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An Examination of Data Mining Approaches in Glaucoma Identification

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***Abstract*: Glaucoma is a genetic eye disorder that can lead to blindness. Early detection is challenging, requiring automated techniques like feature extraction and machine learning algorithms. However, these methods only identify the type of glaucoma. A thorough evaluation of over more than machine learning approaches, including support vector machine (SVM), K-means, and fuzzy c-means clustering algorithm, was conducted to identify the most accurate methods for detecting and predicting glaucoma. In this paper we have analysis of systematic review can identify the most reliable method for detecting and forecasting glaucoma, which can be used to improve future methods.**

***Keywords*: Concepts, Fundus image, Glaucoma detection, Models, Optical coherence tomography.**

1. Introduction

Glaucoma is a severe eye disease affecting millions globally, affecting 3.5% of people over 45. With population growth predicted to reach 80 million by 2020 and 111.8 million by 2040, early detection and treatment are crucial for preventing visual issues. Heuristic approaches use a combination of data and catalogue to define characteristics and improve understanding of the disease.

Glaucoma, a worldwide optic neuropathy that affects over 90 million people, is the second largest cause of blindness and disability. The number of persons with glaucoma aged 40 to 80 is anticipated to increase to 111.8 million by 2040 as the population ages. Early identification is critical for preventing future vision loss. Fundus photography is the most widely used tool for identifying glaucoma, however clinical judgement are subjective and prone to mistake. AI and deep learning (DL) models are developing fields that automate the interpretation of retinal images. Advances in computer systems and vast datasets enable these systems to imitate human brain processes, making deep learning a potential field for automating glaucoma detection. The following some of the key factors for the glaucoma detection, such as, Eye illnesses like diabetic retinopathy, glaucoma, cataracts, and macular degeneration affect both rural and urban populations. Glaucoma, a complex condition causing visual loss, is inherited and can be caused by high intraocular pressure. In India, around 12 million people suffer from it, with 1.2 million experiencing blindness. Other causes include eye injuries, infections, clogged blood vessels, and inflammatory diseases. Secondary glaucoma is the most prevalent, often linked to other disorders like cataracts or diabetes. Pigmentary glaucoma occurs when a pigment from the iris penetrates the eye [1].

The paper provides a section II: The concepts of glaucoma, in next section III: literature review and then section IV discusses outlines its applications using various approaches in glaucoma detection, followed by section V conclusion.

2. Concepts of Glaucoma

Glaucoma is an assortment of disorders that can cause visual loss, with some affecting the retina and optic nerve. Lowering IOP is an effective therapy for open-angle glaucoma (OAG). Early identification is critical for effective therapy and halting development. Glaucoma is diagnosed using a retinal examination, imaging techniques, VFs evaluation, and IOP measurements. Early identification is critical for successful therapy and halting development.

Glaucoma is an irreversible visual neuropathy produced by injury to the optic nerve head, which causes vision loss. Retinal fundus photography helps with detection but is subjective and time-consuming. Computer-based glaucoma detection is made possible by computational technologies like eye image processing and machine learning classifiers, allowing for bulk screening [2].

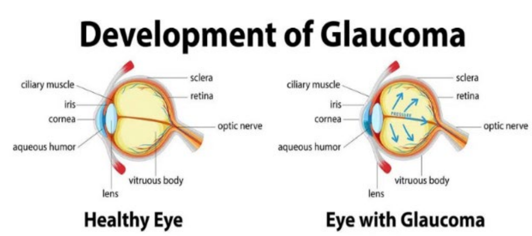

Fig. 1. Comparison of Normal vision and Glaucoma vision [23]

A. Model for Assessing Glaucoma

1) Visual Fields

SAP is the primary method for monitoring glaucoma changes, with VFs being the gold standard for diagnosis. AI systems and advanced testing equipment enhance efficiency and accuracy. Deep learning algorithms extract data from VFs, excluding high-risk samples. More patient characteristics are

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gathered for further identification, and results' validity can be confirmed by comparing them with doctor assessments [22].

2) Fundus images

Artificial intelligence (AI) is being used in fundus photography to detect early fundal abnormalities, making early detection more comfortable. AI has been used in diagnosing diabetic retinopathy and glaucoma, focusing on segmenting and detecting the optic nerve head, optic disc, and RNFL. Early AI algorithms were simple, but deep learning systems and multi-integrated CNN models have improved the accuracy and speed of fundus lesion detection [22].

3) OCT

Optical Coherence Tomography (OCT) has improved sensitivity and specificity over fundus imaging, enabling AI improvements. Spectral domain OCT (SD-OCT) and scanning source OCT (SS-OCT) improve axial resolution, allowing quicker and more precise morphological data recording. An Anterior segment OCT measures biometric characteristics, while the Deep Learning model categorizes and identifies lesion locations. SD-OCT is commonly used in ophthalmology and can be integrated with 3D deep learning systems for glaucomatous optic nerve head degeneration [22].

3. Data Mining in Glaucoma Detection

Classifiers are increasingly used in medical diagnosis, and data mining helps identify categories, patterns, and linkages. However, data mining has limitations, such as requiring specific data types and formats. Decision tree learning is a predictive modeling approach used in statistics, machine learning, and data mining to forecast attribute values. Support Vector Machines (SVM) have been successfully used for diagnosing breast cancer, recognizing handwritten digits, faces, and categorizing text. Regression is a mathematical prediction approach that predicts continuous values [24].

