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Deep Learning-Based Diagnosis Of Diabetic Retinopathy

Jharna Maiti[1],Ashu Nayak[2],Dr. Ritu Talwar[3]
[1]Assistant Professor, Department of Biochemistry, Kalinga University, Raipur, India.
[2]Assistant Professor, Department of CS & IT, Kalinga University, Raipur, India. ku.ashunayak@kalingauniversity.ac.in 0009-0002-8371-7324
[3]Assistant Professor, New Delhi Institute of Management, New Delhi, India., E-mail: ritu@ndimdelhi.org, https://orcid.org/0000-0002-8617-4479

Abstract
Macular edema occurs commonly to patients as a consequence of DR. Macula, the central portion of the retina, is dilated that is responsible for central, acute vision. Thus, it can significantly affect the visual loss. Hence, frequent eye exams are offered to identify DR as early as possible sometimes involving dilating the pupils in order to be able to view the retina in greater depth. Some imaging techniques like fundus photography and optical coherence tomography (OCT) et al are used to demonstrate the specific edition regarding retinal components. Prevalence of this rises with the prolonged duration of diabetes, leading to vision impairment and blindness mainly in the working age population. What initiates and advances DR is primarily risk factors such as elevated A1C, poorly controlled blood glucose, blood hypertension, hyperlipidaemia, and a family history. Ongoing exposure to hyperglycaemia causes changes in the retinal microvasculature to perform such actions as Microaneurysms, retinal haemorrhages, and neovascularization.
Keywords: diabetic retinopathy, fundus images, CNNs, activation functions

INTRODUCTION

Metabolic function is a significant body process to transform food that we eat into energy and efficiently transport to different parts for maximum functioning [1]. The three macronutrients, carbohydrates, lipids, and proteins, are being metabolized normally, but one's metabolism will be interfered with if and when excessive levels of glucose in the blood exist, caused by poor secretion of insulin, and thus there are metabolic disturbances improper metabolism termed Diabetes Mellitus. Diabetes hasn't merely spread all over the world, but particularly in India. Diabetics are 25 times more vulnerable to becoming blind compared to non-diabetics. Vision impairment is one of the biggest and dreaded risks of being a diabetic [2]. When the disease isn't treated for a long period of time, only then does the disease become worse. It begins as a minute area on the retina, the light-sensitive layer at the rear of the eye. With the retinal profile changes, especially with the effects of the silent killer disease known as diabetes mellitus, extra concern on medical, social, and economic levels is needed [9]. Two frequent ocular diseases linked with diabetes and their related risks are discussed in this paper. Diabetic Retinopathy (DR), which affects least 10 percent of diabetic population at base, makes the best maxim such as" Prevention is better than cure." The ophthalmologist's suspicion of push fundus to check is these symptoms. Symptoms are primarily in the macular zone, and in retinal edema's vicinity, but is also present in other regions of the fundus [3]. When macular edema areas are occupied by lipoproteins and water, in conjunction with macular ischemia due to perifoveal capillary occlusions, the clinical syndrome is referred to as diabetic maculopathy. It is clearly documented on fundus fluorescein angiography (FFA) testing. Macular ischemia secondary to diabetic maculopathy has never or uncertainly been shown to be the cause of vision loss in the majority of patients, but a lipid-filled macular edema has been shown to result in blindness [4-5].

Review of literature

Neurons are stimulated by the neural network's activation functions, which use mathematical functions to decide whether a neuron should fire. Without an activation function, a model would merely be a linear regression; however, the activation function allows the model to learn from complicated datasets with high accuracy by introducing nonlinearity to the output neurons [11]. The primary model in deep learning for identifying, classifying, and predicting medical images is the convolutional neural network (CNN). This study uses a CNN architecture with an enhanced activation function to automatically identify diabetic retinopathy (DR). The recently suggested activation function is tested against other functions that already exist using publicly available datasets including DRIVE, CHASE, DIARETDB0, and Kaggle [6]. By including this innovative activation function, the present CNN model is improved and produces exceptional outcomes [7].

