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CLASSIFICATION OF DIABETIC RETINOPATHY USING HYBRID ALGORITHM

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Abstract—Diabetic retinopathy (DR) has been discovered to be the main factor contributing to avoidable blindness. Despite the fact that there are many undiagnosed and untreated cases of DR, precise and appropriate retinal screening could aid in the early detection and treatment by hybrid algorithm technique. The goal of this project is to create a reliable DR screening and detection model in order to reduce the incidence of DR-related blindness. DR-infected eyes should be sent to an ophthalmologist for additional inspection and diagnosis, which may lessen the risk of vision loss and offer quick and correct diagnostic information. In this paper, the multiclass Support Vector Machine learning technique is employed to identify and categorize images of diabetic retinopathy. Lesion and vascular analysis of the retinal images are also done. To distinguish between normal and abnormal diabetic retinopathy image data, a multi-layer deep learning algorithm is used. By recognising the proper medical DR instances, the algorithm analyses and classifies coloured fundus images as five stages of Diabetic retinopathy which are Severe DR, Proliferative DR, Moderate DR, Mild DR and No DR. Hence, this project employs a hybrid multiclass Support Machine learning classifier and Deep learning Technology with Convolution Neural Network to classify the stages of Diabetic Retinopathy.

Keywords: Diabetic Retinopathy, Support Vector Machine Learning, Multilayer Deep learning, Convolution Neural Network.

I. INTRODUCTION

Diabetic retinopathy (DR) has recently been identified as the primary cause of preventable blindness. Diabetic retinopathy is a diabetes-related complication that affects the eyes and specifically the retina, which is the light-sensitive tissue at the back of the eye. It is a leading cause of vision loss and blindness in people with diabetes. Diabetes, especially when poorly controlled or left untreated, can lead to damage to the blood vessels in various parts of the body, including the eyes. In diabetic retinopathy, the tiny blood vessels in the retina become damaged and can leak fluid or bleed, leading to swelling and distortions in vision.

Insufficient insulin production or inadequate insulin usage are the causes of diabetes. Diabetes damages a number of organs. Examples include diabetic neuropathy harming brain neurons, diabetic retinopathy harming eye retina, and diabetic nephropathy harming kidney nephrons. In type II diabetes, diabetic retinopathy (DR), the retina of the eye is harmed, and if the condition is not treated, it can lead to visual loss. DR frequently causes blurred or lost vision in the eye. Diabetes patients have a far higher risk of becoming blind than healthy people do. DR is thus one of the main causes of blindness between the ages of 20 and 65 worldwide. According to the World Health Organisation (WHO), DR might affect up to 500,000 people. Diabetes has a significant negative impact on the economies of low- and middle-income nations. There will be 600 million diabetic people globally by 2040, and 33% of them are predicted to suffer diabetic retinopathy[15].

There are two stages to the progression of diabetic eye disease.

NPDR (non-proliferative diabetic retinopathy), the most prevalent kind of diabetic eye illness. Diabetes patients frequently experience it. In NPDR, the retina enlarges as a result of tiny blood vessel leakage. When the macula enlarges, macular edema develops. The most typical reason for diabetic-related vision loss is this. Due to NPDR, blood vessels in the retina may potentially close. This condition is called macular ischemia. When this happens, blood cannot reach the macula. Small particles called exudates may form in the retina. Vision may also be impacted by these. Having NPDR will cause blurry vision.

PDR (proliferative diabetic retinopathy) is a type of Diabetic retinopathy. PDR is the most advanced stage of diabetic eye disease. When the retina starts to grow new blood vessels, it happens. This process is called neovascularization. The vitreous commonly bleeds into these tender, immature vessels. One could see a few black floaters if they only faintly bleed. They can have trouble seeing if they bleed excessively.

The development of scar tissue is likely with these new blood vessels. The macula may become irritated by scar tissue, or the retina may become detached. Peripheral (side) and central (frontal) vision can both be impacted by PDR, a serious disease. In order to lower the prevalence of DR-related blindness, the aim of this research is to develop a trustworthy DR screening and detection model. Sending DR-infected eyes to an ophthalmologist for extra examination and diagnosis can reduce the risk of vision loss and provide timely, accurate results. In spite of the fact that there are a lot of cases of DR that go misdiagnosed and untreated, accurate and useful retinal screening might help with early diagnosis and treatment using a hybrid algorithm method[11].