4. Literature Review

Glaucoma is a disorder that damages optic nerves, leading to blindness and irreversible visual loss. It affects 80 million people in 2020 and is projected to reach 111 million by 2040. Early identification and treatment are crucial to prevent vision loss. Manual screening is time-consuming due to a lack of skilled ophthalmologists. Automated diagnostic methods are needed for accuracy and efficiency. Fundus pictures can be used to diagnose and categorize glaucoma, including fundoscopy and optical coherence tomography. The ratio of the optic cup and optic disc size and shape are crucial indicators in fundus imaging. In this section the few oof theoretical review of glaucoma detection as follow as,

Yu, S. *et al.* [4] A modified U-Net architecture is used for optic disc and cup segmentation, combining pre-trained ResNet-34 with conventional U-Net decoding layers. The model achieved an average dice value of 97.31% for disc segmentation and 87.61% for cup segmentation, achieving robust performance without retraining or fine-tuning. Soltani *et al.* [6] employed canny edge detection to extract OD and OC contours, and a fuzzy engine with CDR and patient health data to identify fundus pictures as normal or glaucoma. Chia *et al.* [7] created a fully convolutional network to extract OD and OC contours, with a 91% accurate classification rate. Arai-Okuda, M. *et al.* [8] A study found no significant difference in lactate concentrations between individuals with primary open-angle glaucoma and cataract. However, body mass index positively correlated with lactate concentration in POAG patients. Glaucoma disrupts lactate metabolic equilibrium, causing a compensatory surge in glucose and glutamate in the retina.

Perdoma *et al.* [9] created a three-step CNN model with 15 layers for OD and OC segmentation and 12 levels for extracting morphometric characteristics, achieving an 89% classification accuracy on the Drishti dataset. Sevastopolsky *et al.* [10] created an OD and OC segmentation algorithm based on U-Net, with dice coefficients of 94% and 85%, respectively. Thakur *et al.* [11] created a hybrid model for segmenting OD and OC using adaptive FCM and level sets, which achieved 93% and 92% accuracy on the Drishti dataset, respectively.

Soorya *et al.* [3] developed a method for obtaining OC contours by tracing bends in the vessel inside the OD. The approach employed CDR as a characteristic for glaucoma identification and obtained an average accuracy of 97% on 225

Table 1
The recent applications of glaucoma detection using various techniques

S.No.	Paper	Author	Year
1	Potentially compromised systemic and local lactate metabolic balance in glaucoma, which could increase retinal glucose and glutamate concentrations [8]	Mina Arai-Okuda, Yusuke Murai, & Makoto Nakamura	2024
2	Automated glaucoma screening method based on image segmentation and feature extraction [12]	F. Guo, W. Li, J. Tang, B. Zou, and Z. Fan,	2020
3	Adopting run length features to detect and recognize brain tumor in magnetic resonance images [13]	A. S. Derea, H. K. Abbas, H. J. Mohamad, and A. A. Al-Zuky	2019
4	A review on glaucoma disease detection using computerized techniques [14]	F. Abdullah, R. Imtiaz, H. A. Madni	2021
5	Frequency domain analysis of grey level intensities for extraction of optic disc in retinal images [15]	S. D. Bharkad	2021
6	Image forgery detection using singular value decomposition with some attacks [19]	N. Rathore, N. K. Jain, P. K. Shukla, and U. Rawat	2021
7	Computer-aided diagnosis of glaucoma using fundus images: a review [18]	Y. Hagiwara, J. E. W. Koh, J. H. Tan, S. V. Bhandary, A. Laude, and E. J. Ciaccio,	2021
8	Iris tissue recognition based on GLDM feature extraction and hybrid MLPNN-ICA classifier [20]	N. Ahmadi and G. Akbarizadeh	2018
9	Estimating functions for visual field progression in newly diagnosed exfoliation glaucoma patients in Sweden [15]	Marcelo Ayala	2023
10	Mult objective genetic algorithm and convolutional neural network based COVID19 identification in chest X-ray images [21]	P. K. Shukla, J. Kaur Sandhu, A. Ahirwar, D. Ghai, P. Maheshwary, and P. K. Shukla	2021

pictures from a nearby hospital. with average dice coefficients of 97% and 87%, respectively. Kasu *et al.* [5] used fuzzy-C-mean (FCM) and the Otsu thresholding approach to segment OD and OC, achieving an average dice coefficient of 97% and 87%, respectively.

5. Applications of Glaucoma Detection

Glaucoma, a serious eye condition, has few available statistics due to its wide patient population and subtypes. To improve accessibility, a complete glaucoma dataset catalogue is created by standardising dataset properties into organised tables. This data description enables high-quality models using machine learning techniques, and artificial intelligence, increasing the availability of glaucoma research. the following table 1 shows some of the recent applications in glaucoma detection using various methods.

6. Conclusion

Eye images are crucial for studying the visual system and evaluating health. Glaucoma, a leading cause of blindness, can be diagnosed using costly techniques like optical coherence tomography and Heidelberg Retina Tomography. A low-cost automated glaucoma diagnosis method based on digital fundus pictures differentiates normal and glaucoma classes. By 2040 about eleven million individuals globally might be expected to get affected by Glaucoma, an advancing sight neuropathy which affects the optic nerve head and disc. In this paper presents the concepts of glaucoma and reviewed few studies conducted in the fields of data mining, machine learning, and deep learning approaches to predict and detect glaucoma.

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