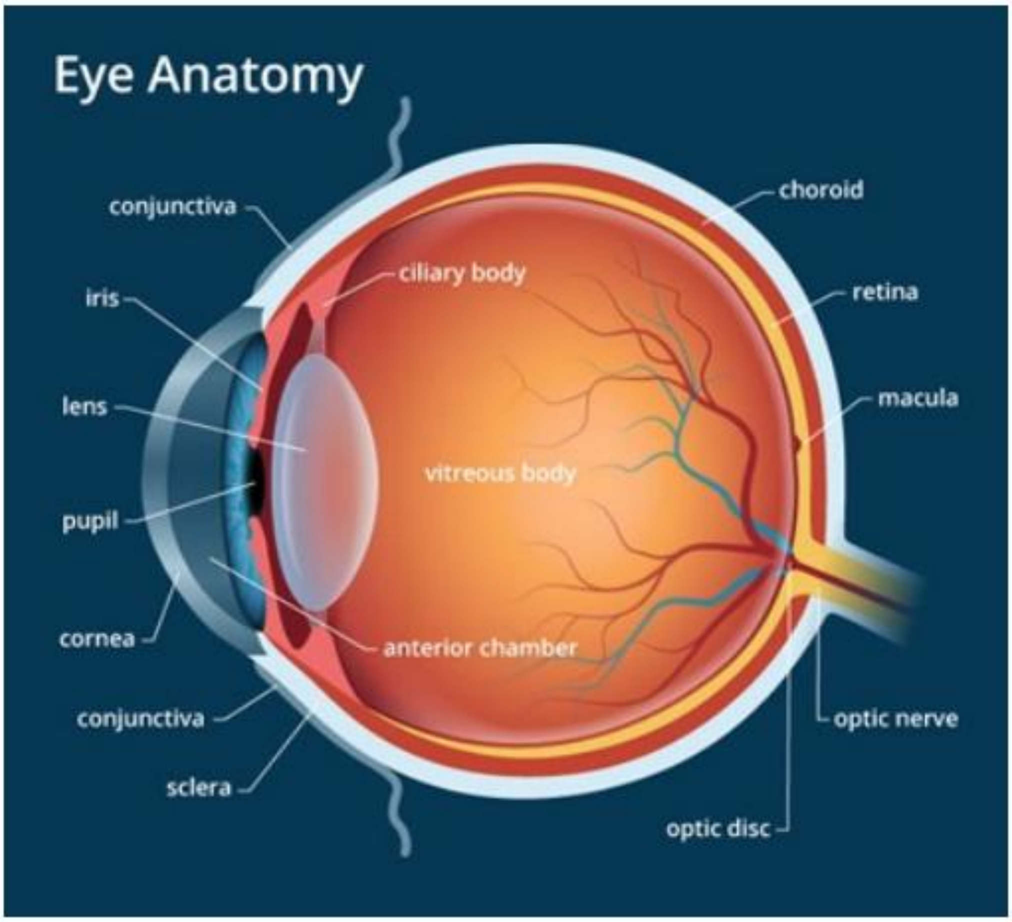

Figure 1: Structure of human eye

Our contribution is the accurate and efficient identification of DR by retinal fundus image analysis. Additionally, the improved CNN model's performance will be evaluated and demonstrated [10]. Notably, the suggested model can function on a typical PC or laptop with mediocre processing power, negating the need for specialized, unobtainable, or costly equipment for fundus picture grading. The approach facilitates clinical review and automated diagnosis verification by precisely seeing aberrant spots in fundus pictures in addition to detecting and classifying them. Because of their small size, microaneurysms are difficult for ophthalmologists to detect[8].

MATERIALS AND METHODS

The convolution layer receives inputs from the fundus image matrix and filter. Convolutional neural networks, or CNNs, use receptive fields and shared weights to recognize images. A convolution layer identifies features by applying receptive fields and eliminating parts of the fundus image. CNN feature maps are generated differently for each application, even though they use the same weights and biases. These shared parameters indicate consistent features in fundus images. The fundus pictures' features are extracted using an activation map. It is crucial to adjust hyperparameters during diabetic retinopathy (DR) fundus image training in order to enhance performance. The DR model's second layer is in charge of classifying the fundus image, while the first layer concentrates on learning the image's edges. Using a stride of 1 × 1 in dense layers and a kernel size of 3 × 3, the max pooling layer's updated activation function reduces overfitting [12].

