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DEEP LEARNING FOR DIABETIC RETINOPATHY DETECTION AND CLASSIFICATION BASED ON FUNDUS IMAGES

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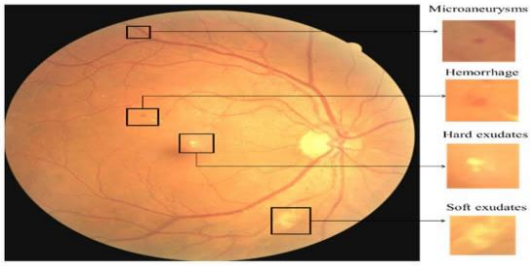
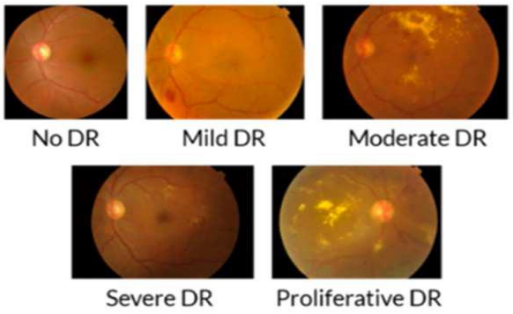
Abstract Diabetic Retinopathy (DR) is an eye disease associated with chronic diabetes. DR is the leading cause of blindness among working aged adults around the world and estimated it may affect more than 93 million people. Progression to vision impairment can be slowed or controlled if DR is detected in time, however this can be difficult as the disease often shows few symptoms until it is too late to provide effective treatment. Currently, detecting DR is a time-consuming and manual process, which requires an ophthalmologist or trained clinician to examine and evaluate digital color fundus photographs of the retina, to identify DR by the presence of lesions associated with the vascular abnormalities caused by the disease. The automated method of DR screening will speed up the detection and decision-making process, which will help to control or manage DR progression. This paper presents an automated classification system, in which it analyzes fundus images with varying illumination and fields of view and generates a severity grade for diabetic retinopathy (DR) using machine learning models such as CNN, VGG-16 and VGG-19.This system achieves 80% sensitivity, 82% accuracy, 82% specificity, and 0.904 AUC for classifying images into 5 categories ranging from 0 to 4, where 0 is no DR and 4 is proliferative DR.

1. INTRODUCTION

Diabetic retinopathy (DR) is one of the most complicated issues of diabetic patients in which the retina becomes damaged and leads to blindness. It affects the blood vessels in the retina and due to leakage of fluid distort the vision completely. DR progress through mainly four stages; The earliest stage is Mild nonproliferative retinopathy, where only microaneurysms can occur. The second stage is Moderate nonproliferative retinopathy, where the blood vessels' lose their ability of blood transportation because of their distortion and swelling with the progress of this disease . The next stage is Severe non-proliferative retinopathy, which results in deprived blood supply to the retina due to the increased blockage of more blood vessels signaling the retina for the growing of fresh blood vessels. The final stage is Proliferative diabetic retinopathy, which is an advanced stage , where the growth features secreted by the retina activate proliferation of the new blood vessels, growing along the inside covering of retina in some vitreous gel, filling the eye. Each and every stage has its own characteristics and particular properties. But doctors possibly could not take some of them into account and thus make an incorrect diagnosis. So this leads to the idea of creation of an automatic solution for DR detection. DR can lead to a loss of vision if it is in an advanced stage. Worldwide, DR causes 2.6% of blindness. The possibility of DR presence increases for diabetes patients who suffer from the disease for a long period. Retina regular screening is essential for diabetes patients to diagnose and to treat DR at an early stage to avoid the risk of blindness.



Different types of DR lesions
DR is detected by the appearance of different types of lesions on a retina image. These lesions are micro-aneurysms (MA), hemorrhages (HM), soft and hard exudates (EX). Microaneurysms (MA) is the earliest sign of DR that appears as small red round dots on the retina due to the weakness of the vessel's walls. The size is less than 125 μm and there are sharp margins. Michael et al. classified MA into six types.The types of MA were seen with AOSLO reflectance and



The Diabetic Retinopathy stages

Existing System

Proliferative DR represents the latter stages of DR and represents an antigenic retinal response, in which angiogenesis is a physiological process in which new vessels form from pre-existing blood vessels. As a future direction, upcoming studies should focus on leveraging SSL methods to not only generalize but also be able to generate new fundus images based on the learned features using generative networks. Generative adversarial networks (GAN) and Variation auto-encoders (VAE) can be combined with existing networks to synthesize a whole range of enhanced fundus images that can be made available for training.

