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Research Article

A Novel Approach for Detecting Glaucoma Using Convolutional Neural Networks

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ABSTRACT

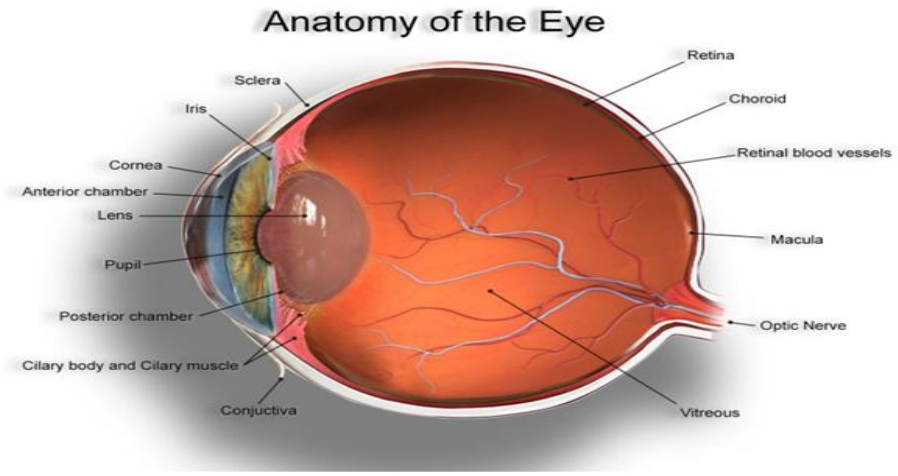
Glaucoma is an eye disease that often affects people with a history of diabetes. In clinical diagnosis, Glaucoma can be detected. Previously, image processing was used for detection. Now, a new method uses Convolutional Neural Network (CNN), a type of Deep Learning. CNN is trained to identify if an eye is normal or affected by Glaucoma by analyzing input data.

Keywords: Glaucoma, Convolutional Neural Network, Deep Learning

1. INTRODUCTION

Eye diseases are very common in all ages especially who is above 60.There are different types of eye diseases are seen widely. Few are Retinopathy, Cataract and Glaucoma which is very commonly seen around us. Retinopathy's occurs because of Diabetics and Glaucoma occurs due to an increased Intraocular pressure resulting in damage to the optic nerve of eye. Clinical diagnosis of glaucoma by specialists is possible but the methods used are either expensive or takes a lot of time. **1.1 Glaucoma:**

Glaucoma (Gl) is an ocular disease that damages the optic nerve which connects the eye to the brain. When the fluid pressure inside the eye, known as intraocular pressure (IOP), is high, the optic nerve is damaged. Glaucoma, which leads to blindness and a loss of vision if not detected early . Vision loss from glaucoma, once it has occurred, is permanent. According to the American Academy of Ophthalmology, glaucoma is the leading cause of blindness in adults aged 60 more older.



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Research Article

1.1.2 Types of Glaucoma

There are different types of glaucoma: Open-angle glaucoma (OAG), Closed-angle glaucoma (CAG), and Childhood glaucoma. Open-angle glaucoma, also known as OAG, is the most common type, accounting for about 85% of cases. Closed-angle glaucoma also called CAG is less common.

Open-angle glaucoma:

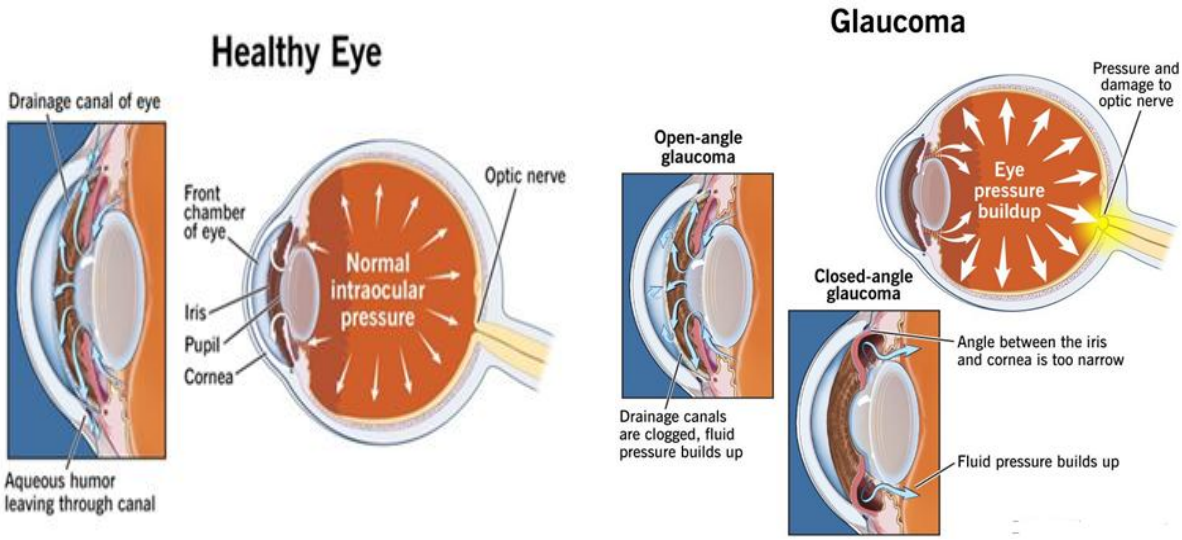
When there is a limited fluid released via the trabecular meshwork, open-angle glaucoma develops. The amount of fluid that is not being drained raises the intraocular pressure, or IOP, in the eyes. The iris-cornea angle is open in OAG, but the drainage through the trabecular meshwork is partially occluded. Open-angle glaucoma causes relatively gradual damage to the neurons, and the majority of people do not experience symptoms until significant damage has already taken place. If untreated, side vision may start to deteriorate, then central vision may follow .A dilated eye exam is often used to make the diagnosis.

Closed-angle glaucoma:

A damaged iris can lead to closed-angle glaucoma, also known as angle-closure glaucoma or CAG. This occurs when the drainage angle between the iris and cornea is blocked or narrowed, causing a fluid buildup and increased eye pressure. Symptoms of CAG, such as sudden eye pain, blurry vision, dilated pupil, redness, and nausea.

Childhood glaucoma:

A rare type of glaucoma called childhood glaucoma may be present at birth or may appear in the first few years of life.



1.1.3 Stages of the Glaucoma:

There are various phases of glaucoma, and the severity should dictate your course of treatment:

Stage 1 - Mildly elevated intraocular pressure is a common early symptom of the initial stage of glaucoma. This stage is usually characterized by changes in the optic nerve and the eye's ability to drain fluid through the trabecular meshwork.

Stage 2 - These might include light to severe eye discomfort or hazy or spotty vision.

Stage 3 - The third stage of glaucoma is officially referred to as the "advanced" stage. Treatment options, such as medications or surgery, may be recommended by the doctor based on the level of blockage and angle-closure present.

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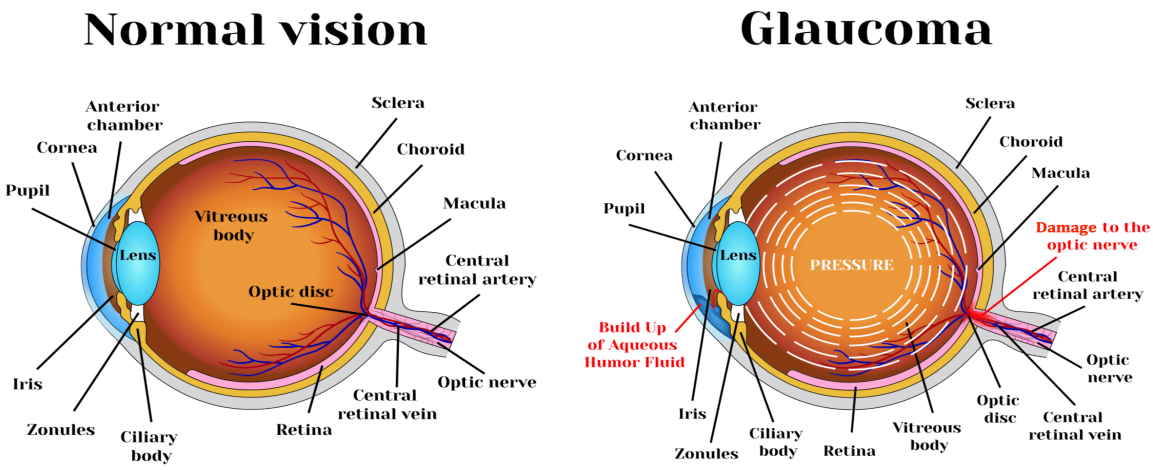
Stage 4 (End-Stage) - End-stage glaucoma occurs when there is minimal healthy eye tissue remaining, leading to a gradual deterioration of vision. While blindness may not always occur, the risk significantly rises at this advanced stage of the disease.