In this project, the multiclass Support Vector Machine learning approach is employed to identify and categorize images of diabetic retinopathy. Lesion and vascular analysis of the retinal images are also done. To distinguish between normal and pathological diabetic retinopathy picture data, a multi-layer deep learning algorithm is used. The algorithm analyzes and categorizes colored fundus images as either Proliferative Diabetic Retinopathy, which is the disease's more advanced form, or Non-Proliferative Diabetic Retinopathy, which is the disease's early stage, during which symptoms will be mild or nonexistent. A hybrid multiclass Support Machine Learning classifier and Deep Learning Technology using Convolution Neural Network are therefore used in this project.

II. LITERATURE REVIEW

Mohanarathinam, C. S., et al., [2022] the Diabetic Retinopathy Detection and Classification Using Hybrid Multiclass SVM Classifier and Deep learning Techniques. The medical industry's most effective therapy is early illness identification. In diabetic retinopathy, the retina develops a lesion that impairs vision. Early diagnosis of diabetic retinopathy reduces the risk of visual loss. The detection and classification of diabetic retinopathy may be done using AI technologies like machine learning and deep learning methods. Here, we use diabetic feature analysis to assess the different phases of retinal infection caused by imbalanced diabetics. For retinopathy picture classification, conventional approaches employ deep learning with a convolutional neural network model. The key drawbacks of existing work are the difficulty of handling large datasets, complex training, and computation time. In the proposed work, the multiclass Support Vector Machine learning approach is used with lesion and vascular analysis of retinopathy pictures, and the Deep Learning technique is used to identify and categorize images of diabetic retinopathy. A multi-layer deep learning method is utilized to categorize image data of normal and bad diabetic retinopathy. The purpose of this work is to develop a multiclass system for the prediction and categorization of diabetic retinopathy using deep learning and hybrid machine learning methods. On an open source diabetic retinopathy picture data collection, the proposed algorithm was tested. When experimental results are compared to traditional procedures, the proposed work outperforms them by having an Accuracy of 93.33, Sensitivity of 96.71, and Specificity of 99.22. The suggested approach, based on the findings, generated somewhat better results than the currently used conventional techniques. It was decided that the approach that was provided might be used as a diagnostic tool for finding diabetic retinopathy as a consequence[1].

C. Mahiba and A. Jayachandran [2019] studied the severity analysis of diabetic retinopathy in retinal images, using a hybrid structural descriptor and revised CNNs. Due to its critical significance in the diagnosis and treatment planning of diabetic retinopathy, imaging is a significant diagnostic indicator in treatment planning and outcomes assessment. Due to its application in the diagnosis of diseases, retinal image categorization is becoming more and more popular among computer vision researchers. For the identification and prediction of many forms of changes, Computer Aided Diagnosis (CAD) is frequently employed in clinical work; the automated image categorization systems used for such applications must be extremely precise because incorrect detection might be catastrophic. Another prerequisite for the system's viability is a high rate of convergence[2].

[2019] Yasashvini R et al. Classification of diabetic retinopathy using hybrid deep convolutional neural networks and CNN. One of the main factors in adult blindness is diabetic retinopathy (DR), an eye condition that mostly affects people with diabetes. The infection's spread may cause irreversible vision loss. Manual diagnosis of diabetic retinopathy with an ophthalmologist's help has been a time-consuming and labor-intensive process. This study employs deep learning (DL) and transfer learning to analyze different phases of diabetic retinopathy in addition to diagnosing the condition. To automatically determine whether level DR has advanced, CNN, hybrid CNN with ResNet, and hybrid CNN with DenseNei are employed on a sizable dataset containing around 3662 train images. In the proposed study, five DR stages- 0 (no DR), 1 (mild DR), 2 (moderate), 3 (severe), and 4 (proliferative DR) are processed. The model receives input from the patient's eye images. To extract the properties of the eye for efficient categorization, deep learning architectures including CNN, hybrid CNN with ResNet, and hybrid CNN with DenseNet 2.1 are proposed. The models' respective levels of accuracy were 96.22%, 93.18%, and

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75.61%. The analysis of the CNN, hybrid CNN with ResNet, and hybrid CNN with DenseNet architectures is compared at the end of the article, which identifies hybrid CNN with DenseNet as the ideal deep learning classification model for automated DR detection[3].