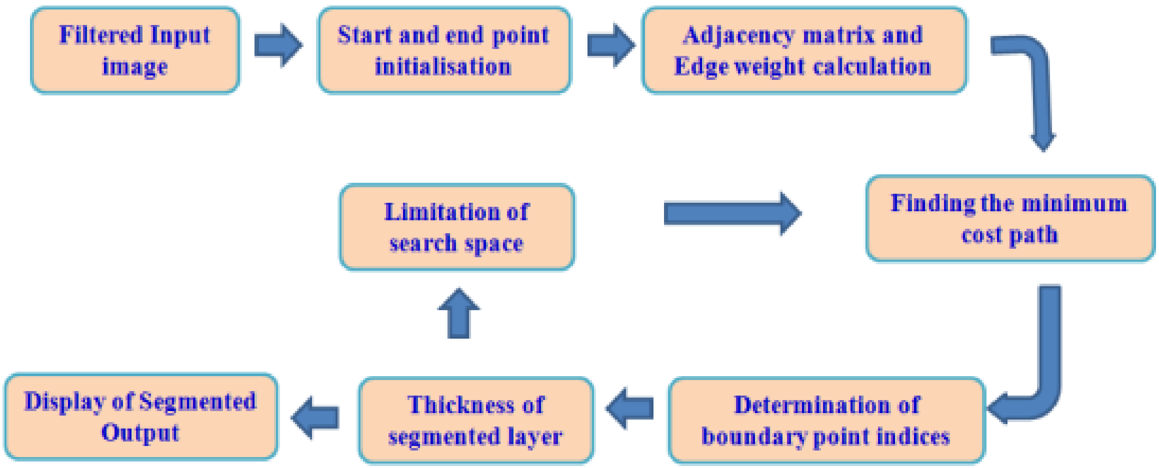

Figure 2: Flow of segmentation

For the testing phase, we employed four pooling layers, four convolutional layers, and two fully linked layers. Advanced activation functions were added to each of these layers to improve them. Each convolutional layer employed multiple filters with distinct coefficient values, while the pooling layers employed maximum pooling. Because the CNN automatically captures implicit and invariant distortion information, it is perfect for DR classification. By dividing the activation map and keeping the maximum from each section, the max-pooling layer, a nonlinear down-sampling method, effectively eliminates redundant information depending on the features in the image.This pooling layer further decreases the probability of overfitting through decreased network parameters and processing requirements. The presented new activation function facilitates greater sparsity between the hidden units and makes the training of CNNs more efficient in comparison to Sigmoid and other functions. This enhanced feature averts saturation cases and normalizes inputs when training. Testing revealed considerable reduction in loss and processing time as compared to regular activation functions since the enhanced activation function has the ability to avoid saturation and prevent gradients from reaching zero while normalizing inputs during training.

RESULT AND DISCUSSION

We performed experiments using and Mish, on the DiaretDB0 dataset for diabetic retinopathy. Experiments were run for 5000 epochs with a learning rate of 0.01 and a batch size of 64, using the Nadam optimizer [8]. With the batch size of 64, we experimented with different hidden layer settings along with the proposed activation function, Nadam optimizer, and dense layers.

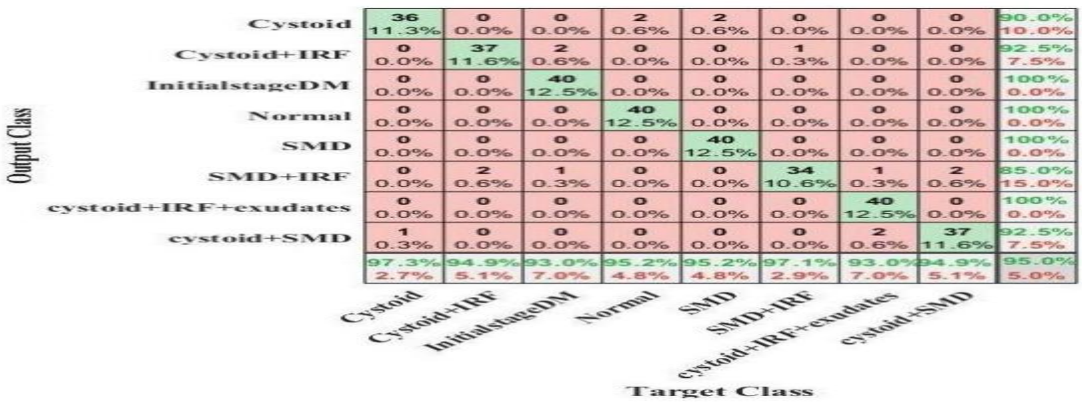

Figure 3: Confusion matrix such as SELU, ReLu, Sigmoid, and ELU. The comparative performance of the existing activation functions with various model architectures was compared and recorded[14]. The model developed showed better testing accuracy, model loss, and processing time compared to existing models when tested with the Kaggle dataset [13] .