2. LITERATURE SURVEY

A Convolutional Neural Network (CNN), also called a ConvNet, is a type of feed-forward neural network typically employed for analyzing visual images. It processes data in a grid-like manner and is specifically designed for detecting and classifying objects within images.

2.1 Layers in a Convolutional Neural Network

A convolution neural network has multiple hidden layers that help in extracting information from an image. The four important layers in CNN are:

1. Convolution layer
2. ReLU layer
3. Pooling layer
4. Fully connected layer

1. Convolution Layer: This is the first step in the process of extracting valuable features from an image. A convolution layer has several filters that perform the convolution operation. Every image is considered as a matrix of pixel values.

2. ReLU layer: ReLU stands for the rectified linear unit. Once the feature maps are extracted, the next step is to move them to a ReLU layer. ReLU performs an element-wise operation and sets all the negative pixels to 0. It introduces non-linearity to the network, and the generated output is a rectified feature map. Below is the graph of a ReLU function:

$$R(z)=\max(0,Z)$$

3. Pooling Layer: Pooling is a down-sampling operation that reduces the dimensionality of the feature map. The rectified feature map now goes through a pooling layer to generate a pooled feature map. The pooling layer uses various filters to identify different parts of the image like edges and corners.

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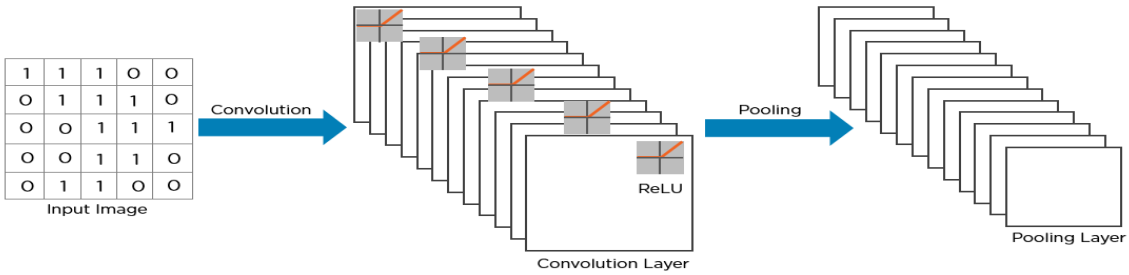
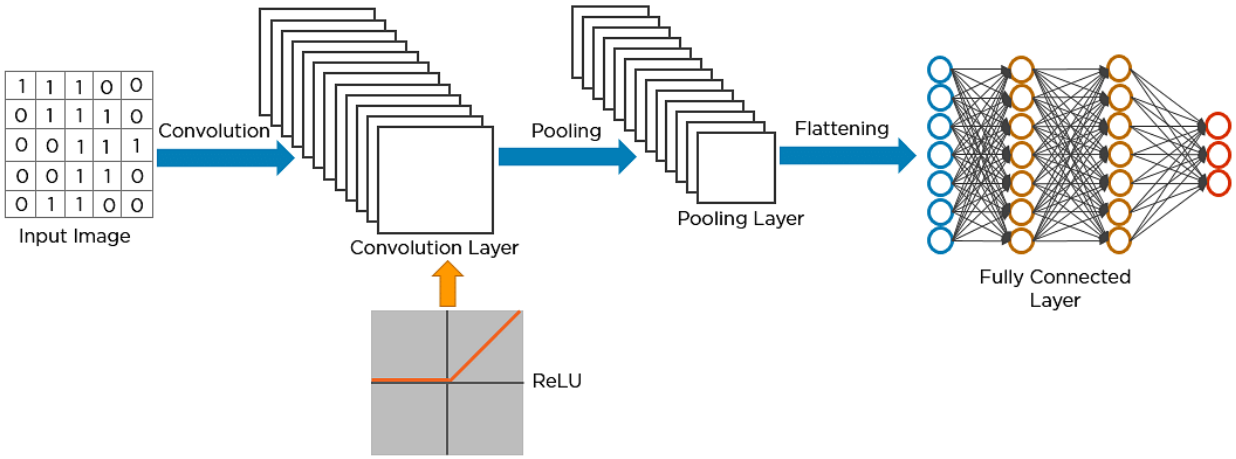


