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# Review on Application of Artificial Intelligence and Image Processing on Glaucoma Diagnosis

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## Abstract

Today, glaucoma is the leading cause of blindness worldwide. In fact, the damage to the visual field is the major outcome of glaucoma. As the goal of its treatment is preventing the deterioration of the quality of life, detecting variations of the visual function on a time degree basis is principal for monitoring the effectiveness of the therapy. This paper presents an overview on glaucoma diagnosis using artificial intelligence and image processing.

**Keywords:** Diagnosis, artificial intelligence, image processing, ophthalmology, glaucoma.

## 1. Introduction

Glaucoma is an eye disease that causes an irreversible decrease in the optical field. It is characterized by a progressive destruction of the optic nerve. The sufferer may become blind if he does not receive any treatment (Minna, 2012). Besides, glaucoma is the second leading cause of blindness worldwide and mainly in least developed countries. One of the main signs of this lesion is the enlargement of the excavation of the papilla (Chahuan, 2010).

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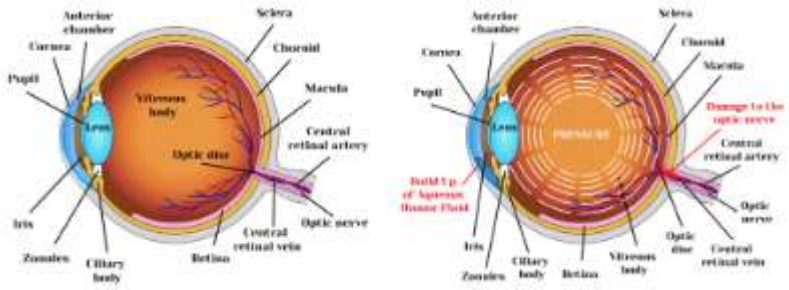
In fact, the papilla or the optical disc is the union of fibers which form the optic nerve, while the excavation is the depression observed in the optical disc characterized by the disappearance of the optical fibers (Medeiros &al., 2010). The report "cup / disk", a report between the size of the excavation and that of the optical disk (normally around 0.3) tells us about the presence of glaucoma (Heijl, 2010).

Figure 1: Comparison between normal vision and glaucoma




Generally, linear regression analysis and the other systems for detecting the glaucomatous functional progression rely on the dB deviation from normative data or on the probability estimate the loss has occurred in a given locus of the visual field (Medeiros & al., 2011) (Schank, 1991) (Lombardo & al., 2020).

Artificial intelligence and image processing have been widely utilized in glaucoma diagnosis. This paper presents a quick overview of the theme.

## 2. Part of artificial intelligence and image processing

Since glaucoma is a group of eye diseases which result in damage to the optic nerve and cause vision loss.The most common type is open-angle (wide angle, chronic simple) glaucoma, in which the drainage angle for fluid within the eye remains open, with less common types including closed-angle (narrow angle, acute congestive) glaucoma and normal-tension glaucoma.

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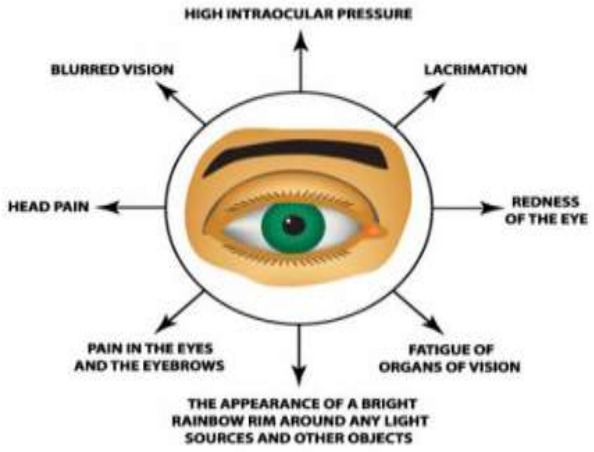
There are multiple goals of artificial intelligence in glaucoma. The first aim has been detection of glaucoma by classifying visual fields, optic nerve imaging, or other clinical data. Second, artificial intelligence has been utilized to detect worsening earlier than conventional algorithms.

Glaucoma increases the cup to disc ratio (CDR), affecting the peripheral vision loss. Many authors have addressed the various image processing techniques to diagnose the glaucoma based on the CDR evaluation of preprocessed fundus images (Chakravorty, 2018) (Gonzalez, 2018).

Figure 2: Symptoms of Glaucoma




Artificial intelligence (AI) is intelligence established by machines, unlike the natural intelligence displayed by humans and animals. Leading AI textbooks describe the field as the study of "intelligent agents": any device that perceives its environment and takes actions that maximize its chance of successfully achieving its goals (Ben Mansour & al., 2015) (Maini & Aggarwal, 2009).

The field was founded on the assumption that human intelligence can be so in particular described that a machine can be made to simulate it. This raises philosophical arguments about the mind and the ethics of creating artificial beings endowed with human-like intelligence.

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Some people also think AI to be a danger to humanity if it progresses unabated others believe that AI, unlike earlier technological revolutions, will create a risk of mass unemployment (Ionescu & al., 2013) (Hong & al., 2009).

