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Glaucoma Detection using Machine Learning and Deep Learning Approach

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Abstract

Glaucoma is a group of eye conditions that damage the optic nerve, which is important for good vision. It is one of the leading causes of blindness worldwide. The Glaucoma Detection System using Machine Learning and Deep Learning approach aims to develop a robust and accurate tool for the early detection of glaucoma. This system will utilize machine learning algorithms to analyze retinal images and assist ophthalmologists in diagnosis and monitoring. The project's primary goal is to create a highly accurate and efficient system that reduces dependency on manual interpretation. It will offer a user-friendly software application for ophthalmologists, extending its potential utility to general practitioners and telemedicine platforms, thereby improving early diagnosis and enhancing accessibility to glaucoma screening and care.

1 Introduction

The Glaucoma Detection System using Machine Learn- ing aims to develop a robust and accurate tool for the early detection of glaucoma. This system will utilize machine learning algorithms to analyze retinal images and assist ophthalmologists in diagnosis and monitoring. The pro- posed system's primary goal is to create a highly accurate and efficient system that reduces dependency on manual interpretation. It will offer a user-friendly software appli- cation for ophthalmologists, extending its potential util- ity to general practitioners and telemedicine platforms, thereby improving early diagnosis and enhancing acces- sibility to glaucoma screening and care.

1.1 Existing Method

There are many systems for the detection of glaucoma

that mainly focus on CNN using deep learning methodology. Some systems are made on the basis of multiple feature extractions. Disadvantages of the existing methods:

- The system uses many technologies making it com- plex to understand and implement.
- Sample size is relatively small and is from a racially homogenous population.
- The need of downsample of the image need to be of low resolution like 224 X 224
- The system contains old techniques for image analy- sis and no further research is made.

1.2 Literature Survey

1. Heyming Tina Song, Ing-Chou Lai, And Yi-Zhu Su, “A Statistical Robust Glaucoma Detection Framework Combining Retinex, CNN, and DOE Using Fundus Images,” IEEE, July 7, 2021.

In this research paper, the authors present a novel and effective automated framework for glaucoma detection using fundus images, addressing the limi- tations of manual detection and existing automated methods. They combine Retinex theory, convolu- tional neural networks (CNN), and robust design of experiments (DOE) to enhance the accuracy and robustness of glaucoma detection. The proposed framework demonstrates high effectiveness with sensitivity, specificity, and accuracy estimates all above 0.95, making it a promising solution for glaucoma diagnosis. The approach is characterized by its simplicity, utilizing a basic CNN model, and is supported by clear mathematical notations and intuitive graphs for reproducibility. This system uses many technologies making it complex to understand and implement. Though the paper uses complexities the result of previous research is more accurate.

2. H. Fu, J. Cheng, Y. Xu, C. Zhang, D. W. K. Wong,
J. Liu, and X. Cao, “Disc-aware ensemble network for glaucoma screening from fundus image”, IEEE Trans. Med. Imag., vol. 37, no. 11, pp. 2493–2501,
Nov. 2018.

In this research paper, the authors propose a novel deep learning-based approach for glaucoma screening directly from fundus images. The Disc- aware Ensemble Network (DENet) integrates both global and local image information to enhance glaucoma detection. DENet comprises four streams: a global image stream, a segmentation-guided network, a local disc region stream, and a disc polar transformation stream. These streams work together to provide a comprehensive assessment of the fun- dus image, improving glaucoma detection accuracy. Experimental results on two datasets demonstrate that DENet outperforms state-of-the-art methods in glaucoma screening. The proposed approach offers a promising and innovative solution to address the challenges of early glaucoma detection from fundus images. Size of the trained data relatively small and is from a racially homogenous population.

S. Gheisari, S. Shariflou, J. Phu, J. P. Kennedy, A. Agar, M. Kalloniatis, and M. Golzan, “A combined convolutional and recurrent neural network for enhanced glaucoma detection”, Sci. Rep., vol. 11, Jan. 2021.

The paper presents a novel approach for glau- coma detection by combining Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs). This combined CNN/RNN model is designed to not only extract spatial features from individual fundus images but also capture temporal features from sequences of fundus images, such as those obtained from fundus videos. Using a dataset consisting of both fundus images and videos, the study demonstrates that this approach outperforms traditional CNN models, achieving an average F-measure of 96.2

3. R. M. Haralick, K. Shanmugam, and I. Dinstein, “Textural features for image classification”, IEEE Trans. Syst., Man, Cybern., vol. SMC-3, no. 6, pp. 610–621, Nov. 1973.

The paper focuses on the development of tex- tural features to describe and classify images. It presents a comprehensive analysis of texture and proposes a set of textural descriptors for image analysis. These descriptors enable the quantification of textural patterns in images, providing valuable information for image classification and segmen- tation. The paper laid the foundation for the use of textural features in image processing and has been instrumental in various applications, such as computer vision, pattern recognition, and remote sensing.

