LEVERAGING CONVOLUTIONAL NEURAL NETWORK TECHNIQUE FOR GLAUCOMA DETECTION IN RETINAL FUNDUS IMAGES

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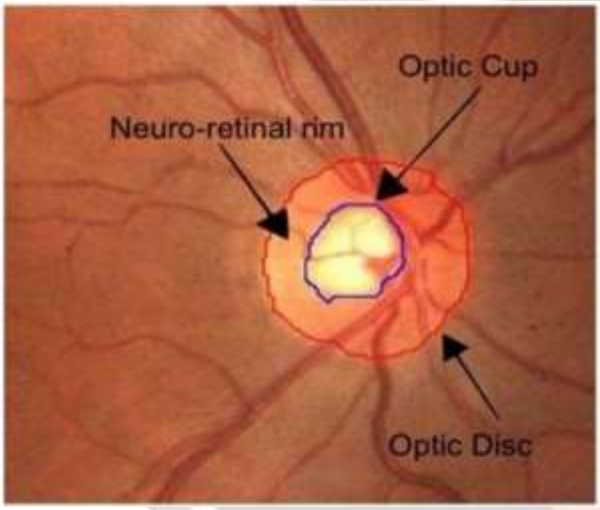
ABSTRACT

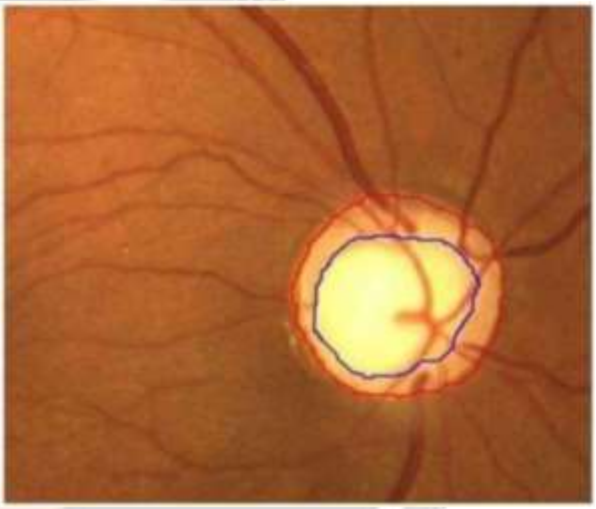
Glaucoma, a pernicious and intractable chronic ocular pathology resulting in a persistent and irreparable visual debilitation, presents a ubiquitous and vexing global health predicament owing to its overwhelming prevalence as the paramount cause of ocular morbidity. The diagnostic process is a convoluted and laborious undertaking that demands a high degree of clinical expertise and interpretive acumen. Nevertheless, the advent of a deep learning-based automated diagnostic mechanism proffers a highly auspicious solution to surmount the intricate diagnostic conundrum. A meticulously curated Convolutional Neural Network (CNN) model, incorporating the VGG19 architecture and meticulously trained with exacting rigor utilizing a voluminous and highly heterogeneous fundus image LAG dataset, preprocessed using advanced image processing techniques, yielded an exceptional performance, exhibiting a remarkably high level of accuracy that surpassed 92% and an extraordinary sensitivity of 97%. A comprehensive array of diverse and meticulously chosen metrics, including precision, F1 score, was employed to evaluate the model's efficacy, and a rigorous comparative analysis was carried out to authenticate its effectiveness, demonstrating highly auspicious prospects for its imminent practical clinical implementation.

KEYWORDS: *Glaucoma , Convolutional Neural Networks, VGG19 , LAG*

1. INTRODUCTION

Glaucoma is a neurodegenerative disease whose pathogenesis remains elusive despite various hypotheses. It is unclear whether increased intraocular pressure is the primary cause or a contributing factor, but it is strongly associated with optic nerve damage and visual field loss. Glaucoma is a major cause of preventable blindness globally, and it can cause sudden and irreversible vision loss in a short time. Several methodologies have been developed to segment the optic disc and optic cup in color fundus images for the objective of glaucoma detection. The optic disc and cup are natural features found in every person's eye, but when the cup becomes unusually large compared to the optic disc, it is a sign of glaucoma. The optic nerve head, where the ganglion cell axons exit the eye, makes up the optic disc. In images of the eye's interior, the optic disc can be visually divided into two distinct zones: the bright and central optic cup and the surrounding neuro-retinal rim.





