International Journal of Engineering Technology & Advanced Learning
ISSN: 3107-4227, Vol. 01 (01), March 2025, pp. 53-57

Glaucoma Diagnosis from Fundus Images using Convolutional Neural Network Model: VGG-19

Seema Kirar[1], Manoj Soni[1]

[1]*Department of Electronics and Communications Engineering, Bansal Institute of Science and Technology, Bhopal, Madhya Pradesh, India.*

Abstract

Machine learning has emerged as an especially profound method for easy solutions, making medical procedures more and more accurate, easy to use, and fairly accurate. This research study focuses on glaucoma which is one of the more common yet less spoken of visual disorders in the country and in the world. We study and see the likely increased load on the health system due to this disease and consider proposing a deep learning models that can easily and accurately point out glaucoma within patients, reducing the workload of doctors. The potential model picked for this work is VGG-19. A detection Acc of 98.34 % for the indication of glaucoma is provided using VGG-19, thus assuring a novel application and answer about the detection of glaucoma.

Keywords: Eye Disorder, Glaucoma, Deep Learning, VGG-19 Model.

1. Introduction

Healthcare, one of the deepest applications of deep learning, is easily used and fairly accurate, off of easing solutions and making medical procedures more and more accurate. Thus, this paper tries to approach one of the more common and yet less spoken of visual disorders in the country and in the world, namely, glaucoma. According to the national Institute of health, approximately 11.2% 40 years and older have glaucoma in India. The primary open angle is estimated a problem of effect in about 6.4% whereas the problem of effect with primary angle closure glaucoma is 2.54 million [1]. Roughly speaking, animated prevalence of glaucoma in adults aged 40 years and above is between 2.5 percent amongst Indians [2]. According to studies, Glaucoma is estimated to affect 27.8 by 2040 in Asia alone, amongst which India and China being the bearers of maximum population concentrated areas in the region will most likely have to be the maximum load [3]. Glaucoma is a fault of the eyesight of our eye. That is often hatching based related to the conditions of because the optic nerve the eye especially. The optic nerve transmits image formed from signals received from the retina to the brain [4] and damage caused due to high pressure in the eye can occur, causing intake of low amounts of ocular solutions. Glaucoma is a disease of the optic nerve that usually occurs with age and primarily affects adults aged 60 or over when it comes to its symptoms. Due to the first modern lifestyle and its effects on the visual power of the upcoming generations, glaucoma has begun to develop spins at the age of 40 and even in early teens as well [5].

2. Related Work

Recent research studies utilized machine learning algorithms on classifications of datasets in the last decade, as part of a broader medical trend in detecting glaucoma. In the last decade, major research works were performed in the field of diagnosis approach for glaucoma. Noronha et al. [7] published a method that used higher-order spectra cumulates along with support vector machine classification. Acharya et al. [8] used Gabor Transform features in classifying the glaucoma dataset. Singh et al. [9] presented a wavelet-based approach in the year 2016, whereas Maheshwari et al. [10] applied the VMD methodology to the RIM-ONE dataset in the year 2017 [11]. Soltani et al. [12] presented a fuzzy logic-based approach that considered many risk indicators, and Mohamed et al. [13] developed a cup and disc segmentation algorithm based on the RIM-ONE [11] dataset. Subsequent studies employ VGG-19 and CNN for feature extraction through the two-dimensional empirical mode decomposition (BEMD) technique, while PCA is applied for dimensionality reduction. When these features are combined with an SVM-based classifier, they achieve an impressive 98.92% A_{cc} on the ACRIMA [14] dataset and an overall A_{cc} of 98.31% [15]. In addition, the study integrates machine learning and deep learning on raw fundus images based on a new CNN model for deep feature extraction. Applying the hybrid model-the combination of CNN and Adaboost on the ACRIMA dataset performs excellently with an A_{cc}92.96%, an F1 score of 93.75%, and an AUC value of 0.928 [16]. Authors in [17-22] have proposed several techniques for detecting glaucoma, including SVM, QB-VMD, CVMD, DWT, and EWT. In

E-mail ID: cmadhakad@gmail.com

their study, Kirar et al. [22] employed a methodology that combines SS-QB-VMD with SVM. This research considers a total of 705 images sourced from the ACRIMA repository [14]. Authors in [23-28] have proposed several techniques for detecting glaucoma using Generalized Deep Learning Model, Hybrid Feature, Texture Information, Transfer Learning, convolutional neural network, DenseNet, MobileNet, Neural and DL models.

