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"A REVIEW ON GLAUCOMA DETECTION IN RETINAL FUNDUS IMAGES USING VARIOUS DEEP LEARNING ARCHITECTURES"

Priya Jijnodiya [1], Ashish Tiwari [2]

[1] *M.Tech Scholar, Department of Computer Science & Engineering, Swami Vivekanad college of Engineering indore, Madhya Pradesh, India*

[2]*Assistant Professor, Department of Computer Science & Engineering, Swami Vivekanad college of Engineering indore, Madhya Pradesh, India*

pjijnodiya07@gmail.com

ashishtiwari@svceindore.ac.in

ABSTRACT

Glaucoma has become one of the most common reasons why people go blind all over the world. It's a disease that never goes away and can't be cured. Early diagnosis and screening for glaucoma are two of the most important things you can do to fight this disease. The use of deep learning in this situation looks very promising. In this study, Proposed tested the effectiveness of three different deep learning (DL) architectures. One of them was a Convolutional Neural Network (CNN) model that used maximum pooling. Glaucoma is a type of neuropathy that affects the optic nerve and gets worse over time. It is one of the main reasons why people lose their eyesight for good. This condition, which is also a common cause of blindness, is most common among older people.This study looks at the latest research on glaucoma screening, segmentation, and classification based on images of the papilla and excavation and algorithms for deep learning. It was written as a response to these changes and was based on them. Based on papilla and excavation images, it has been shown that these ways of screening for glaucoma have a high sensitivity and specificity. After that, the automatic segmentation of the optic disc's edges and the excavation make it possible to find out what kind of glaucoma a person has and how bad it is getting. Because of this, Proposed looked into whether deep learning techniques could be used to make accurate and cost-effective glaucoma measurements. If this works, it will encourage patients to take care of themselves and help doctors keep a better eye on them.

Key Words: *Eye diseases; glaucoma screening; artificial intelligence; deep learning; image processing; glaucoma classification.*

I. INTRODUCTION

Glaucoma afflicted 64 million people in 2016 and is expected to affect 95 million people by 2030, according to the World Health Organization [1]. Glaucoma, if left untreated, can result in permanent visual loss by injuring the optic nerve. High intraocular pressure in the eye pushes against the optic nerve, resulting in irreversible vision loss [2]. It is currently the biggest cause of blindness in the world. The area around the optic nerve has a wider cup and a narrower inferior rim as a result of the wounded nerve fiber. The condition's progression may result in a "pale disc" and disc hemorrhage. They both have different warning symptoms, yet they are both connected to high intraocular pressure (IOP). Angle-closure glaucoma expresses itself in a multitude of ways due to the disease's angle-closure nature. Open-angle glaucoma, as opposed to swiftly advancing and leaving no symptoms, takes its time and leaves no evidence until

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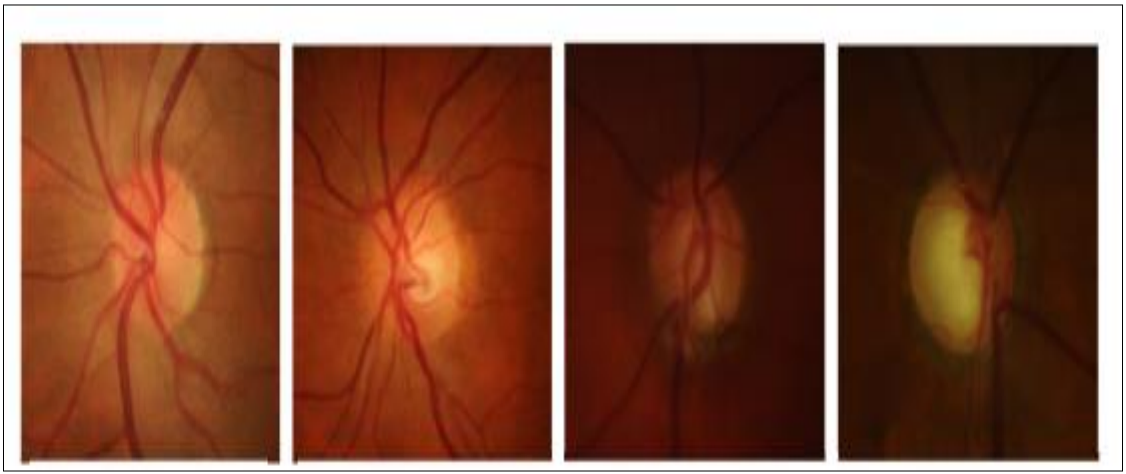
peripheral vision is lost. Because the percentage of individuals with glaucoma increases rapidly with age, especially for those with early warning signs, a yearly eye exam is essential and recommended for early glaucoma screening. Clinical glaucoma screening now involves intraocular pressure measurement, visual field testing, and optic nerve head examination, but only the latter can detect early-stage glaucoma [3]. As a result, evaluating the optic nerve in retinal images has become a standard glaucoma diagnostic technique. Glaucoma damage to the OD region causes OD anomalies such as an expanding cup to disc ratio, a pale color, hemorrhage, or modifications surrounding the OD. In Figure 1, the OD of a healthy eye is compared to that of a glaucoma sufferer and displays a patient at different stages of glaucoma development.