1.3 Proposed Method

The paper focuses on the development of textural features to describe and classify images. It presents a compre- hensive analysis of texture and proposes a set of textural descriptors for image analysis. These descriptors enable the quantification of textural patterns in images, providing valuable information for image classification and segmen- tation.

2 Methodology

1. **Data Preparation:**
Collect a dataset comprising 650 fundus images, containing 168 glaucomatous and 482 healthy cases. Divide the dataset into training, validation, and test sets.

2. **Image Processing:**
Process each image in the dataset by:

(a) Converting the input image to grayscale.

(b) Resizing the image to a standardized resolu- tion, such as 78x116 pixels.

(c) Applying a median filter to reduce noise and enhance image quality.

3. **Object Detection:**
Implement an object detection algorithm to identify the optic nerve and surrounding structures, including the cup and macula, in the processed image.

4. **Feature Extraction:**
Extract pertinent features from the detected regions to characterize the structures. This may encompass features such as shape descriptors, texture patterns, and intensity statistics.

5. **Classification:**
Employ a classification model, such as a machine learning algorithm or a deep neural network, to cat- egorize the image based on the extracted features. Train the classifier using the training dataset and evaluate its performance using the validation set. Fine-tune the model parameters if necessary.

6. **Evaluation:**
Evaluate the model's performance using the test dataset. Calculate classification metrics such as ac- curacy, sensitivity, and specificity for glaucoma de- tection based on the model's predictions.

3 Result Analysis

In our analysis, we evaluated the performance of three algorithms—decision tree, logistic regression, and CNN—implemented in our Glaucoma Detection System.

Firstly, employing the decision tree algorithm yielded an accuracy of 63.46%. Despite achieving a relatively moderate accuracy, this model exhibited a balanced per- formance in terms of precision, recall, and F1-score for both glaucomatous and healthy cases. However, it demon- strated a limited capability in correctly identifying glau- coma cases, as indicated by its lower sensitivity.
Moving on to logistic regression, we observed a notable improvement in accuracy, achieving 79.81%. This model exhibited superior performance compared to the decision tree, particularly in terms of precision, recall, and F1- score for identifying glaucoma cases. It demonstrated a higher sensitivity, suggesting its effectiveness in correctly diagnosing glaucoma.
Lastly, our CNN implementation achieved an accuracy of 76.92%. Although this model performed competitively, its accuracy fell slightly below logistic regression. How- ever, CNN showed promising results in terms of sensitiv- ity, specificity, and F1-score, indicating its potential for accurate glaucoma detection.
Overall, our analysis underscores the importance of selecting appropriate algorithms for glaucoma detection, considering factors such as accuracy, sensitivity, and ease of implementation. While logistic regression emerged as the top performer in our experiments, CNN also show- cased significant potential, highlighting the benefits of leveraging deep learning techniques in medical image analysis. Further refinement and optimization of these algorithms could enhance the efficacy of our Glaucoma Detection System, ultimately contributing to early diag- nosis and improved patient outcomes in the management of glaucoma.

4 Conclusion

This proposed system focused on the importance of hav- ing a method to identify and document the structure of the optic nerve as a routine part of glaucoma care. While ad- vanced imaging techniques show promise in aiding glau- coma diagnosis and care, they haven't proven to be signif- icantly better than the established methods. The proposed system highlights the need for further research and de- velopment in this field to ensure that glaucoma patients receive the best possible care and that optic nerve evalua- tion becomes an integral part of standard glaucoma man-

Table 1: Results Analysis agement.

Decision Tree

Metric	Value
Accuracy	0.6346
F1 Score	0.6387
Precision	0.6433
Recall	0.6346

Logistic Regression

Metric	Value
Accuracy	0.7981
F1 Score	0.7941
Precision	0.7916
Recall	0.7981

CNN Algorithm

Metric	Value
Accuracy	0.7692
F1 Score	0.7541
Precision	0.7631
Recall	0.7784

References

1. Heyming Tina Song, Ing-Chou Lai, And YI-zhu su "A Statistical Robust Glaucoma Detection Frame- work Combining Retinex, CNN, and DOE Using Fundus Images", IEEE, July 7, 2021

2. H. Fu, J. Cheng, Y. Xu, C. Zhang, D. W. K. Wong, J. Liu, and X. Cao, "Disc-aware ensemble network for glaucoma screening from fundus image", IEEE Trans. Med. Imag., vol. 37, no. 11, pp. 2493–2501, Nov. 2018.

3. S. Gheisari, S. Shariflou, J. Phu, J. P. Kennedy, A. Agar, M. Kalloniatis, and M. Golzan, "A combined convolutional and recurrent neural network for en- hanced glaucoma detection", Sci. Rep., vol. 11, Jan. 2021

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