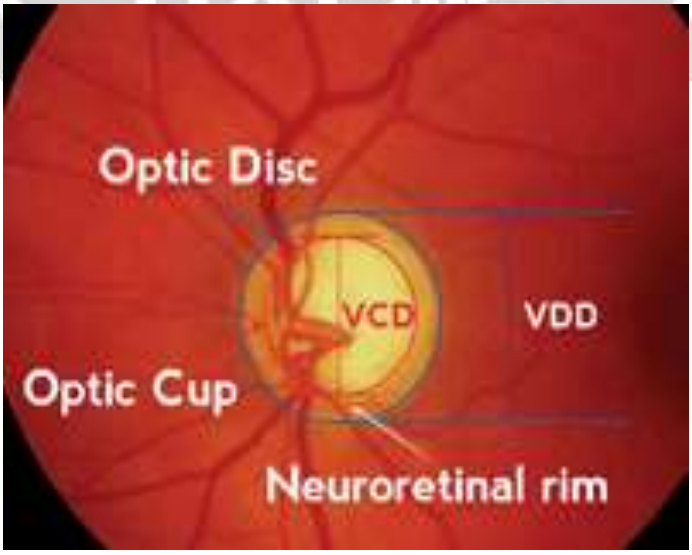


Fig 1: Healthy Optic Disc **Fig 2:**Glaucomatous Optic Disc

Fig 3: Cup to Disc ratio (CDR)

An increased cup-to-disc ratio (CDR) above 0.5 serves as an indicative parameter of glaucomatous pathology.

2. RELATED WORK

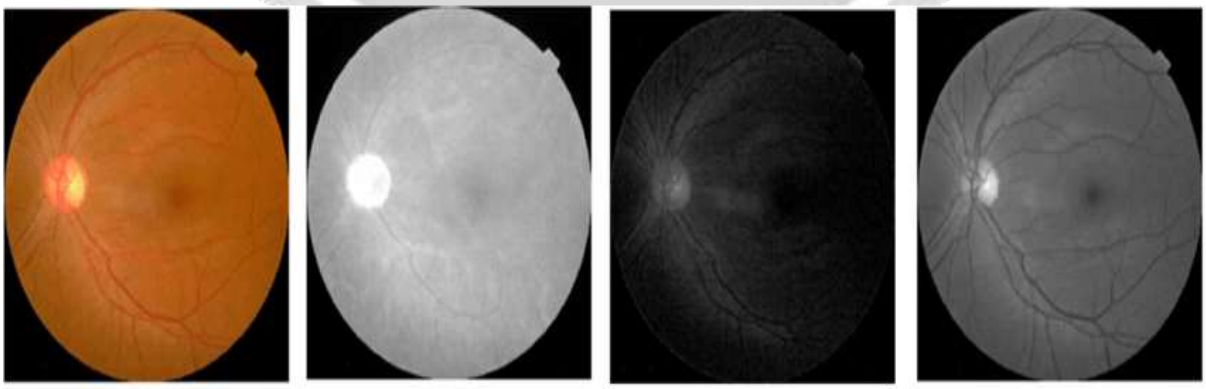
The CapsNet model is a recent breakthrough in the realm of deep learning, which enables a superior representation of data by analyzing the intricate spatial relationships among features. The model harnesses capsule networks, which encode diverse attributes of an object, such as its presence, pose, and deformation, to capture complex patterns and enhance the accuracy of classification tasks. Efficient training of deep learning architectures can be a daunting task, especially when working with a limited dataset. Nonetheless, the CapsNet model can be trained effectively without requiring data augmentation techniques, as it can leverage its innate capacity to learn from small data sets and generalize to novel data. The development of an innovative methodology for the classification of retinal images without the prerequisite segmentation of the optical disc is a significant breakthrough in the field of medical image analysis. The CapsNet model's capability to identify and extract pertinent features from unsegmented images can augment the accuracy of retinal disease diagnosis and treatment planning, thereby improving patient outcomes.