a) Healthy OD (b)Mild Glaucoma (c) Moderate Glaucoma (d) Severe Glaucoma

Figure 1. Grading of glaucoma diseases: (a) healthy OD; (b) Mild Glaucoma; (c) Moderate Glaucoma and (d) severe glaucoma.

As people age or acquire early warning symptoms, the number of patients increases substantially. Clinical glaucoma screening now involves intraocular pressure measurement, visual field testing, and optic nerve head examination, but only the latter can detect early-stage glaucoma. As a result, evaluating the optic nerve in retinal images has become a standard glaucoma diagnostic technique. Glaucoma damage to the OD region causes OD anomalies such as an expanding cup to disc ratio, a pale colour, hemorrhage, or modifications surrounding the OD. In Figure 1, the OD of a healthy eye is compared to that of a glaucoma sufferer. Figure 1. displays a patient at different stages of glaucoma development. As seen in Figure 2 one eye has normal pressure while the other has excessive pressure (right).

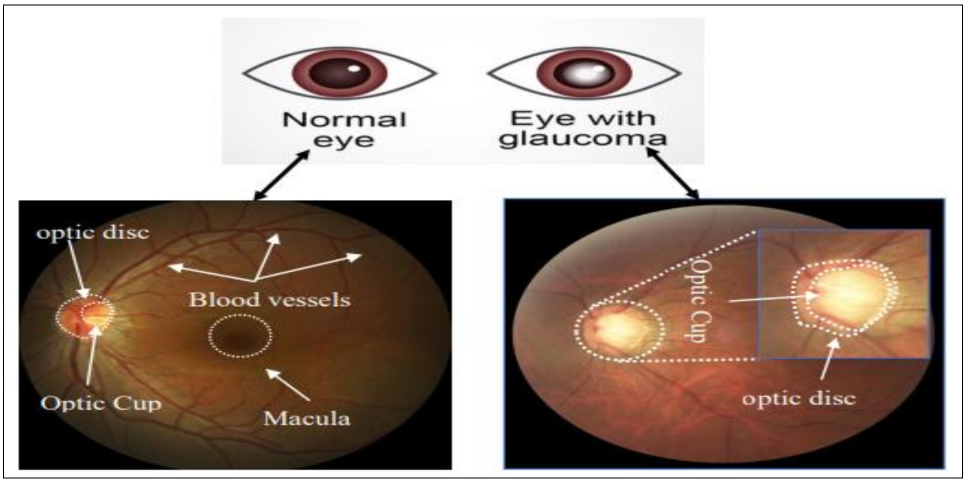


Figure 2 Images of a healthy retina (left) and one with glaucoma (right).