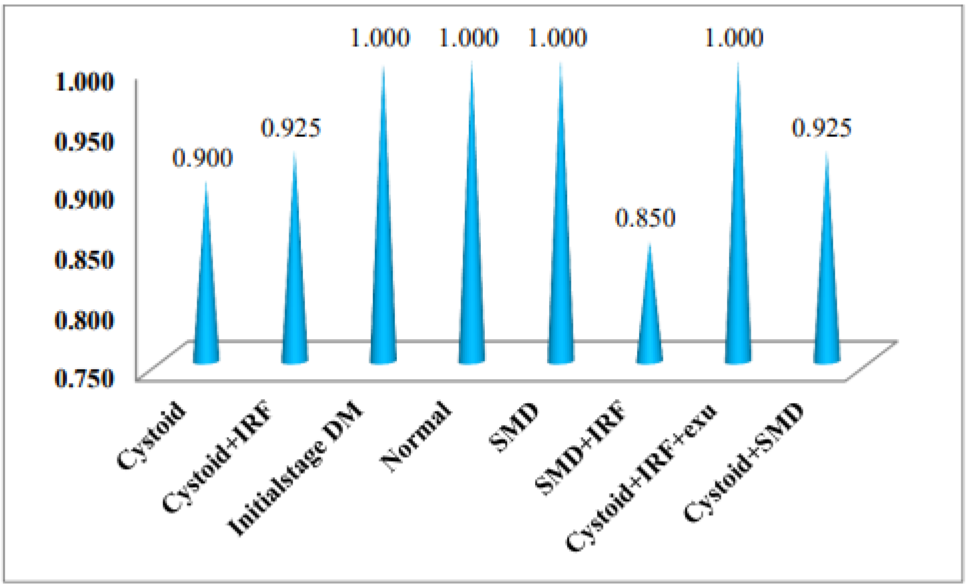

Figure 4: Sensitivity plot

The results show that the recommended activation function may achieve quick processing times and minimum loss.

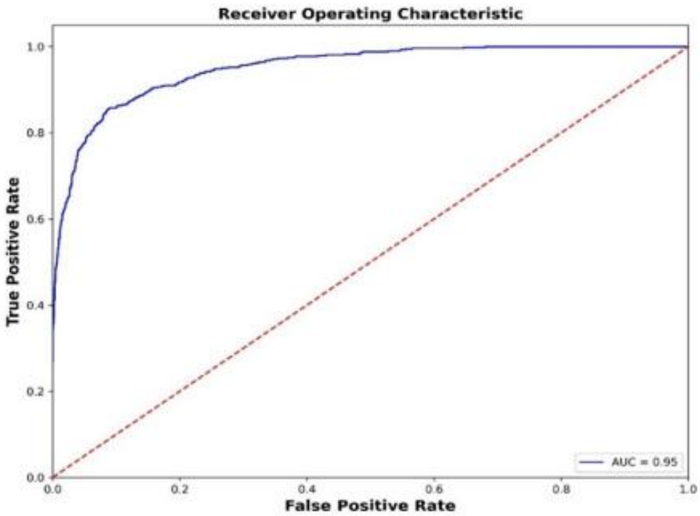

Figure 5: ROC plot

Figure 5 demonstrates how the processing time and loss associated with the recommended activation function compare across multiple CNN models with various activation functions [15] .

CONCLUSION

The improved CNN model was responsible for the improvement in image processing. The DiarteDB0 dataset's results showed a 99.1% F1 score, a 96.6% classification accuracy, a 97.96% sensitivity, and a 99.5% precision. The DRIVE dataset achieved an F1 score of 99.57%, a classification accuracy of 97.84%, sensitivity of 98.45%, and precision of 99.68%. The model's classification accuracy, sensitivity, and precision for the CHASE dataset were 99.05%, 98.45%, and 99.89%, respectively. The Kaggle dataset achieved an F1 score of 99.93%, sensitivity of 98.28%, precision of 99.89%, and classification accuracy of 99.41%. With retinal scans, the proposed model is able to detect diabetic retinopathy correctly. Our proposed activation function exhibited improvements in diagnosis and classification accuracy compared to conventional deep models. By avoiding the indivisible classification of nonlinear data, the CNN model's improved activation function not only improved accuracy but also cut processing time by about 7 ms.

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