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# **An Early Detection of Diabetic Retinopathy Approach using Machine Learning**

**C.Ganesh, M.Mahera Thabasum**

Assistant Professor, Dept. of Master of Computer Applications, Vivekananda Institute of Information and Management  
Studies, Tiruchengode, Namakal, Tamil Nadu, India

Dept. of Master of Computer Applications, Vivekananda Institute of Information and Management Studies,  
Tiruchengode, Namakal, Tamil Nadu, India

**ABSTRACT:** Diabetic retinopathy is a disease caused by uncontrolled chronic diabetes and it can cause complete blindness if not timely treated. Therefore early medical diagnosis of diabetic retinopathy and its medical cure is essential to prevent the severe side effects of diabetic retinopathy. Manual detection of diabetic retinopathy by ophthalmologist takes plenty of time and patients need to suffer a lot at this time. An automated system can help detect diabetic retinopathy quickly and we can easily follow-up treatment to avoid further effects to the eye. This study proposes a machine learning method for extracting three features like exudates, hemorrhages, and microaneurysms and classification using a hybrid classifier which is a combination of support vector machine, k-nearest neighbour, random forest, logistic regression, multilayer perceptron network. From the results of the experiments, the highest accuracy values are 82%. The hybrid approach produced a precision score of 0.8119, recall score of 0.8116 and f-measure score of 0.8028.

**KEYWORDS:** Diabetic Retinopathy, KNN, SVM, Random Forest, Retinal Fundus Images

## **I. INTRODUCTION**

Diabetes occurs when there is an excess of glucose in the blood. This condition can arise if the pancreas does not produce enough insulin, leading to elevated blood sugar levels. High blood sugar can result in serious health complications, including heart disease, kidney disease, nerve damage, and blindness. Diabetic retinopathy (DR) is a severe complication of diabetes that can damage the retina of the eye due to prolonged high blood sugar levels. Throughout the body, diabetes affects blood vessels. In the retina, blockages in small blood vessels can cause fluid to leak or bleed, resulting in eye damage. In response to these blockages, the eyes create new blood vessels; however, these new vessels are often less functional, increasing the risk of bleeding or leakage. The differences between a healthy retina and one affected by diabetic retinopathy. According to the World Health Organization (WHO), diabetic retinopathy is responsible for approximately 37 million cases of blindness worldwide. Current treatments for DR primarily focus on delaying or preventing further deterioration of vision, highlighting the importance of regular eye screenings with advanced computer systems. Several factors may contribute to low adherence rates for diabetes medications or annual eye examinations. Early diagnosis and treatment of Vision-Threatening Diabetic Retinopathy (VTDR) are crucial to minimizing the risk of vision loss.

Diabetes mellitus is prevalent in Saudi Arabia, particularly in the form of diabetic retinopathy. According to the World Health Organization (WHO), Saudi Arabia has the second-highest prevalence of diabetes in the Middle East and ranks seventh globally. It is estimated that around 7 million people, approximately twice the population of Oklahoma, are living with diabetes, while over 3 million individuals, about the population of Arkansas, are classified as having pre-diabetes in the country. Additionally, the prevalence of diabetic retinopathy (DR) ranges from 27.8% to 36%, with 53% of these cases reporting proliferative diabetic retinopathy (PDR).

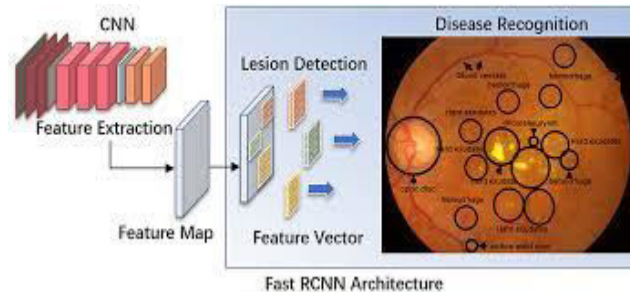


Fig 1: Artificial intelligence in diabetic retinopathy

Diabetic Retinopathy is a complication that affects the eye due to the result of high blood glucose called diabetes. It can cause vision loss and in severe condition can lead to complete blindness. Early symptoms of diabetic retinopathy include blurred vision, darker areas of vision, eye floaters and difficulty in perceiving colours. Proper detection of diabetic retinopathy in early stage is extremely important to prevent complete blindness. Of an estimated 285 million people with diabetes mellitus worldwide, approximately one third have signs of diabetic retinopathy. Globally the number of people affected with diabetic retinopathy will increase from 126.6 million in 2010 to 191.0 million by 2030. Non Proliferative Diabetic Retinopathy (NPDR) is an early stage of disease in retina where tiny red spots occur. RCNN These tiny spots may represent haemorrhage and abnormal pouching of blood vessels represents microaneurysms. The lining of these blood vessels can become damaged enough to allow leakage of fluid and fatty material called exudates. Available physical tests to detect diabetic retinopathy include pupil dilation, visual acuity test, optical coherence tomography, etc. But they are time consuming and patients need to suffer a lot. This paper focuses on automated computer aided detection of diabetic retinopathy using machine learning hybrid model by extracting the features haemorrhage, microaneurysms and exudates. The classifier used in this proposed model is the hybrid combination of SVM and KNN.