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Digital images account for a significant amount of multimedia data, and content-based image analysis is employed in a wide range of computer vision applications. Medical image analysis has advanced significantly in recent decades, with several novel applications developing. A significant focus of medical image analysis research is to study pictures for sickness identification [5]. The optic nerve of the eye is gradually destroyed by chronic glaucoma. Because it is a neurodegenerative illness, it has the potential to cause blindness. Because nerve degeneration is irreversible, it results in permanent vision loss. Much research has been conducted in order to ascertain the number of people afflicted by this chronic illness. Glaucoma is the second most prevalent cause of visual loss [6]. By 2020, the number of people suffering from glaucoma will have climbed from 60 million to more than 80 million. Glaucoma causes irreversible vision loss by increasing intraocular pressure (IOP) and damaging the optic nerve. The illness has received the moniker "hushed burglar of vision" due to the difficulties in describing and quantifying early-stage glaucoma symptoms. Even though there is no cure for glaucoma, it is possible to keep from going blind if the disease is found, treated, and kept under control early on [7].
Computer-Aided Diagnosis (CAD) assists in the treatment of damaged eyes. Several studies have employed fundus imaging as a technique to detect glaucoma early and avoid additional damage. Glaucoma, a group of illnesses and conditions that result in reduced vision and imparity, is caused by alterations in the retinal nerve fiber cushion and nervous optic head [8].Researchers seek to reduce the impact by using improved illness diagnostics and therapies, such as the immediate Trabecular Micro-Bypass (TMB). The authors [9] did a brief evaluation of current state-of-the-art approaches for detecting glaucoma early. Methods such as the Optic Cup Disc Ratio and the Retinal Nerve Fiber Layer (RNFL) have been scrutinized. As a consequence of their results, this research helps to more reliably diagnose glaucoma. For the purpose of clarity, they've divided the survey findings into two categories: those that employ segmentation and those that don't. [10] Examined current techniques for detecting glaucoma, which assisted them in forecasting their own proficiency and accuracy. This is a fantastic survey that defines the leading information for researchers in terms of glaucoma approach and dataset selection for future study.

II. LITERATURE REVIEW

Glaucoma is a neuropathic disease characterized by ganglion cell loss. As a result, as the optic nerve fiber decreases, the rim tissue erodes, resulting in the formation of a cup. Detecting glaucomatous structural damage and changes is one of the most difficult aspects of disease detection methods currently Intraocular pressure (IOP), which should be more than 22 mmHg without treatment, glaucomatous cupping of the optic disc, and glaucomatous visual field abnormalities are all ways to tell if someone has glaucoma. One of the most challenging elements of glaucoma diagnosis is determining whether or not someone has the ailment when there are no symptoms. The number of patients who have not been diagnosed outnumbers those who have. However, the size and shape of the optic cup disc should be considered when diagnosing glaucoma so, an extension of the cup in the vertical direction is a sign of glaucomatous optic neuropathy [11-12].

Nazmus Shakib et. al. 2022 [13] Glaucoma is known to be one of the most common causes of blindness around the world. Early diagnosis and screening are two of the most important parts of fighting this disease. The use of deep learning in this situation looks very promising. In order to figure out how well deep learning models work, public datasets with 1250 different pictures were used. Images of the fundus are the main source of information that doctors use to confirm glaucoma in a clinical setting. This study looks at how far along the deep learning framework for diagnosis is on its way to being fully grown up. Measures of how well different kinds of deep learning frameworks work are looked at and compared. At the end, a summary of how machine learning works and some suggestions for where future research should go are given. Glaucoma is an irreversible disease of the nervous system that causes high pressure inside the eye. This happens when the aqueous humor level goes up and the drainage system between the eye and the cornea gets clogged. It's hard to figure out at an early stage, so screening at regular times is strongly recommended. [14-15].

Yves Attry, Kalin, et. al. 2022[14] Glaucoma is an example of a condition that might threaten an individual's vision. This illness, which affects the optic nerve in the eye and can cause sudden blindness, is potentially lethal. Attempts have been made to identify glaucoma by combining Machine Learning and Deep Learning Models with other concepts;

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nevertheless, the diagnostic efficiency of these models is insufficient for a disorder of such basic importance. In this work, proposed have assembled a variety of Deep Learning Architectures depending on an assortment of criteria. MobileNetV2, DenseNet121, InceptionV3, InceptionResNetV2, ResNet50, and VGG16 are among these. These architectures are intended to appeal to more than two classes classified as "G" and "NG." The dataset was compiled from numerous sources and preprocessed to provide the best degree of precision. To validate the efficacy of our inventions, numerous metrics, including precision, recall, F1-score, Cohen Kappa Score, and area under the curve (AUC), have been added.

