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A Critical Analysis of Approaches to Glaucoma Detection

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Abstract: *This research paper focuses on building an accurate deep learning model to facilitate glaucoma detection. The document explains the approach used to detect glaucoma in retinal eye scans. The results of this research open the way to the widespread use of this model in the medical fraternity, because we investigated different techniques to solve this problem using different open source and freely available models that were compared. All these templates provide a clear experience to the users who are related to this article. However, the success of these applications also depends on factors such as the quality of retinal scans, the quality of images trained with a deep learning model, etc. The paper concludes with a model that is most suitable for people to create real-time applications in the medical field and improve glaucoma awareness and early detection before it is too late.*

Keywords: "Training," "Bounding Box", "Glaucoma", "DETECTRON2".

I. INTRODUCTION

Glaucoma is a group of eye diseases that can lead to vision loss and even blindness if left untreated. It is characterized by damage to the optic nerve, the part of the eye that transmits visual information from the retina to the brain. The most common cause of glaucoma is elevated intraocular pressure (IOP), which can damage the optic nerve over time. Early detection is critical in the treatment of glaucoma, as it can often be effectively treated with medication or surgery to lower eye pressure and prevent further damage to the optic nerve. Regular eye exams, especially if you have risk factors such as glaucoma in your family or are over 40, are essential for early diagnosis and treatment of glaucoma.
This research paper focuses on the comparison of different models used to facilitate the detection of glaucoma in retinal scanning and finally proposes the most suitable model for glaucoma detection in retinal scanning.

II. APPROACH

One of the evaluations that an ophthalmologist will perform to diagnose glaucoma in a patient is by evaluating the optic disc. Typically the rise in intraocular pressure can be seen as a deformation of the optic disk or changes in the size and shape of the optic nerve head. Signs of cupping or damage of the optic nerve can be an indication of glaucoma.

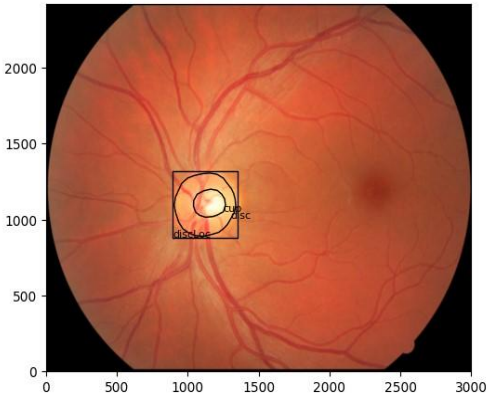

Figure 1. Retinal Scan along with the Bounding Box

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An ophthalmologist would take a scan of the patient's retina and look for any damage on the optic nerve. Our proposed model detects retina scans for such damages on the optic nerve which would otherwise cost valuable human effort and time. The dataset used for developing our model contains roughly thousand labelled images of retina scans taken by a fundus camera. The labels are segmentation masks around the optic cup and the optic disk as well as a bounding box for the entire optic disk.

III. ANALYSIS OF EXISTING MODELS

To capture changes in the optic disc and cup it is crucial to develop image recognition models. Convolutional Neural Networks (CNNs) serve as fundamental cornerstones for image processing tasks. There are various models which make use of CNNs for complex image processing, some of which were considered for the project.

3.1 VGG-16

It is a CNN model 16 layers deep consisting of about 138 million parameters. It makes use of 3 by 3 convolution filters making it computationally expensive. It is trained over a thousand images from the ImageNet database. The pretrained model is capable of distinguishing thousand different classes.

3.2 ResNet-50

ResNet-50 is a deep neural network architecture which makes use of 50 layers. It is deeper than VGG-16 but introduces residual blocks - skipped connections, making it more efficient and trainable. It also helps solve problems like the vanishing gradient problem due to its unique architecture.

3.3 Inception Networks

Inception Network models are known for their use of "inception modules" that combine multiple convolutional filters of different sizes in parallel. Inception-v4 is an advanced version. It also contains residual layers. It has increased depth and incorporates more filters and layers. Despite increased depth it is computationally efficient.
Some or all layers of such pretrained models can be used to extract certain features in new models. They can be used as feature extraction modules as part of other applications. This is generally achieved by modifying the output layer or appending layers to existing networks.