DR is diagnosed using several key methods. The primary approach is a comprehensive dilated eye exam, where the eye doctor administers drops to dilate the pupils and carefully examines the back of the eyes, including the retina and blood vessels, to detect signs of DR. Another important diagnostic tool is fluorescein angiography (FA), which involves injecting a dye into a vein in the arm. This dye then travels to the blood vessels in the retina, and a specialized camera captures images of the retina as the dye circulates. This helps identify leaking blood vessels and other signs of DR. Optical coherence tomography (OCT) is also essential for assessing DR, providing a detailed analysis of the retina to identify structural changes like subclinical diabetic macular edema. OCT can even predict outcomes and treatment responses by identifying specific imaging biomarkers. Additionally, fundus photography (FP) plays a critical role, capturing detailed images of the back of the eye, including the retina, optic disc, and macula, using specialized cameras with complex microscopes and flash capabilities. Colored filters or dyes like fluorescein and green indocyanine are often used during FP to enhance visualization.

## II. LITERATURE REVIEW

Zeng et al.'s study delved into the automatic identification of referable diabetic retinopathy. They did this by dividing fundus images into two severity classes. The study utilized the "Diabetic Retinopathy Detection" high-quality fundus image dataset from Kaggle. Their method employed a specific form of deep learning model, the convolutional neural network. This model was created by modifying an already-existing one (transfer learning) to make it unique. This model, in contrast to other techniques, simultaneously examined images from both eyes and independently predicted the severity for each eye. This method produced an area under the ROC curve of 0.951, which is marginally better (by 0.011) than the current approach that analyzes one eye at a time.

In a paper by Voets et al., researchers conducted a study to validate previous studies on detecting diabetic retinopathy (DR) in retinal pictures using publicly available datasets. Instead of using the dataset used in the original work, they chose to utilize a different one from Kaggle EyePACS and Messidor-2. Like the original method, the algorithm was trained using the InceptionV3 neural network architecture. Techniques for ensemble learning were also included to improve the training process even more. The replicated approach obtained area under the curve (AUC) ratings of 0.951 and 0.853 on the separate Kaggle EyePACS test dataset and Messidor-2, respectively.

[Farrikh Alzami, 2019] described a system for diabetic retinopathy grade classification based on fractal analysis and random forest using MESSIDOR dataset. Their system segmented the images, then computed the fractal dimensions as features. They failed to distinguish mild diabetic retinopathy to severe diabetic retinopathy. [Qomariah 2019] proffered an automated system for classification of Diabetic Retinopathy and normal retinal images using concurrent neural network (CNN) and support vector machine (SVM). Features comprised of exudates, haemorrhage and microaneurysms. The author partitioned the proposed system into 2 parts: the first part composed with feature extraction based on neural networks and the second part performed classification using SVM. [Kumar, 2018] proposed a system for improved diabetic retinopathy detection by extracting area and number of microaneurysms using colour fundus images from DIARETDB1 dataset. Pre-processing of fundus images were performed using green channel extraction, histogram equalization and morphological process. Principal component analysis (PCA), contrast limited adaptive histogram equalization (CLAHE), morphological process, averaging filtering were applied for microaneurysms detection and classification is done by linear support vector machine (SVM). [Mohamed Chetoui, 2018] proffered a system which detect diabetic retinopathy using different texture feature and machine learning classification model. Two features haemorrhage and exudates are extracted using local ternary pattern (LTP) and local energy- based shape histogram (LESH). SVM is used for leaning and classification of extracted histogram using feature vectors of LTP and LESH. [S Choudhury, 2016] proposed a system which deals with fuzzy C means based feature extraction and classification of diabetic retinopathy using SVM. Blood vessels extraction is performed using top hat filter and mathematical morphology. Retinal vessel density and exudates are chosen as the features. Exudate extraction is done by fuzzy C means segmentation. Gaussian Radial Basis function is used to map the training data into SVM kernel space. [Sangwan, 2015] described a system that identifies different stages of diabetic retinopathy based on blood vessels, haemorrhage and exudates. The features are extracted using image pre-processing and they are fed into the neural network.

SVM based training provided into the data and classify the images into three categories as mild, moderate non proliferative diabetic retinopathy and proliferative diabetic retinopathy. But the system could not give expected results if the exudate areas in the fundus images exceeds that of an optical disc size.