D. Shamia et al 2022 [15] Diabetes-related retinopathy, glaucoma, and cataracts have been identified as the three most common causes of blindness in one or both eyes. In light of this, the authors of this paper describe an automatic or self-diagnosing technique that employs a deep learning model. This technology can accurately anticipate and diagnose all three diseases in less than one minute, with a high rate of accuracy. In this research, proposed propose a DCNN-based expert system that uses an internet platform to detect three distinct diseases. This system would contain input, neurons, hidden layers, and output, akin to the human brain. The accuracy of detection was 91% for images impacted by glaucoma, 90% for images impacted by cataracts, and 91% for images damaged by DR. Designed alongside the system is a Graphical User Interface (GUI) that is intuitive, user-friendly, and accessible online.

Hongyong Zhang et. al. 2019 [16] Applying a controlled force to in-vitro-grown retinal cells suggests a method that is both doable and effective for studying the quantitative relationship between high intraocular pressure and glaucoma. In this research study, alginate hydrogel microbeads are made so that retinal cells can be grown in the lab. In order to make alginate microbeads successfully, a simple flow-focusing microfluidic system was made out of syringe needles and silicone tubing. The first step in making these tiny beads is for water droplets to form in oil inside of a silicone tube. The alginate droplets are then cross-linked with the calcium solution. After the cultivation process, a cell is effectively sealed inside the hydrogel microbeads, where it can live and grow.

Chaodong Ling et. al. 2019 [17] This research talks about a way to divide up blood vessels that is based on the Markov model and takes place in the wavelet domain. To get accurate segmentation results, the algorithm must take into account both the presence of a visible vein of blood and the fact that the object is inside of something else. Guided Filter can be used to make photos have more contrast. It also makes the intricate vein patterns in blood vessels stand out. After the pretreatment is done, pictures of the retina are taken from inside the blood vessels. Simulation results are given to show that the proposed segmentation method can be used and is effective. The DRIVE, STARE, and FIRE data sets were used to come to these conclusions.

Weingart, Mircea, et. al. 2019[18] Some ways to process images of the retina are explained below. These include getting rid of noise and using the ARIA and B-COSFIRE filters. With these methods, images of blood vessels in the retina can be broken up into their parts. Eye-fundus images are used as the source of data for experiments with the KSVD and BM3D methods for getting rid of noise. The contrast limited adaptive histogram equalization technique is another method Proposed use to improve image contrast. Proposed also offer a powerful method for image segmentation that is based on a method of optimization that is inspired by the natural world. Particle Swarm Optimization is the name for this method. In the end, machine learning techniques are used to automatically classify images of the back of the eye (fundus) to find diseases. This is done by automatically putting the images into groups.

Xiao et. al. 2018 [19] Because of retinal vascular segmentation, eye diseases can be seen clearly and diagnosed correctly, early treatment can be given, and surgery can be planned. Deep learning-based methods for segmenting the blood vessels in the retina have recently reached a level of performance that is considered to be state-of-the-art. Even with these approaches, there are still problems with small, thin vessels, low discriminative capacity in the area of the optic disc, and other problems caused by the large changes in the shape of the vessels against a noisy background. In this piece of research, proposed came up with a model similar to U-Net that uses a weighted attention mechanism and a skip connection strategy to deal with these problems. Using two benchmark datasets, the proposed methods were tested to show how useful they were, and the results were convincing.

