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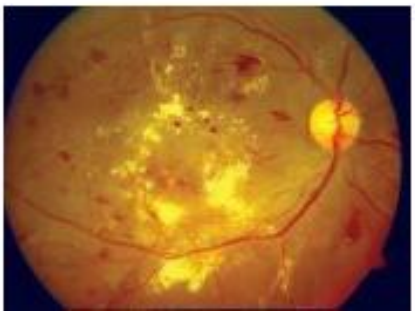
Ai-Based Detection Of Diabetic Retinopathy From Fundus Images

Venu Anand Das Vaishnav[1],Aakansha Soy[2],Dr. U K Neogi[3]
[1]Assistant Professor, Department of Pharmacy, Kalinga University, Raipur, India.
ku.venuananddas@kalingauniversity.ac.in, 0009-0005-3775-6156
[2]Assistant Professor, Department of CS & IT, Kalinga University, Raipur, India.
ku.aakanshasoy@kalingauniversity.ac.in,0009-0002-1955-6909
[3]Professor, New Delhi Institute of Management, New Delhi, India., E-mail: uk.neogi@ndimdelhi.org, https://orcid.org/0009-0008-1281-3697

Abstract
Early detection of Diabetic Retinopathy (DR) is a hot topic among researchers. Various Artificial Intelligence (AI) techniques have been employed to screen and diagnose DR early on, aiming to protect diabetic patients from blindness, which is often linked to the severity of the condition. Unfortunately, many existing models fall short due to time inefficiencies and premature convergence, which pose significant challenges in real-world applications. In light of these limitations, three key gaps have emerged: first, there's a critical lack of available medical data; second, there's a need for enhanced optimization algorithms to prioritize and select features for improved outcomes; and finally, relying on a single algorithm can be limiting when a combination of algorithms might yield better results. To tackle these challenges, this research proposes a novel computerized model for DR identification that incorporates three innovative methodologies. Diabetic Retinopathy is a leading cause of blindness among diabetic patients, primarily because it often shows no symptoms until significant damage has occurred. Early detection of this disease can help prevent blindness. Accurately identifying key features in fundus images, such as the optic disc, is crucial. Timely recognition of signs like hemorrhages, optic disc changes, exudates, cotton wool spots, and microaneurysms can slow the progression of the disease and assist doctors in providing effective treatment.
Keywords: *identification, Artificial Intelligence, techniques, DR*

INTRODUCTION

Diabetes is a metabolic disease because of lack of or reduced activity of pancreas secretion's insulin hormone in human body. In the long run, uncontrolled diabetes influences the eye, kidneys, heart, and even the human nervous system. Diabetes forms an eye disease named Diabetic Retinopathy (DR). In the future, it will lead to permanent blindness if left untreated in the initial stage of DR. Uncontrolled glucose levels in the blood increase the DR, then the controlled blood glucose levels. DR is one of the significant reasons for permanent eye blindness [1]. One-third of the number of diabetic patients fall under DR, and one-tenth of them experience the severity of permanent loss of vision[2]. Twenty to seventy-year-old individuals lose their eyesight primarily because of DR in USA. Hence, periodic, at least yearly retina screening is required [9]. The retina screening begins by obtaining a fundus photograph of the retina with the help of paramedical staff using a mydriatic camera. Then, this fundus photograph is examined by the specialist physicians of the eye to identify DR. In India, DR is currently being managed in numerous manners, e.g., eye checkup camps once a year in rural as well as urban areas. Sometimes patients with diabetes report to the eye hospitals for other eye ailments, at other times by using telemedicine facilities, fundus photographs are obtained for scrutiny, and DR is identified by the doctor. [3].



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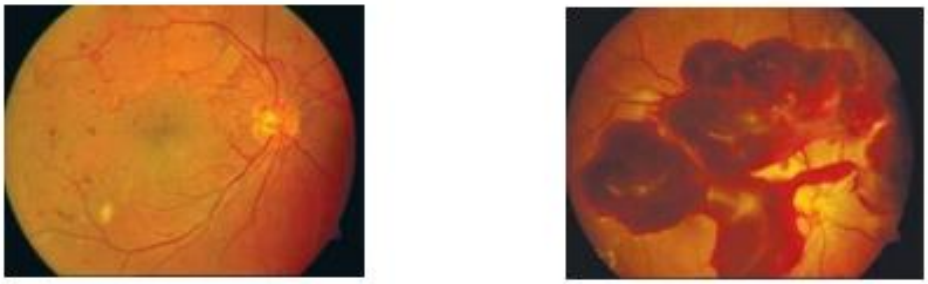


Figure 1: Various types of DR

Retinopathy refers to a group of disorders that harm the eye's tissues, leading to vision loss. There are three main types of retinopathies that affect people globally and have been extensively studied (see figure 1). These are Diabetic Retinopathy (DR), Age-related Macular Degeneration (AMD), and Glaucoma. AMD occurs due to changes in the retinal layers as they age, while DR is linked to irregular blood flow[10]. Glaucoma encompasses a range of eye diseases that impact the optic nerve. The following sections delve into detailed descriptions of these conditions [13]. Diabetes is a condition where the body either doesn't produce enough insulin or the cells become resistant to it, resulting in abnormal blood sugar levels[4].