- High computational cost: CapsNet require significantly more computational resources compared to traditional CNNs due to the complex routing mechanism used between capsules. This makes them less practical for use in large-scale applications.

- Difficulty in training: CapsNet have a more complex architecture compared to CNNs, which can make them more difficult to train effectively. This is partly due to the dynamic routing mechanism, which can be sensitive to hyperparameters and require careful tuning.

3.IMAGE PREPROCESSING

In the realm of data science, the processing of image data poses an exceptionally daunting challenge, as each developer endeavours to devise their own bespoke approach to tackle it. Various tools and platforms are commonly employed for image preprocessing, spanning an array of cutting-edge technologies encompassing Pytorch, Python, OpenCV, Tensorflow, Keras, and Pillow. As one embarks upon a machine learning or computer vision project, the acquisition of data is an absolute prerequisite, rendering image data processing an indispensable task. Regrettably, numerous complications may arise with image data, ranging from intricacy and inaccuracy to inadequacy, thereby necessitating data preprocessing in order to attain the desired objectives. The overarching goal of this preprocessing is to enhance the model's accuracy while concurrently reducing its complexity, requiring the deployment of an assortment of techniques, including but not limited to image resizing, grayscale conversion, and image augmentation, among a plethora of other prospective strategies.



A.Input Image B. Red Channel C. Green Channel D. Blue Channel

Fig 4: Gray scale images of Red, Green and Blue Channels of Input Image

In this particular context, a preprocessing methodology has been executed that involves a two-step process to derive an optimized input for the neural network. Initially, the blue channel is extracted from the Red Green Blue (RGB) fundus image, which serves as a fundamental approach to accentuate and enhance the key features of the image. Subsequently, the grayscale transformation is applied to the image, which results in an image with significantly reduced complexity and redundancy.