3. Methodology

3.1. Image dataset Dataset

Acquiring a well-labeled dataset is crucial for the effective development of glaucoma detection methods. However, finding such datasets can be challenging due to the limited number of samples and the need to protect patient privacy. In this case, we were able to overcome these challenges by utilizing the reliable ACRIMA Dataset [14]. This dataset includes images of both glaucomatous and normal eyes, comprising 310 images of normal eyes and 395 images of glaucomatous eyes, totaling 705 eye images. Typical examples from both categories are displayed in Figure. 1.

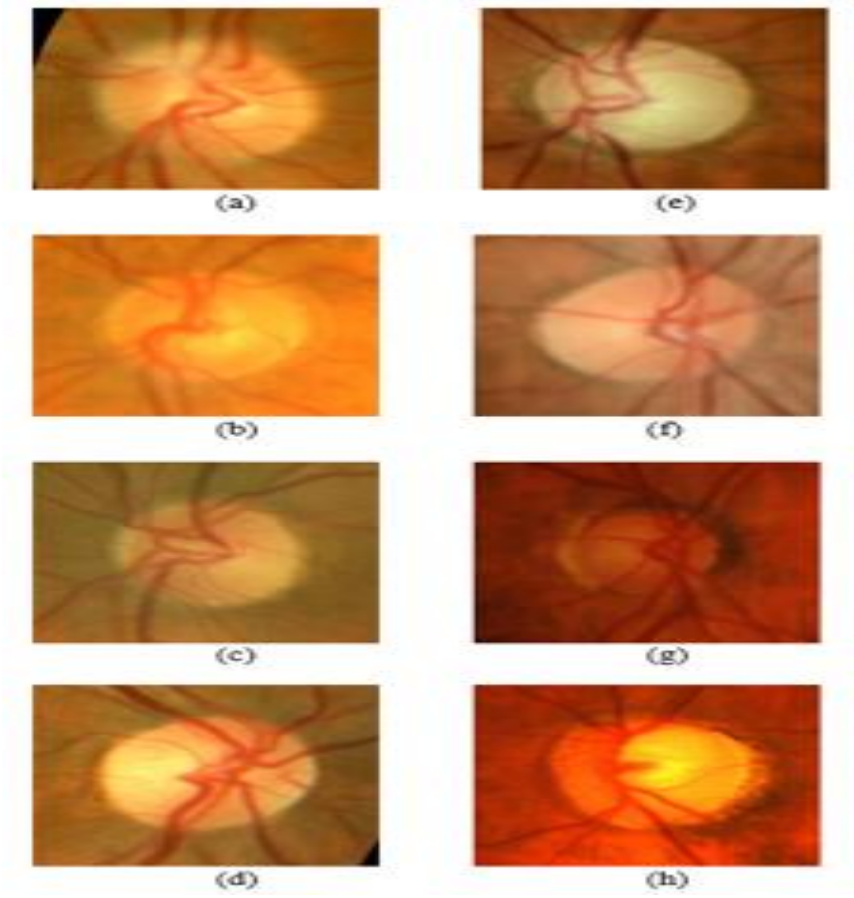

Figure 1. Typical images for binary class: (a-d) Healthy, and (e-h) glaucoma.

3.2. Proposed Methodology

Figurer 1 Depicts the approaches for this research. We intend to merge a number of already pre-trained deep learning models in order to classify glaucoma and apply a data preprocessing step that involves image processing normalization at the front end to normalize the model inputs. Data then fitted VGG-19 [29] model under consideration.