Materials and methods

DR is a microangiopathy in nature and involves primarily retinal precapillary arterioles and capillaries and result in microvascular occlusion and blood spillage. Pathogenesis under microvascular occlusion is capillary change that results from swelling of the base membrane of capillary. The inner blood-retinal barrier is created by the tight association of endothelial cells. Neo-vascularization results due to growth factor on the retina and optic nerve head. Endothelial cells and pericytes are the cellular components of retinal capillaries[6]. The inner blood-retinal bloked is constituted by the tight alignment of endothelial cells. Pericytes encircle the capillaries and support the structural integrity of the vessel wall [5-11]. Normal individuals have one pericyte for each endothelial cell but diabetics possess fewer pericytes. The strength of the vessel wall is maintained by the pericytes, which are a covering within the capillaries. Local capillaries bleed or thrombose and form microaneurysms. Due to distension of the capillary wall with this loss of pericytes, the blood-retinal barrier is disrupted, and the plasma components penetrate into the retina. Diffuse or focal intraretinal haemorrhage is caused by increased vascular permeability. The hard exudates are created by the chronic localized retinal odema at the border of the healthy and oedematous retina. The Lipid-filled macrophages and lipoproteins are the major constitutions of exudates. Clinically, diabetic retinopathy can be detected by the following lesions in the fundus image of the eye [7].

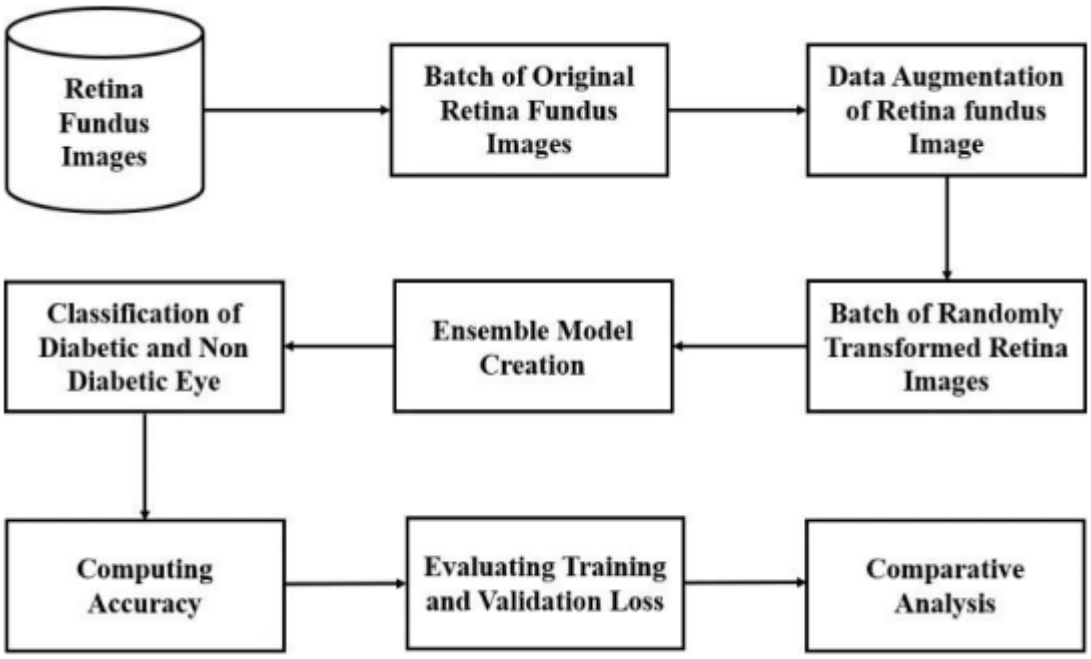


Figure 2. Proposed Methodology

In this initial study, we apply classification techniques to explore uncertainty models. We gather features from fundus images, pulling from all available characteristics in electronic health data to perform a correlation-based feature assessment and compare them to a more limited set of characteristics.