Saif Hameed Abbooda et al. [2022], Hybrid Retinal Image Enhancement Algorithm for Diabetic Retinopathy Diagnostic Using Deep Learning Model. Diabetic retinopathy (DR), a common acute stage of diabetes mellitus, causes abnormalities in the retina that impair vision. Blindness will develop if this is not discovered right away. Only eyesight may be preserved with proper maintenance because DR is not permanent. Therefore, the chance of vision loss will be significantly reduced by early identification and treatment with DR. In modern ophthalmology, retinal image analysis has grown in prominence as a technique for disease diagnosis. Ophthalmologists and automated systems routinely employ fundus angiography to identify DR-based clinical signs for DR early detection. This paper presents an approach for improving the image quality that, by reducing noise and increasing contrast, will raise the standard for color fundus images. The process consists of two main steps: first, the photographs are cropped to remove superfluous data, and then the shape crop and gaussian blur are used to increase contrast and lower noise. The experimental findings are evaluated using two widely used datasets, EyePACS and MESSIDOR. Numerous studies have shown that the results of feature extraction and classification from enhanced images outperform those obtained without the use of the enhancement technique. Additionally, smart hospitals are testing the improved algorithm as IoMT application[4].

[2020] Hao Liu, Keqiang et al Hybrid Model Structure for Diabetic Retinopathy Classification. One of the most frequent consequences of diabetes and the main factor in blindness is diabetic retinopathy (DR). Early detection of DR can stop the disease from progressing. The ideal period for diagnosis and treatment was missed, which leads to vision impairment, as a result of disparities in the distribution of medical disorders and low labor efficiencyNeural network models may be used to categorize and diagnose DR, enhancing efficiency and reducing costs. Three hybrid model structures were created in this study Hybrid-a, Hybrid-f, and Hybrid-c to improve the performance of DR classification models together with an improved loss function. EfficientNetB4, EfficientNetB5, NASNetLarge, Xception, and InceptionResNetV2 CNNs were the main models. These basic models were trained using enhance cross-entropy loss and cross-entropy loss, respectively. The output of the basic models was used to train the hybrid model structures. By using enhanced cross-entropy loss, it is possible to greatly speed up the training of the basic models and boost their performance when evaluated using various metrics. The proposed hybrid model architectures can also improve the performance of DR classification. When compared to the best-performing results from the basic models, the accuracy of DR classification was increased by using hybrid model structures from 85.44% to 86.34%, the sensitivity was increased from 98.48% to 98.77%, the specificity was increased from 71.82% to 74.76%, the precision was increased from 90.27% to 91.37%, and the F1 score was increased from 93.62% to 93.9%[5].

III. PROPOSED METHODOLOGY

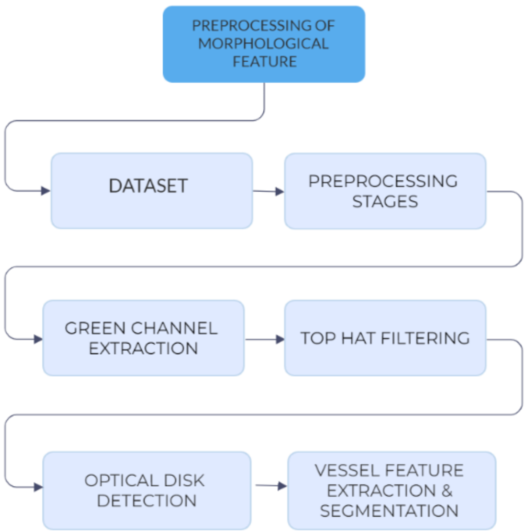

Fig1a. Flow chart for preprocessing of morphological feature

The hybrid multiclass Support Machine learning classifier and Deep learning Technology with Convolution Neural Network method is used for classification of diabetic retinopathy[12].

A. Pre-processing of dataset:

Laplacian concept of Gaussian filter with double factor of filtering approach and top hat transform To adjust the contrast of the retinal image, a Laplacian concept of Gaussian filter is used, along with a double factor of filtering approach and top hat transform filter. The segmentation disk region is visible in the filtered image's threshold. Gray threshold is used to remove the background [8].

B. Filters:

To improve the contrast of the image, top hat filtering is first used in the processing state of morphological performance. This aids in adjusting the image's contract for improved visualization.
Before handling the retina picture to the deep CNN with preprocessing stage, information growth, standardization, and resizing were carried out[13].

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C. Optical disk detection:

The optical disc, often referred to as the optic nerve head, is where the optic nerve enters the eye and is crucial in the diagnosis of diabetic retinopathy for a number of reasons. The segmentation procedure can accurately remove the lesion location from the retinal fundus. The image is first converted to the HSI model, and the divided version is then processed for Optic Disk (OD) detection, which makes use of the extraction of the green hue. [7].