3.3. Extraction of Features

Over the course of feature extraction, attributes are transformed to linear combinations of features that are mutually orthogonal. Such transformation may increase the A_{cc} as well as efficiency of the model and reduce the data complexity. In our case, the extracted feature from the image would be disjoint subsections of pixels around the region of the optical neve, specifically looking for a break in flow or damage in the section of the pixels or pixel density of the same.

3.4. Training and Classification of Model

One model in this work is VGG-19 [29]. Model aiming A_{cc} and efficiency using inception modules for the same. The VGG is a Visual Graphics Models, VGG-19 is essentially an enhanced version of the VGG-16, featuring additional stacking, pooling, and embedding between adjacent layers. The Exception model stands for Extreme Inception model. Performance Matrice isA_{cc}:

$$A_{cc} = \frac{T^N + T^P}{T^N + T^P + F^N + F^P}$$

Where the normal meanings of T^P, T^N, F^P, and F^N are used

4. Results and Discussions

In this paper, we explore the use of VGG-19 deep learning model for the accurate detection of glaucoma. Initially, the images were resized to meet the model's requirements. The processed images were then fed into the model, where they first passed through convolutional layers, followed by fully connected layers, ultimately extracting features and making classifications based on those features.

Table 1. Comparison of Existing Models

Reference	Models	Accuracy
[14]	CNN	79.97%
[23]	GoogleNet	65.00%
[20]	SVM	92.06%
[16]	CNN	92.96%
[26]	TL	96.30%
[27]	ML	92.00%
Proposed	DL	98.34%

The received A_{cc} (in %) for detecting glaucoma is 98.34% using VGG-19. Table I. shows the comparison of models for glaucoma detection. Figurer 3 is a graphical comparative drawn between all of the individual models on the basis of the performance measuring metrics mentioned in this paper, including Acc. This will help us to decide the best performing model across the board in terms of overall performance. In discussion section, with an astounding $A_{cc}$of 98.34%, the suggested VGG-19 model outperforms CNN, Google Net, and SVM models, as the discussion highlights mentioned in Table I. The remarkable A_{cc} of VGG-19 model implies that it is effective in detecting glaucoma, underscoring the significance of model selection for the best possible diagnostic results. The comparison for glaucoma detection models have been mentioned in Figure 3.

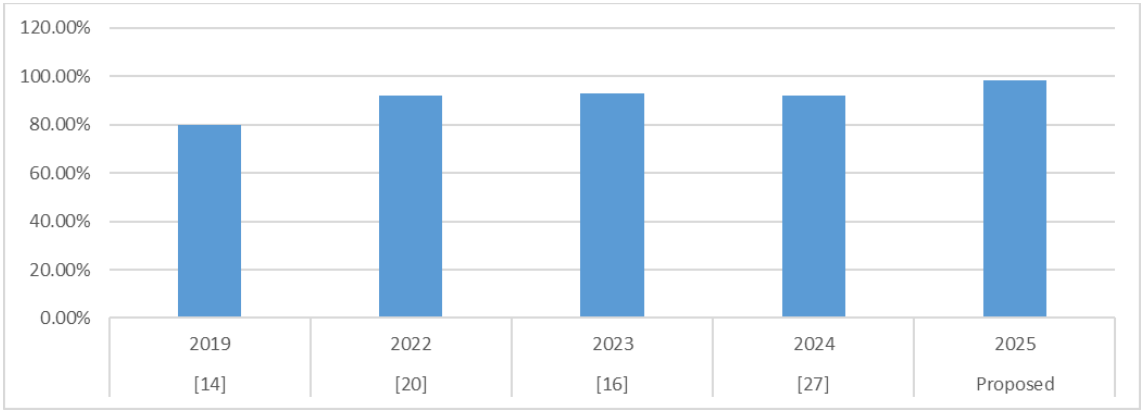

Figure 3. Comparison of glaucoma detection models

5. Conclusions

Glaucoma is a disease found in people of all ages. Early detection of this disease can help mitigate the damages and preserve vision over time. It is one of the leading causes of vision loss. Deep learning models can play a decisive role in detection of glaucoma. In this work, VGG-19 have used on ACRIMA dataset for accurate glaucoma detection. It may also be useful to detect other diseases.