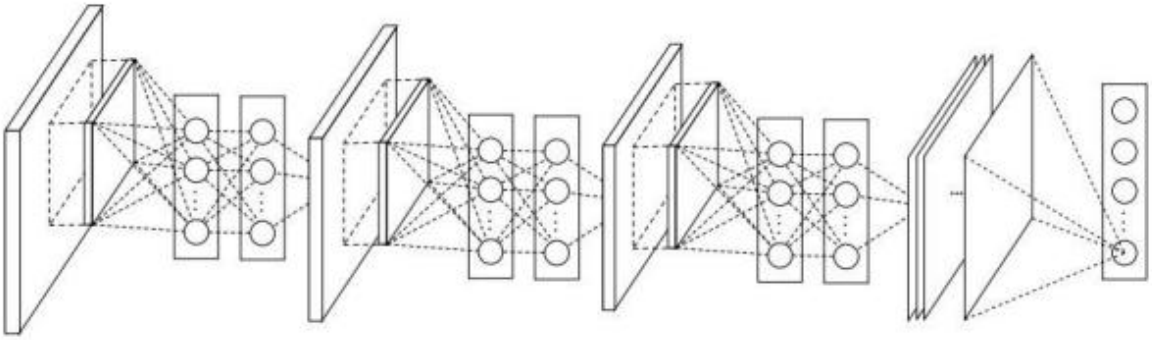


Figure 3: Architecture of Network

All of these strategies create classification models that help assign a level of relevance to each classification standard, which can be incredibly valuable for clinicians. Ensemble learning is an emerging concept in the machine learning field that tackles the challenge of significant variability in both training and test data. Over the past two decades, these effective technologies have been widely used to address complex problems.

Result

Diabetic Retinopathy is a condition that arises from high glucose levels in the blood. This disease is closely linked to diabetes and can cause damage to the tiny blood vessels in the retina, potentially leading to blindness[12].

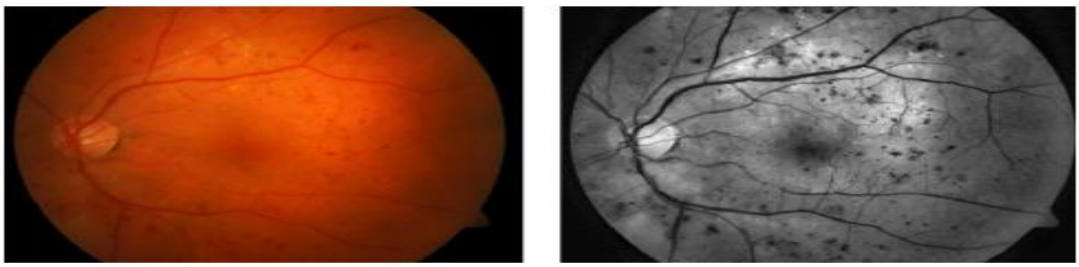


Figure 4: Input image and pre-processing result

One of the challenges with this condition is that it often doesn't show any symptoms until significant damage has already occurred. However, catching diabetic retinopathy early can help prevent vision loss[8]. Unfortunately, detecting these small blood vessels can be quite complex, time-consuming, and prone to errors, which is why it's essential to consult an expert ophthalmologist [14].