IV. FLOWCHART

A flowchart is a diagram that illustrates a process or procedure. The various steps in a process are represented by a set of standardized symbols, and connecting arrows are used to indicate the sequence in which the steps should be completed. A wide range of disciplines, including business, engineering, and computer science, employ flowcharts
In Figure 2. We present the flowchart of the proposed system, as given below, the flow of the application is described diagrammatically. When a user passes an eye scan image to the system, the image is automatically scaled, augmented if needed and passed to the DETECTRON2 which creates a bounding box around the optic disk when identified and predicts the class associated with the disk.
The 2 available classes to predict are as follows:
1. Glaucoma present
2. No Glaucoma present

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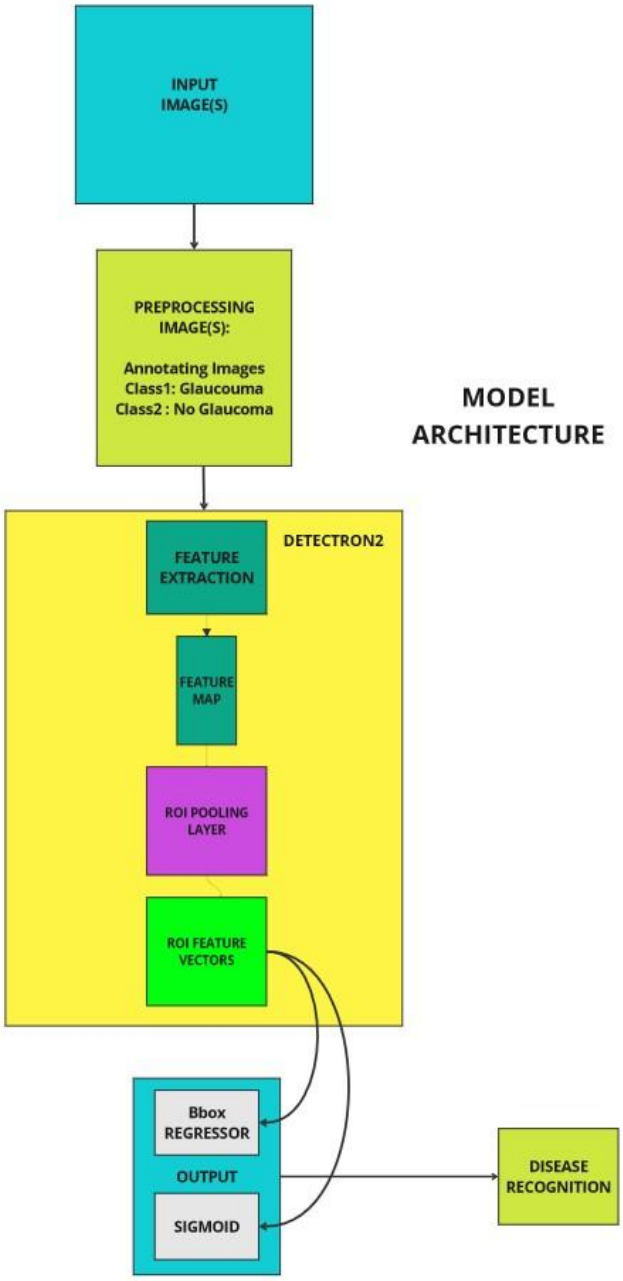

Figure 2. Flowchart of the proposed system

V. SECTIONS

5.1 Experiment and Compare

A. Solution

To find a non-computationally expensive model and tweak it for image classification and support it by comparing it to various existing models.

B. Introduction

The main objective of this study was to find out the best model out there which is best suitable for Glaucoma Detection. To achieve this objective, we conducted an experiment of various existing models with the dataset available and compared their results with our model.

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C. Literature Review

The research gap identified in our literature review is that while [1]the proposed deep learning framework achieved high accuracy in optic disc segmentation in fundus images, further research is needed to validate the framework's performance on larger datasets and in clinical settings to other individuals. The U-Net model[7] is a type of convolutional neural network commonly used for image segmentation tasks. It focuses on the application of the U-Net model in the context of retinal vessel segmentation. This provides limited information about the use of the U-Net model for retinal vessel segmentation and lacks detailed explanations or results.