References

[1] R. George, R. S. Ve, and L. Vijaya, "Glaucoma in India: estimated burden of disease," J Glaucoma, vol. 19, no. 6, pp. 391-397, Aug. 2010.

[2] P. Rewri, "Towards better management of glaucoma in India," Indian J Ophthalmol, vol. 71, no. 3, pp. 686-688, Mar. 2023. Published online Mar 3, 2023.

[3] Y.-C. Tham, X. Li, T. Y. Wong, H. A. Quigley, T. Aung, and C.-Y. Cheng, "Global prevalence of glaucoma and projections of glaucoma burden through 2040: a systematic review and meta-analysis," Review Ophthalmology, vol. 121, no. 11, pp. 2081-2090, Nov. 2014.

[4] K. Boyd, "What Is Glaucoma? Symptoms, Causes, Diagnosis, Treatment," Dec. 04, 2023. Available: https://www.aao.org/eye-health/diseases/what-is-glaucoma

[5] "Glaucoma," https://my.clevelandclinic.org/health/diseases/4212-glaucoma.

[6] "GlaucomaPreventionmethods,"https://www.cdc.gov/visionhealth/resources/features/glaucomaawareness.html#:~:text=Open%2Dangle%20glaucoma%20does%20not,avoid%20vision%20loss%20from%20glaucoma https://www.cdc.gov/visionhealth/resources/features/glaucomaawareness.html#:~:text=Open%2Dangle%20glaucoma%20does%20not,avoid%20vision%20loss%20from%20glaucoma.

[7] K. P. Noronha, U. R. Acharya, K. P. Nayak, R. J. Martis, and S. V. Bhandary, "Automated classification of glaucoma stages using higher order cumulant features," Biomed Signal Process Control, vol. 10, pp. 174–183, 2014.

[8] U. R. Acharya, E. Ng, L. W. J. Eugene, K. P. Noronha, L. C. Min, K. P. Nayak, and S. V. Bhandary, "Decision support system for glaucoma using Gabor transformation," Biomed Signal Process Control, vol. 15, pp. 18–26, 2015.

[9] A. Singh, M. K. Dutta, M. ParthaSarathi, V. Uher, and R. Burget, "Image processing based automatic diagnosis of glaucoma using wavelet features of segmented optic disc from fundus image," Comput Methods Prog Biomed, vol. 124, pp. 108–120, 2016.

[10] S. Maheshwari, R. B. Pachori, V. Kanhangad, S. V. Bhandary, and U. R. Acharya, "Iterative variational mode decomposition based automated detection of glaucoma using fundus images," Comput Biol Med, vol. 88, pp. 142–149, 2017.

[11] F. Fumero, S. Alayón, J. L. Sanchez, J. Sigut, and M. Gonzalez-Hernandez, "Rim-one: An open retinal image database for optic nerve evaluation," in 2011 24th International Symposium on Computer-based Medical Systems (CBMS), pp. 1–6, IEEE, 2011.

[12] A. Soltani, T. Battikh, I. Jabri, and N. Lakhoua, "A new expert system based on fuzzy logic and image processing algorithms for early glaucoma diagnosis," Biomed Signal Process Control, vol. 40, pp. 366–377, 2018.

[13] N. A. Mohamed, M. A. Zulkifley, W. M. D. W. Zaki, and A. Hussain, "An automated glaucoma screening system using cup-to-disc ratio via simple linear iterative clustering superpixel approach," Biomed Signal Process Control, vol. 53, p. 101454, 2019.

[14] A.D. Pinto, S. Morales, V. Naranjo, T. Kohler, J. Mossi, and A. Navea, "CNNs for Automatic Glaucoma Assessment Using Fundus Images: An Extensive Validation", Biomed Eng Online, Vol.18, No.29, pp. 1-19, 2019.

