of the model. It is important to have a representative sample of data in each partition to ensure that the model generalizes well to unseen data.

Training data: The training data is used to train the deep learning model. This includes supplying pre-processed images and labels to the model (eg mild DR, moderate DR, severe DR, no DR). The model learns to identify patterns in images that are associated with different severities of DR.

Test data: Test data is used to evaluate the performance of the model. The model is fed preprocessed test images and its predictions are compared with known labels. This helps assess how well the model generalizes to unseen data and identify areas where it might need improvement.

Classification phase: Here, a deep learning model is used to classify the severity of DR in new images. The model takes the pre-processed image as input and outputs a DR severity level prediction.

CNN: It stands for Convolutional Neural Network, a type of deep learning architecture that is well-suited for image classification tasks. CNNs are able to learn complex features from images by applying filters to the data. ResNet, GoogleNet, AlexNet, and VGG-16 are different types of CNN architectures that have been used for image classification tasks. The block diagram shows that the proposed algorithm can be used with any of these architectures.

Evaluation of results: The results of the classification phase are evaluated using metrics such as accuracy, precision, recall and F1 score. These metrics help assess how well the model is performing.

No DR, Mild, Moderate, Severe, PDR: These are different levels of DR severity. The goal of the algorithm is to accurately classify the DR severity level in new images.

Results

Table: Results and Discussion of Different Authors

S.NO	**Author**	**Dataset** (Kaggle)	**Method**	**Accuracy**	**Precision**	**F1-score**	**Recall**
1	S. H. Abbood	EyePacs	ResNet50	92%	82%	78%	98.1%
2	Dolly Das	Messidor	Inception	94%	-	-	-
3	Rishab Gargeya	Messidor	AlexNet	89%	80%	74%	-
4	Al-hazaimeh	Messidor	SVM	97.60%	98.71%	96.07	-
5	M. Z. Atwany	EyePacs	Inception V3	96.5%	98.9%	95.42%	98.1%
6	S. Ghouali	Kaggle	VGGNet	96.01%	91.44%	91.35%	92.51%
7	K. K. Palavalasa	DIARETDB1	CNN	87%	76%	78%	-
8	Gharaibeh	DIARETDB1	SVM	97.6%	96%	98%	-

The exact number of images and their distribution across these categories can vary depending on the version and release of the dataset. Generally, medical image datasets for diabetic retinopathy include thousands of images. Researchers and healthcare professionals use these datasets to develop and train machine learning models for automated DR detection.

It's advisable to refer to the official sources or recent publications related to the EyePACS dataset for the most accurate and current information. Researchers often publish detailed papers or documentation describing the dataset, its characteristics, and any updates made to it.

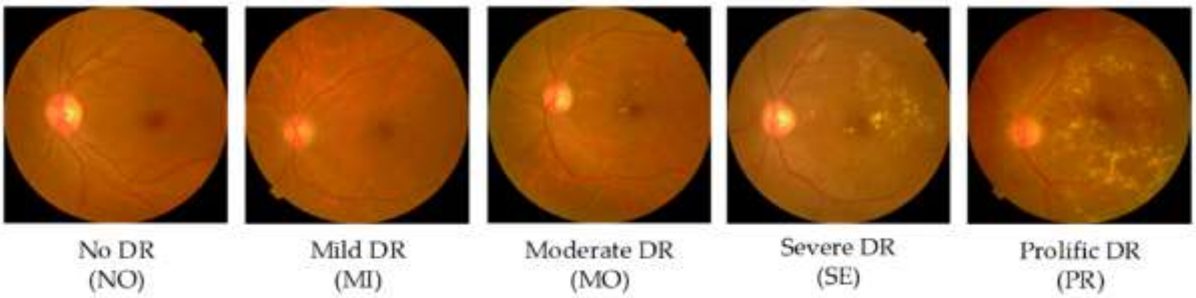

Fig: Sample images of the five DR classes collected from the APTOS 2019 BD dataset along with their class labels.

Dataset:

The EyePACS dataset is a collection of 35109 retinal images used primarily for the detection and diagnosis of diabetic retinopathy (DR).

The classification typically includes the following levels:

No Diabetic Retinopathy (No DR): Images where no signs of diabetic retinopathy are present.

Mild Diabetic Retinopathy (Mild DR): Early signs of diabetic retinopathy, such as microaneurysms.

Moderate Diabetic Retinopathy (Moderate DR): More severe than mild, with a greater number of abnormalities in the blood vessels.

Severe Diabetic Retinopathy (Severe DR): Significant changes in the blood vessels, including the formation of new blood vessels.

Proliferative Diabetic Retinopathy (PDR): The most advanced stage, characterized by the growth of abnormal blood vessels, which can lead to bleeding into the eye.