D. Feature extraction:

In this project we use vessel feature extraction method which include Gray level Co-occurrence Matrix (GLCM) which provides statistical information about the spatial distribution of pixel intensities in an image and to extract texture features such as contrast, correlation, energy to measure the local homogeneity and smoothness of the image[10].

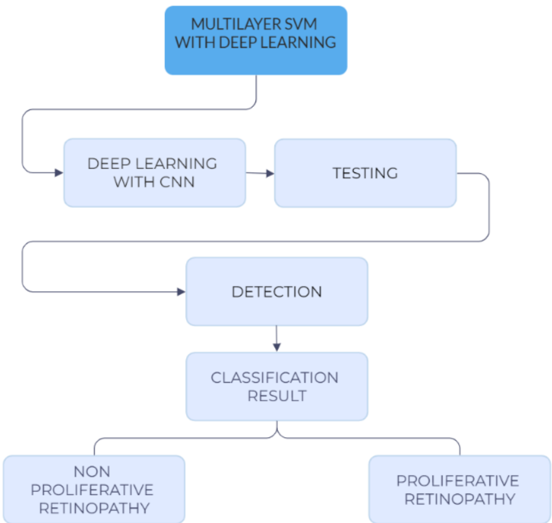

Fig1b. Flow chart for multilayer SVM with Deep learning

E. Detection:

A type of deep neural networks known as convolutional neural networks (CNNs) have shown to be effective in computer vision tasks such image categorization, object identification, object localisation, and neural style transfer.

Convolution layer, pooling layer, and fully linked layer are the three primary layers of CNN. The relevant characteristics are extracted from the input image using convolution layers, which then classify the output image. The necessary features are retrieved using a kernel (filter) of the right size, and after each convolution layer, a pooling layer is added to condense the size of the image[14].

F. Classification:

Following these processes, we are eventually able to classify the disease as either Proliferative Diabetic Retinopathy, which is a more severe form of the condition, or Non-Proliferative Diabetic Retinopathy, which is an early stage of the condition with little or nonexistent symptoms. This is in responsible of categorizing retinal images into various types of diabetic retinopathy.

IV. DATASET

Three separate datasets from the Kaggle diabetic retinopathy detection competition were given by APTOS 2019 Blindness Detection is used for this project. 3,662 training fundus images and 1,928 test fundus images are contained in the APTOS dataset. Each image is labeled with a corresponding severity level of diabetic retinopathy, ranging from 0 to 4, where 0 indicates no diabetic retinopathy and 4 indicates a high level of DR [6]

STAGES	Diagnosis Value	Binary Value
No_DR	0	0
Mild DR	1	1
Moderate DR	2	1
Proliferate DR	3	1
Severe DR	4	1

Table.1 Labelling severity level with Binary Value

V. RESULT AND DISCUSSION

Thus, diabetic retinopathy classification based on No-DR, mild DR, moderate DR, proliferate DR and Severe DR are performed well with hybrid multiclass machine learning technology and deep learning process. The input images of fundus image of DR are given and then it is resized into 224*224 pixel with many pre-processed deep learning models.

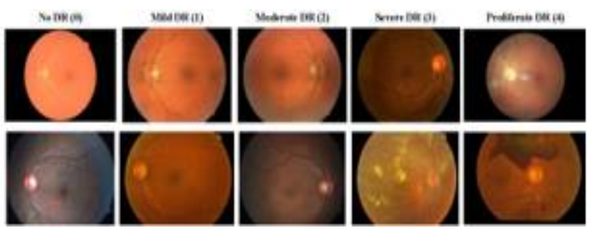

Fig.2 It shows the resized and original sample fundus images of five stages of DR.

The resized images original diagnosis value are mapped with binary values so that it helps to proceed the further process of classification. This can be useful for creating

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categorical labels for machine learning tasks or for organizing and visualizing data in a more human-readable format.

Based on the length of the stages of image it is coded to generates a horizontal bar plot that displays the distribution of different types. The lengths of the bars represent the frequency of each type. It's a visual representation of how many occurrences of each type are present in the dataset. This type of visualization is useful for understanding the distribution and balance of binary categories in a dataset. It can help to quickly grasp how many samples fall into each category, which can be important task for classification where class imbalance can impact model performance.