D. Method

We collected images from various sources on the internet to create a dataset of our own representative of 2 classes namely Glaucoma and No Glaucoma. These images were annotated using various tools like cvat.ai and makesense.ai which we exported to a JSON file which contained the annotation coordinates for each image and their class labels. These images were then trained on DETECRON2 which is an OBJECT DETECTION model developed by META and particularly specializes in scientific related OBJECT DETECTIONS. After training on the training images for 1000 iterations test images were passed to the model to identify and create a bounding box around the optic disk and predict its label: GLAUCOMA or NO GLAUCOMA.

E. Result

The results of the research show and proves the effectiveness of DETECTRON2 over the other existing pre-trained models for Glaucoma detection in eye scans. We compiled a table comparing the existing models and and their accuracy compared to our OBJECT DETECTION model DETECTRON2.Refer to table 1 below.

Sr No.	MODEL	VALIDATIONACCURACY
1.	VGG 16	73.85%
2.	Tiny VGG	73.5%
3.	ResNet50	73.85%
4.	InceptionV4	75%
5.	DETECTRON2	91%

Table 1. Comparison of various existing models and our GlaucAI model

F. Discussion

Looking at Table.1 we can observe that on training the top 4 existing models on the available dataset the accuracy of all the models above remains the same and does not improve with increasing training time and fine-tuning. The DETECTRON2 model however performs well at 91% validation accuracy even when trained on very less annotated image per class, this is a massive advantage over the other existing models.

G. Conclusion

In conclusion, through the experiments performed and the comparisons made with the existing models in table1 we can conclude that DETECTRON2 with its fairly outperforming validation accuracy of 91% makes it a fair choice for users to use in their applications for glaucoma detection in eye scans. DETECTRON2 also requires less data it being an object detection model works well in cases where data is rare.

5.2 Technology Used

Various technologies used to develop our application are as follows:

A. Python

Python is employed to create algorithms and models that can identify and locate objects within images or video streams. Python's extensive library support, especially with frameworks like TensorFlow, PyTorch, and OpenCV,

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facilitates the implementation of sophisticated object detection techniques. These libraries offer pre-trained models and tools that simplify the development process, allowing developers to focus on refining the model's accuracy and efficiency.

B. Detectron2

Detectron2 is a popular open-source computer vision library that serves as a cutting-edge platform for developing and deploying object detection and segmentation models. Built by Facebook AI Research (FAIR), it offers a robust and flexible framework for researchers and developers to create state-of-the-art computer vision applications.

This framework is built on PyTorch, a popular deep learning library, it enables us to easily experiment with and customize various components of object detection pipelines. Detectron2 includes a rich set of pre-trained models, such as Faster R-CNN, Mask R-CNN, and RetinaNet, and supports efficient model training and inference.

C. Pytorch

PyTorch is an open-source machine learning framework that has gained popularity for its flexibility, dynamic computation graph, and robust support for deep learning applications. Developed by Facebook's AI Research lab (FAIR), PyTorch provides a Python-centric interface, making it highly accessible to researchers and developers. It comes with a rich ecosystem of tools and libraries that aid in building, training, and deploying machine learning models. These include libraries like torch vision for computer vision tasks.

D. MakeSense AI

Makesense ai is an innovative platform in the field of computer vision and artificial intelligence that specializes in object detection and segmentation. This technology offers advanced solutions for accurately identifying and delineating objects within images and videos. It employs cutting-edge deep learning algorithms to enable computers to understand and locate objects in visual data, making it particularly valuable for a wide range of applications. From autonomous vehicles and robotics to image analysis and content tagging.

E. CVAT AI

CVAT.ai is a powerful and versatile computer vision platform designed for object detection and segmentation tasks. This innovative tool leverages cutting-edge AI and machine learning technologies to assist users in annotating and labelling images and videos with exceptional precision and efficiency

VI. ACKNOWLEDGEMENT

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VII. CONCLUSION

In conclusion, the object detection model proposed in this research paper offers a fairly less computationally expensive and higher accuracy solution to the image classification problem at hand.

The model is able to make use of the less data available to it and learn the annotations and important features to correctly detect and identify glaucoma in eye scans, without the cost of efficiency and accuracy. Overall, the model described in this research paper has the potential to significantly impact the thought process of users out there and help achieve optimality and efficacy. This is a boon to users who aim to achieve higher accuracy with less data and lesser computation resources.

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