Digital image processing is the employ of a digital computer to process digital images through an algorithm. As a subcategory of digital signal processing, digital image processing has many advantages over analog image processing (Papari & al., 2011) (Ding & Goshtasby, 2001). It allows a much wider range of algorithms to be applied to the input data and can avoid problems such as the build-up of noise and distortion during processing. Since images are defined over two dimensions (perhaps more) digital image processing may be modeled in the form of multidimensional systems. The generation and development of digital image processing are mainly affected by three factors: first, the development of computers; second, the development of mathematics (especially the creation and improvement of discrete mathematics theory); third, the demand for a wide range of applications in environment, agriculture, military, industry and medical science has increased.

Digital image processing technology for medical applications was inducted into the Space Foundation Space Technology Hall of Fame in 1994 (Lakhoua, 2018) (Lakhoua & al., 2016).

The emergence of artificial intelligence has influenced many aspects of our lives. Modern medicine relies profoundly on diagnostic tools using image processing algorithms and artificial intelligence.

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## 3. Review on glaucoma diagnosis

We present some studies of glaucoma diagnosis based on the use of artificial intelligence and image processing that have been presented in various researches:

Researchers (Islam and Indiramma, 2020), have discussed the retinal vasculature conditions which they are important and reliable biomarkers for several cardiovascular and ophthalmologic diseases including Retinopathy of Prematurity, Diabetic Retinopathy, Glaucoma, Macular Degeneration, etc. The retinal-related diseases can be detected and diagnosed in the early stage before developing complexities and causing loss of sight by thoroughly understanding the vasculature condition. Analyzing these conditions is time consuming and tedious task. There have been many studies conducted to automatically extract retinal vessel information from fundus image and this is called retinal vessel segmentation. This paper provides a survey of the existing work that had been conducted to achieve this objective using Deep Learning methods. The authors have briefly discussed U-Net based network architectures proposed for object segmentation and the usage of these networks in medical fields for vessel segmentation. They have further compared the various architectures base.

Researchers (Gabriel & al., 2020), have proposed two different deep-learning based approaches to address glaucoma detection just from raw circumpapillary OCT images. The first one is based on the development of convolutional neural networks (CNNs) trained from scratch. The second one lies in fine-tuning some of the most common state-of-the-art CNNs architectures. The experiments were performed on a private database composed of 93 glaucomatous and 156 normal B-scans around the optic nerve head of the retina, which were diagnosed by expert ophthalmologists. The validation results evidence that finetuned CNNs outperform the networks trained from scratch when small databases are addressed.

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Additionally, the VGG family of networks reports the most promising results, with an area under the ROC curve of 0.96 and an accuracy of 0.92, during the prediction of the independent test set.

Researchers (Chaima & al., 2020), have presented modern ophthalmology which is not out of this context and has undergone a real revolution in recent years. Several studies have focused on combining artificial intelligence and image processing algorithms to provide powerful tools to assist ophthalmologists in their diagnoses and decisions. Recently, new devices combining these two sciences have been developed and the results seem promising. But where does the ophthalmologist stand in relation to this. The authors have tried to support the main scientific advances and describe the advantages, disadvantages and challenges.

Researchers (Borwankar & al., 2020), have automated the process of diagnosis of glaucoma using deep learning approaches. Image processing has gained a lot of attraction and can be used for this problem in forming a computer-aided diagnosis for diseases. The authors have compared their results with previous approaches, which shows that our method has a better accuracy score.

Researchers (Soltani & al., 2018), have treated glaucoma disease which can affect the optic nerve head (ONH), thus causing its destruction and leading to an irreversible vision loss. The authors have presented a new glaucoma Fuzzy Expert System for early glaucoma diagnosis. Original ONH images are first pretreated using appropriate filters to remove the noise. Canny detector algorithm is then used to detect the contours. Main parameters are then extracted, after having identified elliptical forms of both optic disc and excavation. This operation is performed by using Randomized Hough Transform. Finally, a classification algorithm, based on fuzzy logic approaches, is proposed to determine patients' conditions.

ISSN: 2785-9541 VOLUME 4, ISSUE 1, 2021, 64 – 73. www.egyptfuture.org/ojs/

The system is advantageous as far as it takes into consideration both instrumental parameters and risk factors (age, race, family history. . .) which make an important contribution to the valuable identification of cases suspected to have glaucoma. The proposed system is tested on a real dataset of ophthalmologic images of both normal and glaucomatous cases. Compared with other existing systems, the experimental results show the superiority of the proposed methods. The percentage of good predictions is more than 96%, reaching an improvement of 1–9% over earlier methods.

## 4. Conclusion

Glaucoma is termed as one of the most important causes of vision loss and in many cases is irreparable. It is a condition that damages the optic nerve and it goes ignored in early stages as the symptoms are not prominent in the early stages.

In conclusion, the evaluation and description of the development of the functional damage is a fundamental variable in the management of patients suffering from glaucoma.

Recent approaches have been made to automate the detection of glaucoma based on available datasets. So artificial intelligence and image processing have been widely utilized in glaucoma diagnosis.

Staring from this overview on glaucoma diagnosis using artificial intelligence and image processing presented in this paper, work is in progress to develop a system analysis for glaucoma diagnosis for decision-making based on images in the medical field.

ISSN: 2785-9541 VOLUME 4, ISSUE 1, 2021, 64 – 73. www.egyptfuture.org/ojs/

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