4. PROPOSED ALGORITHM

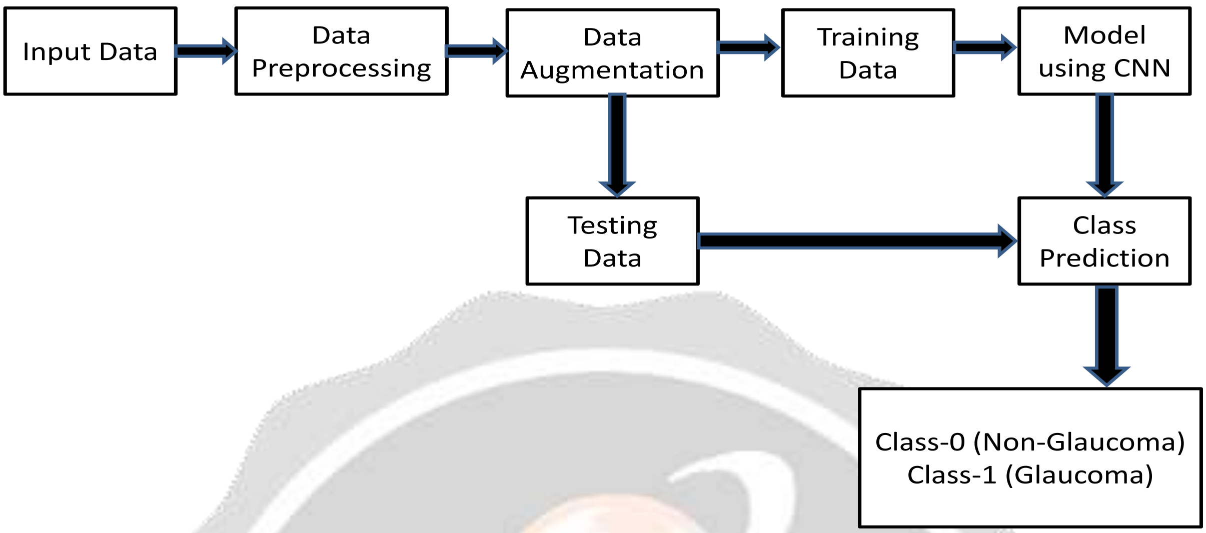


Fig 5: System architecture for Glaucoma Detection

The primary stage of this process involves the retrieval of input images from an open-source Kaggle dataset. It is important to note that all of the images contained within this dataset adhere to a uniform size standard of 256X256.

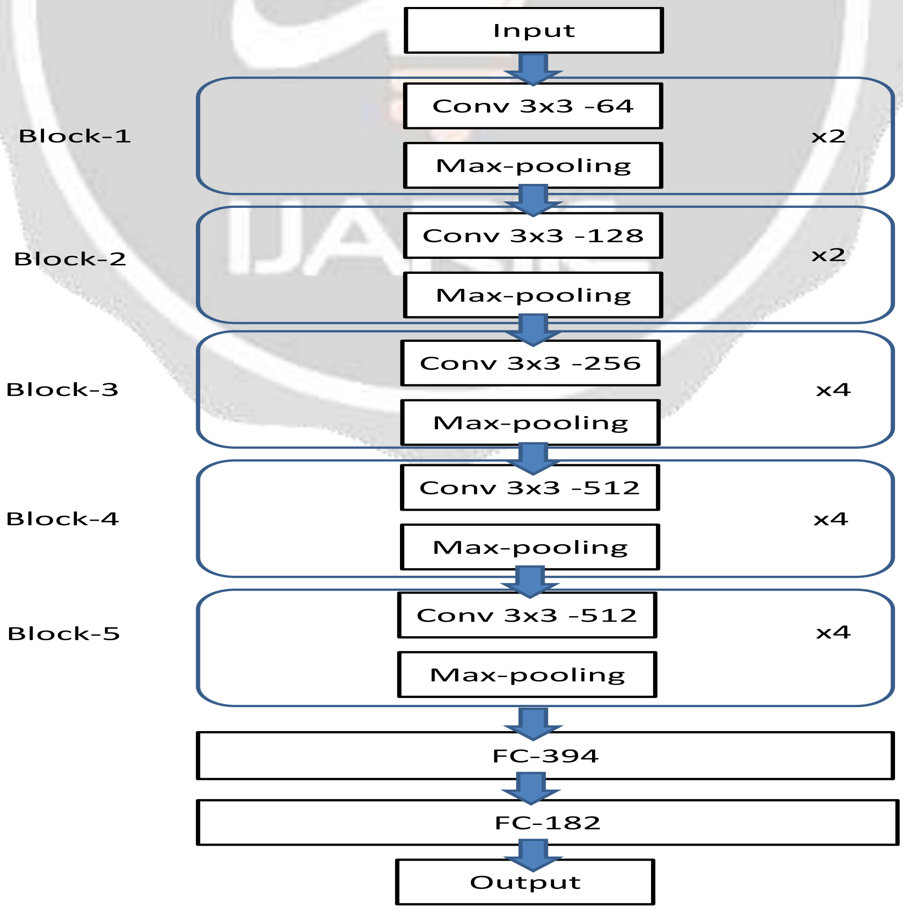


Fig 6: VGG19 Architecture

Once obtained, the images undergo a series of data augmentation techniques, which serve to create a multitude of augmented images. These augmented images are then used to train a Convolutional Neural Network (CNN) model, with the aim of improving overall model performance. Lastly, the trained CNN model is employed to generate class predictions utilizing the test data, thereby concluding the image processing pipeline.