Xiao-Min Li et. al. 2020[20] But because pooling and convolution are done one after the other, spatial information is lost. In this research, proposed show what call DAS-UNet, a network architecture. It is a U-Net with a lot of

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connections. It also has a parallel atrous convolution block and a big computing block. Second, the parallel atrous convolution block, which is also called the PAC Block, uses a number of receptive fields to create more abstract features that help with precise segmentation. Third, by using the salient computing block (SCB), can highlight responsive areas and hide unimportant ones. This lets us make a more clear vessel segmentation map than Proposed could with the U-Net. Extensive testing on the DRIVE benchmark shows that DAS-UNet has a performance that is considered to be at the cutting edge, with a result that is especially clear.

Behnam Azimi et al.,2020 [21] Optical coherence tomography (OCT) images can show if there is a problem with the retina because OCT can show many of the signs that there is a problem with the retina. Fluid areas could show signs of diseases like age-related macular degeneration (AMD) and diabetic macular edoema (DME) (DME). Ophthalmologists can use automatic segmentation of these areas to help them find and treat these conditions. The graph shortest route layer segmentation and fully convolutional networks are used in this study to come up with a fully automated method for separating fluids (FCNs). The proposed method was put to the test by having OCT scans done on 24 different people a total of 600 times. The results show that the suggested FCN model does a better job of fluid segmentation than three current approaches, with an improvement of 4.44 percent in dice efficiency and 6.28 percent in sensitivity, respectively.

Ahmed A. Sleman et. al. 2018[22] Optical coherence tomography (OCT) images can show if there is a problem with the retina because OCT can show many of the signs that there is a problem with the retina. Fluid areas could show signs of diseases like age-related macular degeneration (AMD) and diabetic macular edoema (DME) (DME). Ophthalmologists can use automatic segmentation of these areas to help them find and treat these conditions. The graph shortest route layer segmentation and fully convolutional networks are used in this study to come up with a fully automated method for separating fluids (FCNs). The proposed method was put to the test by having OCT scans done on 24 different people a total of 600 times. The results show that the suggested FCN model does a better job of fluid segmentation than three current approaches, with an improvement of 4.44 percent in dice efficiency and 6.28 percent in sensitivity, respectively.

III. SEGMENTATION APPROACH

A-Model based segmentation approaches

According to **[23]** proposed early glaucoma detection by model-based segmentation. Because this approach only exploits a small fraction of the problematic region, the images are collected locally rather than globally. Deng et al. used the Fourier transform to pinpoint the centre of glaucomatous images by superimposing the Gaussian filter's dimensional function over the linear processes. The characteristics are then separated using K-Means clustering. Different models are chosen based on the searcher's needs as the size of the block varies. The akakie information criteria are used to choose the best model. This research used a dataset of 20 that was built using STARE data. To begin with, the image is converted to a grayscale version. The model utilized is low-cost and easy-to-use, but it faces certain difficulties due to its resilience in operation and the potential uncertainty induced by the tiny scale ratio. The algorithm has 82 percent sensitivity and 93 percent specificity.

According to **[24]** several methodologies are employed to diagnose glaucoma in fundus images, but the findings are not always trustworthy and gratifying. However, he proposes a one-of-a-kind approach to achieving this aim. In this scenario, the Laplace technique is applied. The photographs for this model, which employs two separate sorts of images, were chosen by Gx, a laser-based technique. You may have both bright and dark blood vessels if you use this approach. The image below has been smoothed using a Gaussian filter. This pattern begins in the darkest portion of the space and progresses outwards. This filter divides the items into smaller groups using a Laplacian algorithm.

B-Approaches to Optic Cup Segmentation

Segmentation in the optic cup is more difficult due to the larger density of blood vessels in the optic cup compared to the optic disc. Furthermore, the progressive shift in optical cup intensity and NRR hampers optical cup segmentation. When someone has glaucoma, their cup size changes automatically as a result of the disease. The identification of glaucoma CDR, according to Ingle et al., is a vital procedure with a region of the cup to disc. The suggested approach uses the dataset to determine the cup's area. The ROI changes depending on the picture. In this study, an automated cup region approach was used. Oshi et al. suggested an automated method for detecting glaucoma early on. An automated

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OD parametrization approach is used to segment monocular retinal pictures in this study. Cup segmentation is done using vascular bends, which are quite similar to glaucoma diagnosis. There is a variation between the mathematical and photometric modifications. This method of OC segmentation is very efficient and effective. Damon et al. developed a technique for detecting the optic cup fused with kinks in the same way as Finkelstein et al. did. Blotches are removed from the OD using kinks, and the color and borders of vessels are identified using patches for vessel identification.

