International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 08 | Aug - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

# Enhancing Glaucoma Detection Using Deep Learning

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**Abstract** Deep learning is currently the mainstream method of object detection. In this project Glaucoma is a degenerative disease that affects vision, causing damage to the optic nerve that ends in vision loss. The classic techniques to detect it have undergone a great change since the intrusion of machine learning techniques into the processing of eye fund us images. Several works focus on training a convolutional neural network (CNN) by brute force, while others use segmentation and feature extraction techniques to detect glaucoma. In this work, a diagnostic aid tool to detect glaucoma using eye fund us images is developed, trained and tested. It consists of two subsystems that are independently trained and tested, combining their results to improve glaucoma detection. The first subsystem applies machine learning and segmentation techniques to detect optic disc and cup independently, combine them and extract their physical and positional features. The second one applies transfer learning techniques to a pre-trained CNN to detect glaucoma through the analysis of the complete eye fund us images. The results of both systems are combined to discriminate positive cases of glaucoma and improve final detection. The results show that this system achieves a higher classification rate than previous works. The system also provides information on the basis for the proposed diagnosis suggestion that can help the ophthalmologist to accept or modify it.

**Keywords**—Degenerative Disease, Optic Nerve Damage, Diagnostic Aid Tool, Ophthalmologist Assistance.

## I. Introduction

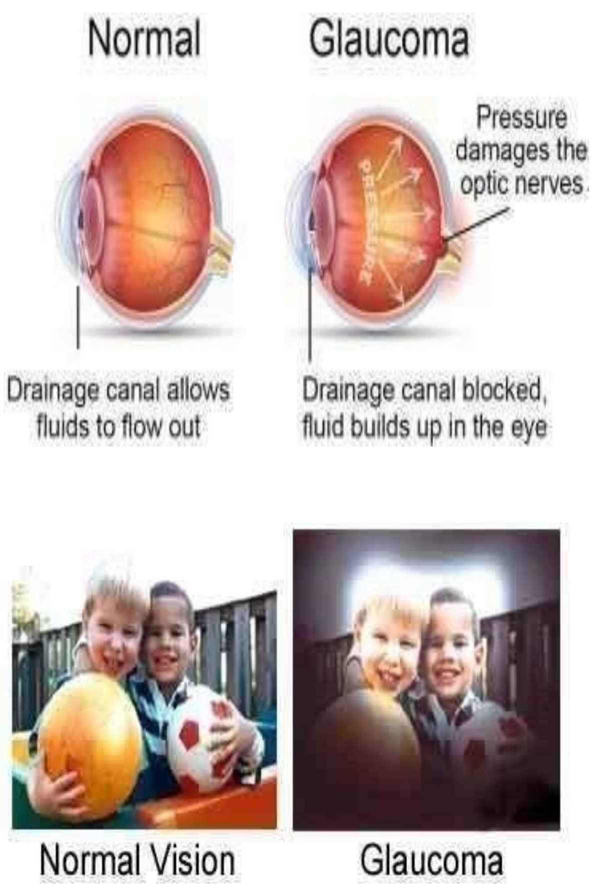
The term Glaucoma is used for a group of progressive neuropathies that affects vision (mostly bilateral) and is characterized by loss of retinal ganglion cells and damage to the optic nerve head, causing loss of the visual field and, finally, blindness. Moreover, it is one of the main causes of irreversible visual damage and blindness worldwide (second leading cause in Europe). There are two main types of glaucoma whose causes are well known:

- Open-angle glaucoma (OAG): the most common form of glaucoma (at least 90% of all glaucoma cases). It is caused by the slow clogging of the drainage canals, resulting in increased eye pressure. ‘‘Open-angle’’ means that the angle where the iris meets the cornea is as wide and open as it should be (also called primary or chronic glaucoma).
- Angle-closure glaucoma (ACG): It is caused by block updrainage canals, resulting in a sudden rise in intraocular pressure. It is also called acute glaucoma or narrow- angle glaucoma and, unlike OAG, ACG is our cult of the angle between the iris and the cornea closing.

There are other glaucoma types like normal-tension glaucoma (the optic nerve is damaged even though the eye pressure is not very high, so it is not well known why this damage is produced), congenital glaucoma (occurs in babies when there is incorrect or incomplete development of the eye’s drainage canals during the prenatal period), and several variants of OAG and ACG. Most of them are not well studied and their causes are not defined yet.

Both main types (OAG and ACG) are usually evaluated separately, obtaining a mean prevalence worldwide of 1.96%for OAG and 0.69% for ACG according to. In any case, the progression from diagnosis to at least unilateral blindness is above 1% per year. Figure1.1 shows the difference between a healthy eye and an eye with glaucoma in fundus images. The images come from the DRISHTI dataset. As the population continues to age, the number of glaucoma patients worldwide is expected to Reach 111.8 million in 2040 [4].

In addition, the global disease bur-den of blindness and visual impairment due to glaucoma has been shown to be significantly associated with a decrease in quality of life, physical functioning and mental health. As detailed above, there is not a unique procedure to diagnose glaucoma because of the different eye characteristics of each patient. Moreover, those exams have to be interpreted by the doctor before making a diagnosis.




However, the study of medical images in general has experienced a great progress with the inclusion of Machine Learning systems capable of automatically extracting the necessary characteristics to make a correct diagnosis.