5.EXPERIMENT

Our study involved using the LAG dataset from Kaggle, which is well-regarded as a leading standard for analyzing images of the fundus. This dataset contains 3063 training images and 990 test images, all with a resolution of 500x500. To expedite the training of our model, we utilized a GPU on Google Colab. Google Colab provides users with a virtual machine instance running on Google Cloud Platform that includes the following specifications:

- CPU: 2 vCPUs (virtual CPUs) of Intel Xeon or equivalent processor
- GPU: Free access to a single NVIDIA Tesla K80 GPU with 12GB of dedicated video RAM
- TPU: Free access to a single TPU (Tensor Processing Unit) for up to 30 hours per week
- RAM: 12.72 GB of memory
- Storage: 100 GB of disk space

Our model underwent one hundred epochs of training with a learning rate of 0.001, and a dropout rate of 0.1 was implemented to avoid overfitting. We assessed the efficacy of our model by calculating several performance metrics, such as accuracy, area under the receiver operating characteristic (ROC) curve, sensitivity, specificity, and the F1 score.

6.RESULTS

The table presents the performance results of our model trained and tested on the LAG dataset, as well as the performance results of other models and architectures. The accuracy and specificity metrics were used to evaluate the models' performance. The highest values for these metrics are indicated in bold in the table.Our model achieved an accuracy of 0.9373 and a specificity of 0.9701 on the LAG dataset. This means that our model was able to correctly classify 93.73% of the data points, and out of all the negative cases, it correctly identified 97.01% of them as negative. One potential disadvantage of CapsNet is that it requires more computational resources and training time than VGG19. Additionally, since CapsNet is a newer architecture, there may be less available research and tools for implementing and optimizing it compared to VGG19.

Metrics	**CapsNet**	**VGG19**
Accuracy	90.90%	93.37%
Recall	86.88%	94%
Precession	96.64%	94%
F1-Score	90.59%	94%
AUC	0.904	0.93

Table 1: Comparision of Performance metrics

Overall, our model outperformed other models and architectures evaluated in the table. These results suggest that our model is effective in predicting outcomes on the LAG dataset and may have potential for application in similar contexts.