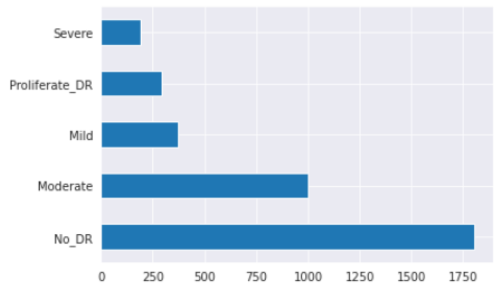

Fig 3. Bar graph of severity category

Once resized image is classified and then gaussian filter is applied to smoothen the image and an edge-detection to enhance edges and details in an image by removing noise in the retinal vessels, so that it is possible to view the severity range of the retinal image. It is performed using series of operations to identify the specific image with the percentage of severity.

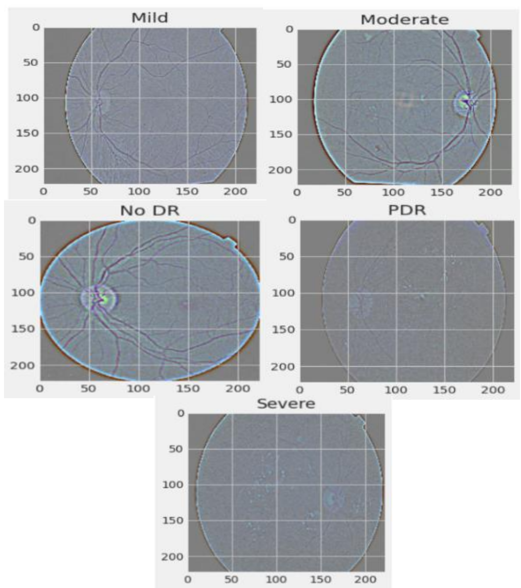

Fig.4 a, b, c, d and e represents the gaussian filter applied Mild DR, Moderate DR, No DR, Proliferate DR and Sever DR.

All the gaussian filtered datasets are put together and performed classification operation to get the accurate results of each image in fig.5

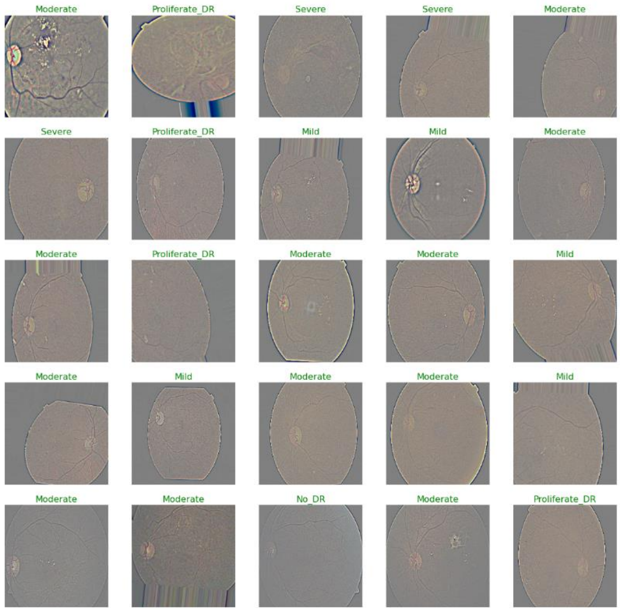

Fig.5, Represents the severity stages of sample retinal images.

Once classification is done the accuracy and loss of data is cross verified by performing algorithm, for that the 40 epochs have taken and involves training a machine learning model using 'FIT' function from keras. FIT is specifically used for training the model with DR dataset where it does training labels, epochs, batch size, callbacks, validation data and shuffling.

It trains the model using the custom learning rate adjustment (LRA) callback and other relevant parameters. Custom callbacks are functions or classes in machine learning frameworks like Keras that allows to define and execute custom logic at various points during training.

The custom callback (LRA) likely implements logic to adjust the learning rate during training based on certain conditions like patience, accuracy, and dwell settings.