These systems require a dataset made up of several images corresponding to glaucoma patients and healthy patients (all of them previously labelled by a professional). Using this knowledge, neural network-based systems are able to automatically analyze those images and extract the characteristics necessary to help diagnosing glaucoma. These systems require other steps: a preprocessing stage, the correct choice of the network architecture, a training stage (that sometimes requires supervision), among others.

Despite all this, the results of using neural networks with medical images in several works (not only for glaucoma diagnosis) are better that the ones obtained by classical diagnostic systems. Thus, based on these premises, this work consists of using Machine Learning techniques applied to medical images of the fundus to obtain an aid system for glaucoma diagnosis.

## II. LITERATURE SURVEY

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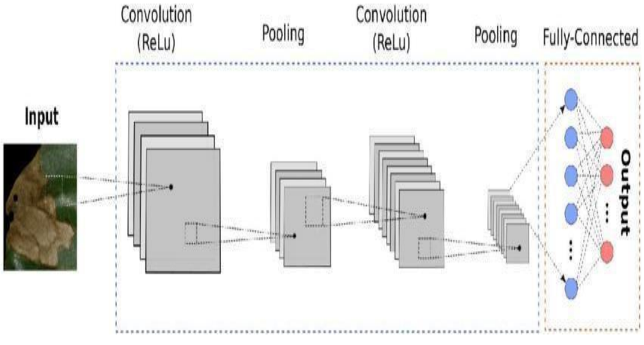
## III. DESIGN AND IMPLEMENTATION

System design is the process of defining the elements of a system such as the architecture, modules and components, the different interfaces of those components and the data that goes through that system. It is meant to satisfy specific needs and requirements of a business or organization through the engineering of a coherent and well-running system.

Systems design mainly concentrates on defining the architecture, components, modules, interfaces, and data for a system to satisfy specified requirements. Systems design could be seen as the application of systems theory to product development.

Systems design implies a systematic approach to the design of a system. It may take a bottom-up or top-down approach, but either way the process is systematic wherein it takes into account all related variables of the system that needs to be created from the architecture, to the required hardware and software, right down to the data and how it travels and transforms throughout its travel through the system. Systems design then overlaps with systems analysis, systems engineering and systems architecture.

The proposed system for leaf disease detection and management leverages Python as the front end and TensorFlow as the backend, offering a comprehensive solution for farmers and agricultural professionals. At the front end, a user-friendly web- based interface is developed using Python frameworks like Flask or Django. This interface enables users to easily upload leaf images, view disease detection results, and receive tailored pesticide recommendations based on advanced machine learning algorithms. The main objective of system design is to create a solution that meets the requirements of the system in terms of functionality, performance, reliability, scalability, maintainability, and usability. It involves making design decisions such as selecting appropriate technologies, defining interfaces and data structures, allocating system resources, optimizing performance, and ensuring the system's overall integrity and robustness.




- Visual Studio Code is a free, lightweight but powerful source code editor that runs on your desktop and on the web and is available for Windows, macOS, Linux, and Raspberry Pi OS. It comes with built-in support for JavaScript, TypeScript, and Node.js and has a rich ecosystem of extensions for other programming languages, runtimes (such as .NET and Unity), environments (such as Docker and Kubernetes), and clouds (such as Amazon Web Services, Microsoft Azure, and Google Cloud Platform).

- Aside from the whole idea of being lightweight and starting quickly, Visual Studio Code has IntelliSense code completion for variables, methods, and imported modules; graphical debugging. Much of this was adapted from Visual Studio technology.

## IV. RESULT ANALYSIS

Deep learning has shown promising results in detecting glaucoma, a leading cause of irreversible blindness worldwide. Several studies have utilized deep learning techniques, particularly convolutional neural networks (CNNs), to analyze retinal images for glaucoma detection.

These models typically take retinal images (such as fundus photographs or optical coherence tomography scans) as input and classify them into glaucomatous or non-glaucomatous categories. The deep learning models are trained on large datasets of labeled images, allowing them to learn intricate patterns and features indicative of glaucoma.

The results of these studies have demonstrated high accuracy, sensitivity, and specificity in glaucoma detection, often comparable to or even surpassing human experts. However, it's important to note that further validation and clinical trials are necessary before implementing these models into clinical practice.

The potential benefits of using deep learning for glaucoma detection include early diagnosis, which can lead to timely intervention and better management of the disease, ultimately preserving patients' vision and improving their quality of life. Additionally, automated screening using deep learning models can help alleviate the burden on healthcare professionals and increase accessibility to eye care, especially in underserved communities.

## IV. CONCLUSION

Our system presents a promising avenue for developing a medically acceptable diagnostic assistance tool. By integrating two subsystems, one focused on segmentation and feature extraction, and the other on lightweight classification networks, we achieve robust and sensitive diagnostic results. Further enhancements can be made by training ensembles with additional data from diverse datasets, both public and private. The inclusion of a second lightweight classification subsystem, possibly based on EfficientNet, would significantly enhance the reliability and sensitivity of our diagnostic tool. As deep learning-based diagnosis aids become integral to physicians' daily routines, our system offers comparable performance with lower computing requirements, paving the way for widespread adoption in medical practice.

## V. REFERENCES

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