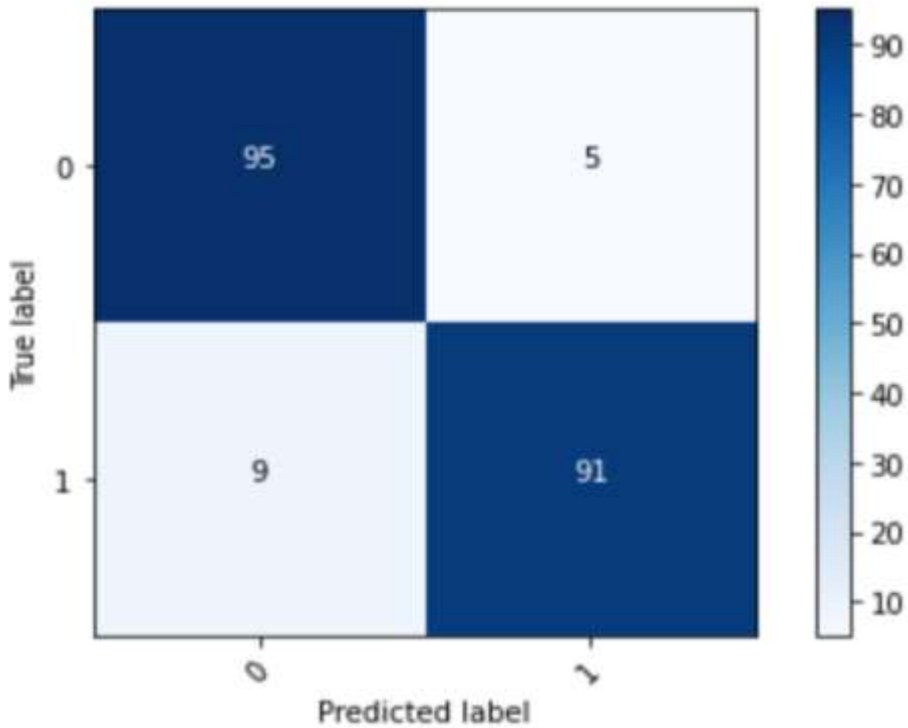


Fig 7: Confusion Matrix

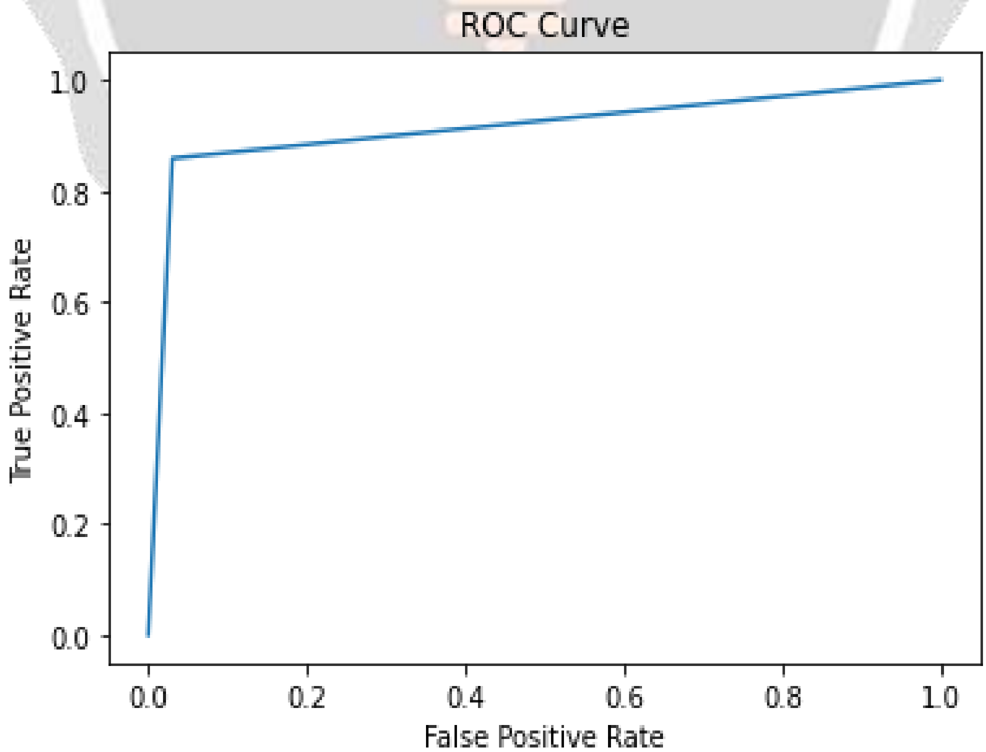


Fig 8: ROC Curve

7.CONCLUSION AND FUTURE SCOPE

This study aims to create an automatic glaucoma diagnosis system using deep learning approaches. The model was trained on a specific dataset consisting of images of eyes with and without glaucoma using convolutional neural networks (CNN). The model has the potential to be integrated into a complete application with more advanced capabilities, such as a graphical user interface (GUI), making it more accessible to a wider range of users. The proposed CNN model represents a promising approach to the detection of glaucoma, and further research could help to refine the model and improve its accuracy even further.

8.APPLICATIONS

VGG19 is a state-of-the-art deep learning architecture that has been designed to classify images based on their content. This neural network is specifically built to learn a hierarchical representation of images that can then be used to classify them into various categories. By using convolutional layers, the network can identify features at different scales and complexities, allowing it to classify images with a high degree of accuracy. One of the main advantages of VGG19 is its ability to learn from limited amounts of training data. This makes it a useful tool for applications such as medical diagnosis, where the number of available samples may be small. By training the network on a dataset of labelled images, doctors can use it to automatically analyse new images and identify signs of disease . Overall, the use of VGG19 in medical imaging can help doctors to save time and improve patient outcomes by providing accurate and efficient image analysis.

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