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Starting training using base model EfficientNetB1 training all layers
Epoch     Loss    Accuracy  V_loss    V_acc     LR       Next LR   Monitor   Duration
1 /40     6.539   55.925    4.89411   60.668    0.00100  0.00100   accuracy  119.83
2 /40     3.818   69.070    2.97838   70.608    0.00100  0.00100   accuracy  96.17
3 /40     2.382   76.891    1.92735   76.435    0.00100  0.00100   accuracy  96.08
4 /40     1.503   84.026    1.25993   83.548    0.00100  0.00100   accuracy  96.09
5 /40     1.001   88.783    0.94479   85.604    0.00100  0.00100   accuracy  96.10
6 /40     0.707   92.254    0.80260   84.919    0.00100  0.00100   val_loss  96.70
7 /40     0.528   94.300    0.60660   89.374    0.00100  0.00100   val_loss  96.17
8 /40     0.430   95.168    0.54183   90.146    0.00100  0.00100   val_loss  96.10
9 /40     0.354   96.282    0.52911   89.032    0.00100  0.00100   val_loss  96.49
10 /40    0.297   97.054    0.45468   91.088    0.00100  0.00100   val_loss  97.74
enter H to halt training or an integer for number of epochs to run then ask again
 H
training has been halted at epoch 10 due to user input
Training is completed - model is set with weights for the epoch with the lowest loss
```

Fig.6, It represents the training the model with weights for the epoch.

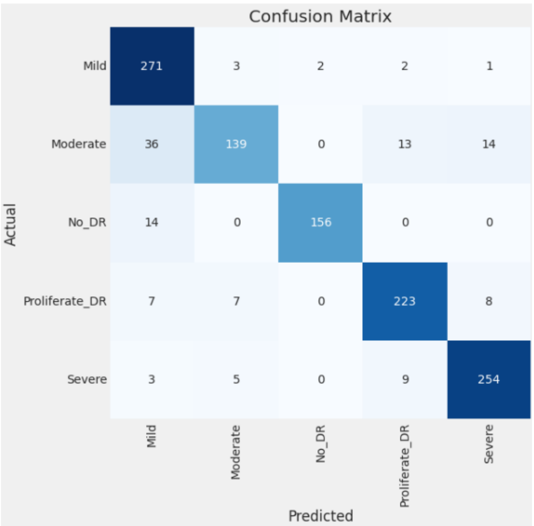

Fig.7, Confusion matrix of proposed system

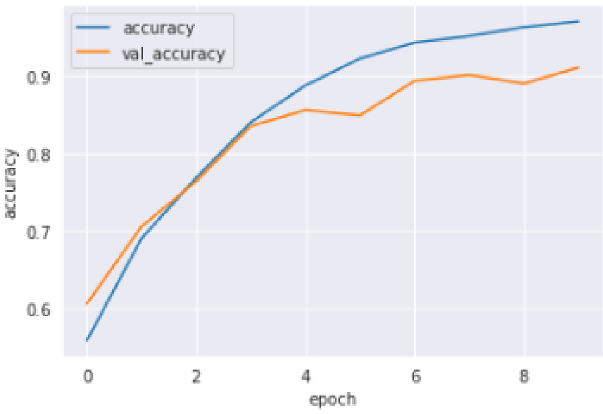

Fig.8a Model Accuracy

The accuracy and loss rate of five stages of classification is compared with the original value and detected value then it is represented as graph shown in fig.8a and 8b.

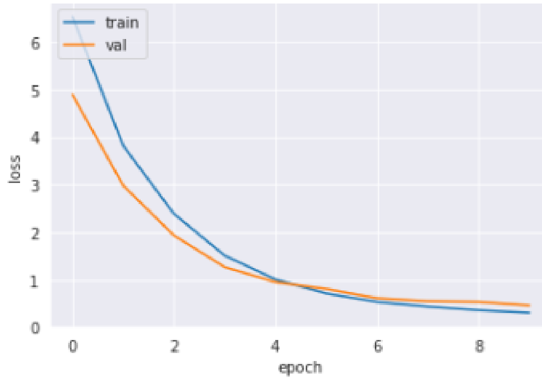

Fig.8b Model Loss

VI. CONCLUSION

The classification of diabetic retinopathy using a hybrid algorithm presents a promising approach to accurately diagnose and categorize this sight-threatening condition. By combining the strengths of multiple machine learning techniques, this hybrid approach leverages both traditional methods and advanced deep learning architectures. The utilization of such an algorithm can significantly enhance the accuracy and robustness of the diagnostic process. These algorithms can effectively extract relevant features from retinal images and provide meaningful insights into the disease’s progression. Concurrently, deep learning components, particularly convolutional neural networks (CNNs), excel at capturing intricate patterns and representations within images. Their ability to automatically learn hierarchical features from raw data contributes to their superior performance in image classification tasks. The hybrid algorithm for the classification of diabetic retinopathy offers a holistic and effective solution by synergizing the benefits of traditional machine learning and deep learning. Its ability to provide accurate, interpretable, and robust predictions makes it a valuable tool in the early detection and management of diabetic retinopathy, thus contributing to better patient outcomes and reducing the risk of vision loss associated with the disease[9].

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