The next step in the process is called flattening. Flattening is used to convert all the resultant 2-Dimensional arrays from pooled feature maps into a single long continuous linear vector. The flattened matrix is fed as input to the fully connected layer to classify the image.



The proposed system describes the step by step process of the glaucoma and gives a detailed view and illustration of the entire process.

3. METHODOLOGY

3.1 Data collection

To build an effective Deep Learning model, it's crucial to be able to train, test, and validate it thoroughly before deploying it for practical use.

3.2 Data Set Selection

When working on prediction systems, data plays a crucial role as the system relies on it. The selection of data is a critical first step that must be carried out properly. The dataset used in this project is sourced from ACRIMA and consists of a total of 705 fundus images, including 396 images of glaucoma and 309 images of normal fundus.

1. Pre-Processing : The dataset contains images of various sizes and formats, some of which may have noise. The image preprocessing techniques are used to reduce the noise in the images and also standardize the data for further image classification. Gaussian Blur is applied to fixed size images of 256x256 pixels to reduce noise and enhance clarity.

2. Classification : The process of classification is to classify an image according to its visual content. The classifier used is k-nearest neighbor. The number of neighbor (k), distance matrix and dataset is given as an input for the algorithm.

3. CNN Model :The CNN model takes the pre-processed image as input, with an input layer, convolution layers, and a fully connected layer. The 256x256 pixel input image serves as the initial layer in the model. In the initial convolution layer, the input image undergoes the application of 16 filters, each consisting of 3x3