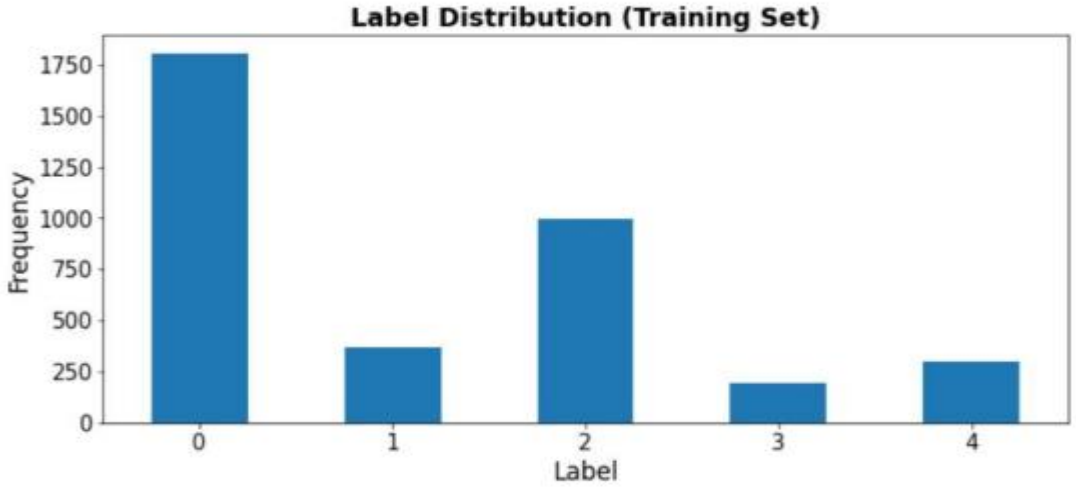
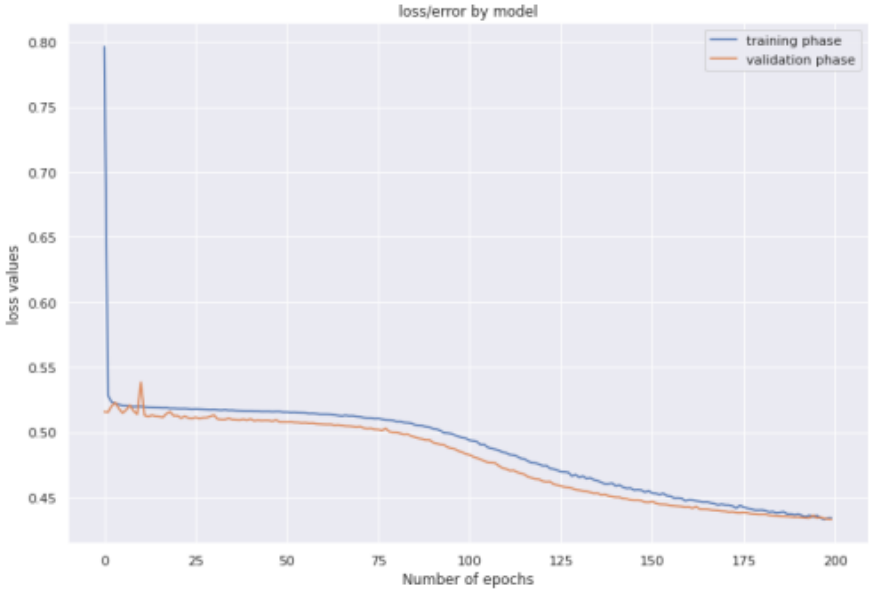
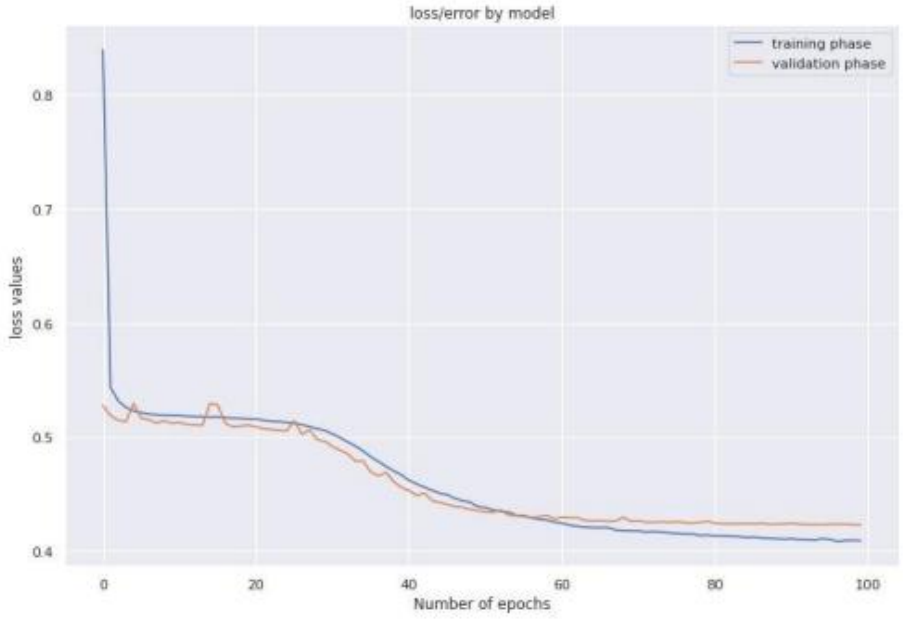


Figure 5: Distribution of different type of diabetic retinopathy Images

To effectively identify key features in fundus images, it's crucial to accurately detect the characteristics of the optic disc[15].



(a)



(b)

Figure 6: Training and Validation Loss

The ophthalmologist utilizes fundus images for the diagnosis of DR, but the images are noise-affected, are exposed to uneven illumination, and are low in contrast. The suggested work has been utilized for pre-processing the fundus images for early diagnosis and stagewise classification of DR.

CONCLUSION

The suggested approach will be applicable for image enhancement of images with similar characteristics. However, the adaptive methods can be used in the future for the suggested approach to enhance the image quality for any type of image. Likewise, for fundus images, deep learning-based denoising methods can also be used in the future. A method for microaneurysm detection in raw retinal fundus images must be designed in the future. A fundus image taken in the presence of cataracts can lead to artifacts that warp the information of the retina, optic nerve, or blood vessels in fundus images. In the future, an image improvement algorithm can be designed to enhance the quality of cataractous fundus images. The

preprocessing algorithm for optical coherence tomography fundus images can be designed to detect retinal diseases. A real-time enhancement algorithm can be designed that can be adopted for point-of-care diagnosis and telemedicine. Additionally, a transformer model-based sophisticated deep learning classifier can be used to detect DR and perform stagewise classification.

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