Proposed System

This paper reviews and analyzes state-of-the-art deep learning methods in supervised, self-supervised, and Vision Transformer setups, proposing retinal fundus image classification and detection. For instance, referable, non-referable, and proliferative classifications of Diabetic Retinopathy are reviewed and summarized. Moreover, the paper discusses the available retinal fundus datasets for Diabetic Retinopathy that are used for tasks such as detection, classification, and segmentation.The utilization of self-supervised vision transformers, such as DINO proposed by to encode better features when large-scale DR sets are provided. Transformers have shown a positive correlation between the number of trainable parameters and accuracy, hence they are immune to saturation with larger sets and varying data distributions. Emphasis has also

been put towards effective image processing techniques as proposed to further enhance model performance. In computer aided diagnosis (CAD), features of exudates and hemorrhages are highly detectable. This allows fundus images to be clustered into proliferative and no proliferative cases, where mild and severe vessel abnormalities are distinguished from low level less critical lesions.
Modules
Diabetic Retinopathy diagnosis categorization contains 4 modules,
they are,

- Diabetic retinopathy
- Diabetes mellitus
- Diabetic macular edema
- Micro aneurysms

Diabetic Retinopathy
Diabetic Retinopathy (DR) is a degenerative disease that impacts the eyes and is a consequence of Diabetes mellitus, where high blood glucose levels induce lesions on the eye retina. Diabetic Retinopathy is regarded as the leading cause of blindness for

diabetic patients, especially the working-age population in developing nations. Treatment involves sustaining the patient's current grade of vision since the disease is irreversible.

Diabetes Mellitus

Diabetes serves as the most prominent reason for blindness for people under the age of 50 years. Diabetes Mellitus is a direct cause of Diabetic Retinopathy (DR) which is a complication of diabetes where glucose blocks blood vessels that feed the eye and causes swelling and leaking of blood or fluids that can cause severe eye injury. The detrimental vision loss due to DR occurs primarily when there is retina central swelling.

Explainable architectures are deemed to be more plausible in the real-world industry. In the medical domain, every decision needs to be justified through insight, research, and scientific proof. Interpretable design is the key in integrating medical imaging models in the end-to-end operational pipelines of many institutions and research facilities.

Diabetic Macular Edema

The classification involved 5 classes, namely, referable diabetic macular edema, moderate or worse DR, severe or worse DR, or fully gradable. The system put forward was used to detect Diabetic Retinopathy on their dataset. Their dataset was divided into four classes with a total of 13,767 images. Cropping, resizing, histogram equalization and adaptive histogram equalization were used to pre-process the images. Image enlargement was done through augmentation followed by contrast improvement by a contrast stretching algorithm that is used for dark images.

Micro Aneurysms

Hemorrhages (HM) are diagnosed by the presence of large spots on the retina with irregular margin sizes of upwards of 125 micrometers, contrary to Micro aneurysms. Hemorrhages can be classified into two categories known as flame and blot, where the spots are superficial and deep, respectively. Microaneurysms and Hemorrhages commonly appear as red lesions, while the two types of exudates appear as bright lesions. Diabetic Retinopathy detection involves identifying 5 stages which are no DR, mild DR, moderate DR, severe DR and proliferative DR illustrates the five possible stages of DR development.

Conclusion And Future Scope

This project successfully detects diabetes by using deep learn-ing on a fundus images and it can be used as one of methods to detect diabetes in the future.CNNs promise to leverage the large amounts of images that have been massaged for physician interpreted screening and learn from raw pixels. The high variance and low bias of these models could allow CNNs to diagnose a wider range of nondiabetic diseases as well. Visualizations of the features learned by CNNs reveal that the signals used for classification reside in a portion of the image clearly visible by the observer. Moderate and severe diabetic retinal images contain macroscopic features at a scale that current CNN architectures CNN for training accuracy as well as validation accuracy. For future work model can train with system, with more number of processed data for getting higher accuracy result Diabetic retinopathy remains a major cause of visual impairment and blindness, just as diabetic nephropathy is a major cause of renal failure, owing to the growing burden of type 2 diabetes. Over one-third of the world's 285 million people with diabetes are estimated to have diabetic retinopathy, and one-third of these (approximately 3.2 million) have vision-threatening retinopathy. Nowadays, image processing techniques with deep learning have performed a vital role in computer-aided systems to diagnose abnormalities in diabetic retinopathy. There are some possible directions that may help to fully utilize the deep learning approaches in a more effective way. In the literature, it was noted that most research work has been performed with the use of convolutional neural network models to develop deep multi-layer frameworks for the diagnosis of diabetic retinopathy using digital retinal fundus images, but on the other hand, the analysis and explanation of retinal photographs need ophthalmologists, which is time-consuming and very expensive task. The risk of vision loss from diabetic retinopathy has fallen dramatically over the past 3 decades with improvements in diabetes and blood pressure treatments, and with advances in laser surgery and intraocular drug delivery. Nevertheless, diabetes remains to be a major cause of blindness. This paper summarizes the state of the art in diabetic retinopathy research and provides a perspective on opportunities for future investigations.

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