Conclusion

The study highlights the importance of deep learning techniques for automated analysis of diabetic retinopathy in fundus images. Comparing different models and their performance metrics on different datasets highlights the robustness and effectiveness of deep learning architectures, especially ResNet50, in achieving accurate DR classification. The integration of these models into healthcare systems, especially through high-end devices such as smartphones, holds promise for real-time processing and timely interventions. With further research and development, deep learning algorithms could be used to improve the early detection and management of DR, which could help prevent vision loss for millions of people worldwide.

Research into the detection of diabetic retinopathy (DR) using deep learning models underscores the transformative potential of advanced technologies in ophthalmology. Despite differences in datasets and evaluation metrics, the overall findings suggest a promising trajectory toward more accurate and efficient DR diagnosis, paving the way for impressive applications in clinical settings. With the increasing emphasis on the use of deep learning techniques, researchers have tried to solve the problems of diabetic retinopathy using datasets such as EyePACS, MESSIDOR and Kaggle. Continued research efforts are critical to refining these models, ensuring their practical implementation in healthcare systems, and ultimately reducing the global burden of visual impairment associated with diabetic retinopathy.

References

1. S. H. Abbood, H. N. A. Hamed, M. S. M. Rahim, A. Rehman, T. Saba and S. A. Bahaj, “Hybrid Retinal Image Enhancement Algorithm for Diabetic Retinopathy Diagnostic Using Deep Learning Model,” in IEEE Access, vol. 10, pp. 73079-73086, (2022).
2. Selvachandran, G., Quek, S.G., Paramesran, R. et al. “Developments in the detection of diabetic retinopathy: a state-of-the-art review of computer-aided diagnosis and machine learning methods,” Artif Intell Rev 56, 915–964 (2023).
3. Das, D., Biswas, S.K. & Bandyopadhyay, S. “A critical review on diagnosis of diabetic retinopathy using machine learning and deep learning,” Multimed Tools Appl 81, 25613–25655 (2022).
4. Grauslund, J. “Diabetic retinopathy screening in the emerging era of artificial intelligence,” Diabetologia 65, 1415–1423 (2022).
5. Rishab Gargeya, Theodore Leng, “Automated Identification of Diabetic Retinopathy Using Deep Learning,” Ophthalmology, Volume 124, Issue 7,(2017).
6. M. Z. Atwany, A. H. Sahyoun and M. Yaqub, "Deep Learning Techniques for Diabetic Retinopathy Classification: A Survey," in IEEE Access, vol. 10, pp. 28642-28655, 2022.
7. Al-hazaimeh, O. M., Abu-Ein, A. A., Tahat, N. M., Al-Smadi, M. M. A., & Al-Nawashi, M. M. (2022). “Combining Artificial Intelligence and Image Processing for Diagnosing Diabetic Retinopathy in Retinal Fundus Images.” International Journal of Online & Biomedical Engineering, 18(13).
8. S. Ghouali et al., "Artificial Intelligence-Based Teleopthalmology Application for Diagnosis of Diabetics Retinopathy," in IEEE Open Journal of Engineering in Medicine and Biology, vol. 3, pp. 124-133, 2022.
9. Li, F., Wang, Y., Xu, T., Dong, L., Yan, L., Jiang, M., ... & Zou, H. (2022). “Deep learning-based automated detection for diabetic retinopathy and diabetic macular oedema in retinal fundus photographs”.
10. Freedman, I. G., Li, E., Hui, L., Adelman, R. A., Nwanyanwu, K., & Wang, J. C. (2022). “The Impact of Image Processing Algorithms on Optical Coherence Tomography Angiography Metrics and Study Conclusions in Diabetic Retinopathy.” Translational Vision Science & Technology. 11(9), 7-7.
11. K. K. Palavalasa and B. Sambaturu, "Automatic Diabetic Retinopathy Detection Using Digital Image Processing," 2018 International Conference on Communication and Signal Processing (ICCSP), Chennai, India, 2018.
12. K. Bhatia, S. Arora and R. Tomar, "Diagnosis of diabetic retinopathy using machine learning classification algorithm," 2016 2nd International Conference on Next Generation Computing Technologies (NGCT), Dehradun, India, 2016.
13. Gharaibeh, N., Al-Hazaimeh, O. M., Al-Naami, B., & Nahar, K. M. (2018). “An effective image processing method for detection of diabetic retinopathy diseases from retinal fundus images.” International Journal of Signal and Imaging Systems Engineering.
14. Fayyaz, A. M., Sharif, M. I., Azam, S., Karim, A., & El-Den, J. (2023). “Analysis of Diabetic Retinopathy (DR) Based on the Deep Learning.” Information, 14(1), 30.
15. Skouta, A., Elmoufidi, A., Jai-Andaloussi, S., & Ouchetto, O. (2022). “Hemorrhage semantic segmentation in fundus images for the diagnosis of diabetic retinopathy by using a convolutional neural network.” Journal of Big Data, 9(1), 1-24.