[15] A. Elmoufidi, A. Skouta, S. Jai-Andaloussi, and O. Ouchetto, "CNN with Multiple Inputs for Automatic Glaucoma Assessment Using Fundus Images," International Journal of Image and Graphics, vol. 23, no. 01, 2023.

[16] T. Aydin Oguz and M. Yaganoglu, "A CNN-based hybrid model to detect glaucoma disease," Multimedia Tools and Applications, 2023.

[17] B.S. Kirar, and D.K. Agrawal, "Glaucoma Diagnosis using Discrete Wavelet Transform and Histogram Features from Fundus Image", International Journal of Engineering & Technology(UAE), Vol.7, No.4, pp.2546-2551, 2018.

[18] B.S. Kirar, and D.K. Agrawal, "Computer Aided Diagnosis of Glaucoma Using Discrete and Empirical Wavelet Transform from Fundus Images, IET Image Processing, Vol.13, pp.73-82, 2019.

[19] B.S. Kirar, and D.K. Agrawal, "Current Research on Glaucoma Detection Using Compact Variational Mode Decomposition from Fundus Images", International Journal of Intelligent Engineering and Systems, Vol.12, No.3, pp.1-10, 2019.

[20] B.S. Kirar, R.S.R. Gosula, and D.K. Agrawal, “Glaucoma Detection Using SS-QB-VMD Based Fine Sub Band Images from Fundus Images,” IETE Journal of Research, Vol.68, No.6, pp. 4421-4428 2022.
[21] D.K. Agrawal, B.S. Kirar, and R. B. Pachori, “Automated Glaucoma Detection Using Quasi-Bivariate Variational Mode Decomposition from Fundus Images”, IET Image Processing Vol.13, pp. 2401-2408, 2019.
[22] B.S. Kirar, D.K. Agrawal, and S. Kirar “Glaucoma Detection Using Image Channels and Discrete Wavelet Transform,” IETE J. Research, doi:10.1080/03772063.2020.1795934.
[23] S. Serte, and A. Serener, "A Generalized Deep Learning Model for Glaucoma Detection," In: Proc. Of 3rd International Symposium on Multidisciplinary Studies and Innovative Technologies (ISMSIT), Ankara, Turkey, pp. 1-5, 2019.
[24] M. Claro, R. Veras, A. Santana, F. Araújo, R. Silva, J. Almeida, D. Leite, “An Hybrid Feature Space from Texture Information and Transfer Learning for Glaucoma Classification”, Journal of Visual Communication and Image Representation, Vol.64, 2019,
[25] P. Elangovan, and M.K. Nath, “Glaucoma assessment from color fundus images using convolutional neural network”, Int J Imaging Syst Technol, pp. 1-17, 2020.
[26] F.J. Xavier and F.F. Fanax, "ODMNet: Automated Glaucoma Detection and Classification Model Using Heuristically-Aided Optimized DenseNet and MobileNet Transfer Learning," Cybernetics and Systems, vol. 55, no. 1, pp. 245-277, 2024.
[27] E. Bouris, O.P Odugbo, H. Rasheed, S. Jin, Z. Fei, E. Morales, J. Caprioli, “A Neural Network for the Detection of Glaucoma from Optic Disc Photographs”, Investigative Ophthalmology & Visual Science, Vol. 65, 1634, 2024.
[28] S. Dixit, B.S. Kirar, and D.K. Agrawal, Performance analysis of DL models for accurate glaucoma detection, 8th IEEE International Students' Conference on Electrical, Electronics and Computer Science (SCEECS), 24-25 February 2024, Bhopal, India, pp. 1-6, April 2024.
[29] T. Siddharth, B.S. Kirar, and D.K. Agrawal, Plant Species Classification Using Transfer Learning by Pretrained Classifier VGG-19. arXiv 2022, arXiv:2209.03076.