IV. Datasets Available For Retinal Images

The majority of the strategies mentioned in this study rely on publicly accessible data. These datasets are included in the table below, which includes a short description and explanation. These are the datasets that researchers often employ to carry out recommended procedures and draw conclusions. the datasets that are available for glaucoma detection studies that may be utilized.

HRF Dataset -This dataset is divided into two picture sets: training and testing. The training set consists of 50 pictures, with ground truth for each image providing information on area boundaries, segmentation soft map, and cup-to disk ratio. The testing set, on the other hand, has 51 photos, and the ground truth for the test set is only available after registration. The image is2896 x 1944 pixels in size and resolution, with a PNG uncompressed image format. The dataset's retinal picture type is Fundus Images.

ONSHD - The fundus has been photographed 99 times by 50 different patients. The type of dataset is pictures of the fundus. These pictures were taken with a Kowa VX-10 alpha digital fundus camera that has a field of view of 50 degrees (FOV). The photos are saved using the JPG file type, and their resolution is 4288 by 2848 pixels. Each individual photo is about 800 KB in size.

IDRiD-IDRiD is a freely accessible retinal fundus picture library that consists of 516 photographs divided into two categories: 1.Retinal age exhibiting DME and/or DR symptoms 2. Normal retinal scans that do not show any signs of DME or DR.

RIGA dataset The RIGA dataset consists of 4,500 manually tagged photos and 750 images acquired from three sources. The photos, which include both glaucomatous and normal images, are stored in JPG and TIFF formats. Three sources have a resolution of a. 2240x1488 **MESSIDOR PIXELS (**460 Images) Riyadh 2743x1936 B. Magrabi Eye Center (95 Images) 2376x1584 Bin Rushed Ophthalmic Center in Riyhad (195 Images) Fundus images are the most common type of retinal image in the collection.

DRIONS-It includes 110 retinal pictures with a resolution of 600 x 400 pixels and a 36-landmark optic disc analyzed by two specialists. The dataset has a resolution of 600x400 pixels. Fundus pictures are a form of retinal image.

DIARETDB1-Each picture is coded by colour, and there are five normal pictures and 84 pictures of moderate non-proliferative diabetic retinal abnormalities. - There are 650 photos in this collection as a whole. 482 didn't have glaucoma, 168 did, and 168 did.

ACRIMA- The dataset is made up of 705 tagged photos, 396 of which show glaucoma and 309 of which show normal conditions. Anyone can access the dataset.

V. Conclusion

In this study, look at all of the available evidence about the role of TPD in open-angle glaucoma. This evidence comes from a systematic review of the literature (OAG). All of the library databases that were available were looked at, including PubMed (Medline), OVID Medline, Science Direct, and SpringerLink. The results of the subsequent meta-analysis of pooled mean differences are reported when it makes sense to do so. Five articles with a total of 396 patients met the requirements to be part of the study. Importantly, included all observational studies, even though the ways they measured ICP were different. This is because there is no consensus on the best way to measure ICP in glaucoma, so there is no agreement. According to the results of our study, the TPD is not only much higher in people with glaucoma than in healthy people, but it is also linked to the structural changes that happen in the optic disc when glaucoma is present. Based on our study, it looks like there needs to be more longitudinal, prospective research done to find out how TPD affects OAG. The main goal of these studies should be to get rid of methodological problems that were present in earlier research. In this survey, looked at recent studies on identifying fifty different types of glaucoma, such as fusion-based, texture feature-based, multi-scale-based, DL Moldes, ML Moldes, and LDA detection using a variety of DL models. 10 of the papers that were looked at on GoogleNet are connected to ResNet50, 5 of the papers that were

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surveyed are connected to densNet, studies are connected to Inception V3, studies are connected to AlexNet 9, studies are connected to MobileNet, and 12 of the papers that were surveyed are connected to CNN.

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