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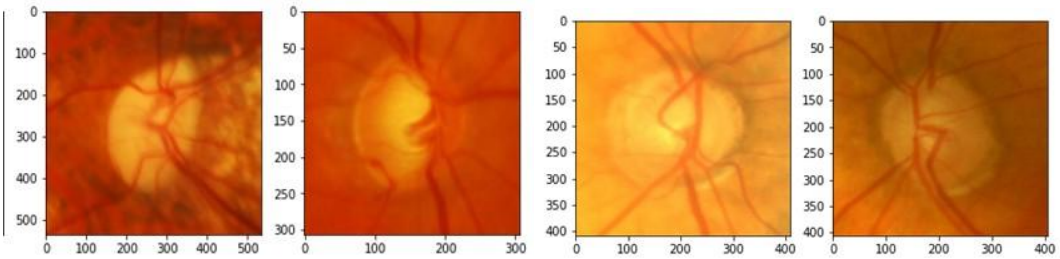
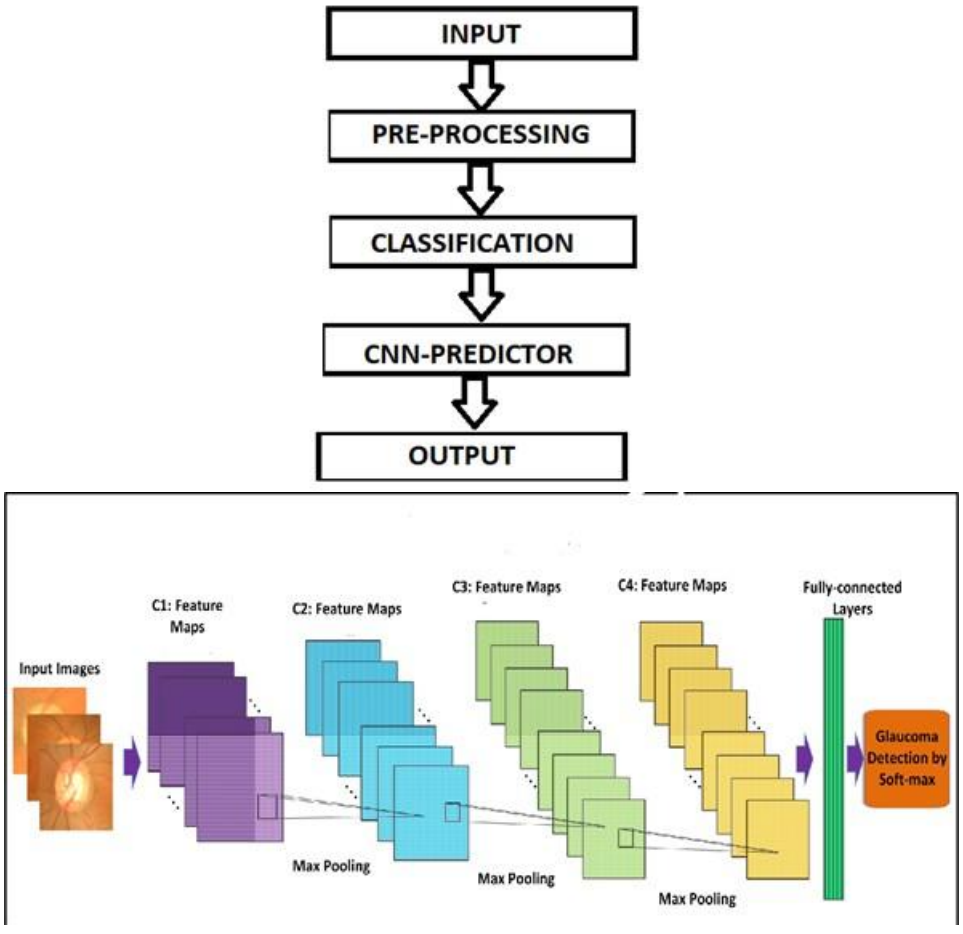
size kernels. These filters glide through the image one by one, resulting in the generation of 16 feature maps. This method is called as feature extraction. The features are then utilized in the ReLU activation function, which carries out a threshold operation for each input variable that has values less than zero. On the output of the ReLU layer, a max pooling layer of 2x2 window size is applied which results in down-sampling of the feature maps to 128x128 pixel. The output from the previous convolution layer serves as the input for the subsequent convolution layer. This following layer consists of 32 filters, each with a 3x3 scale kernel filters, which are applied to the feature maps obtained from the preceding layer. Operations such as ReLU and max pooling are conducted to create down-sampled data of 64x64 pixels. These same operations are then applied to the third layer, which serves as the final layer. In this layer, 64 filters of 3x3 size kernels are utilized, resulting in the production of 32x32 pixel data. The third convolution layer produces the output of 64 32x32 pixel feature maps. These features are flattened into a single 65536-long vector, which serves as the input for a fully-connected layer. This layer utilizes these features to determine whether the image depicts a healthy eye or an eye infected with glaucoma.





Normal images Glaucoma Image

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4. CONCLUSION

This study aimed to detect Glaucoma using a CNN – Deep Learning Method, which proved to be both effective and accurate compared to other existing methods. The study utilized the ACRIMA dataset, but future research plans to expand to private datasets and explore the use of both CDR and Fundus Images in Glaucoma detection.

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