[Morium Akter, 2014] described a system for morphology based exudates detection from colour fundus images. The model uses grayscale conversion, histogram equalisation, thresholding, erosion, dilation, logical AND operation and watershed transformation. The system produces an output with ranges of exudates affected in diabetic retinopathy. [Handayani, 2013] proposed a system for the classification of non-proliferative diabetic retinopathy using soft margin SVM. Hard exudates in the retinal fundus images are used to classify severity level of non-proliferative diabetic retinopathy. Mathematical morphology is applied to segment hard exudates. But the system does not include micoaneurysms and haemorrhage as the features. [Saravanan, 2013] proposed an automated system for the red lesion diabetic retinopathy detection based on microaneurysms using GMM classifier. The feature is extracted using mathematical morphology, filter based method and supervised learning method. Severity level of candidate microaneurysms is detected into four stages. [Venkatalakshmi, 2011] described automated system for hard exudate detection using sharp edge and colour highlights as two features. Methods involved in the detection process were colour based classification, sharp edge detection, and extraction of optic disc. Training and testing were done using DRIVE and DIARETDB0 dataset. The system used MATLAB 7.8 for graphical user interface (GUI).

### III. METHODS

In this study, we utilized two datasets to detect and analyze diabetic retinopathy (DR): the Asia Pacific Tele-Ophthalmology Society (APTOS) dataset [6] and a dataset from Al-Saif Medical Center in Saudi Arabia. These datasets were pivotal in evaluating the model's effectiveness and its applicability to diverse data sources.

The APTOS dataset, which is publicly accessible, consists of 3662 PNG images. Each image is labeled with an id\_code and a DR severity level, categorized on a scale from 0 (no DR) to 4 (proliferative DR). For our research, we adapted this dataset into a binary classification system, dividing the images into two groups: without DR (diagnosis 0) and with DR (diagnoses 1–4). We conducted analyses using the original multi-class and modified binary formats to assess the dataset's versatility and effectiveness across various diagnostic models.

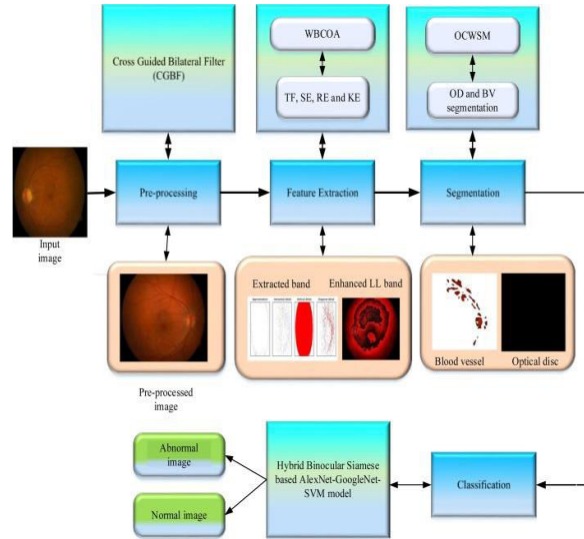


Fig 2: learning approaches for the detection of diabetic retinopathy

Similarly, the Saudi dataset from Al-Saif Medical Center includes 168 JPEG images, each annotated with an id\_code and a DR severity level on the same 0-4 scale. This dataset was collected and annotated by a physician over approximately one month. Like the APTOS dataset, we converted the Saudi dataset into a binary classification system for our analysis. This modification enabled a comprehensive validation of our diagnostic models, utilizing both the original multi-class and binary classification systems.

In this study, we conducted two experiments using the APTOS dataset, a publicly available resource, and a Saudi dataset from Alsaif Medical Center. The experiments included binary classification to determine the presence or absence of DR and multi-class classification to categorize patients into different stages of the disease (No DR, Mild, Moderate, Severe, and Proliferative DR). In the first experiment, we divided the APTOS dataset into training (70%), validation (10%), and testing (20%) subsets. For the second experiment, we used the Saudi dataset for validation and the APTOS dataset for training (80%) and testing (20%). We trained six pre-trained Convolutional Neural Networks (CNNs) models: EfficientNetB3, EfficientNetV2B1, RegNetX008, RegNetX080, RegNetY006, and RegNetY008. We also integrated two new callback functions, EarlyStopping and ReduceLROnPlateau, to improve the training process by preventing overfitting and optimizing the learning rate. Each model underwent rigorous training for thirty epochs to ensure comprehensive data exploration.

#### IV. RESULT ANALYSIS

A pr-trained AI model is a machine learning model that has already been trained on a substantial dataset to perform a specific function. These models are widely used because they save time and resources, requiring less data for fine-tuning specific tasks. They have been particularly transformative in fields like natural language processing, speech recognition, healthcare diagnostics, and cybersecurity, enabling rapid advances by serving as a foundational framework upon which customized solutions can be developed. Based on past literature and extensive trials, we selected EfficientNet and RegNet because they offer an excellent balance of accuracy and efficiency, which is essential in real-world applications like diabetic retinopathy detection.

EfficientNetB3 is a convolutional neural network model that balances high accuracy and computational efficiency for image classification tasks. The number in EfficientNetB3 indicates the scaling factor applied to the base architecture. It has been created by Mingxing Tan using neural architecture search to develop a new baseline network and then scale it up to create a family of models called EfficientNets. This approach involves simultaneous adjustments to the network's depth, width (number of channels in layers), and resolution (input image size) in a carefully coordinated manner. The goal is to achieve the optimal balance between performance and resource usage, resulting in significantly better results than previous ConvNets.

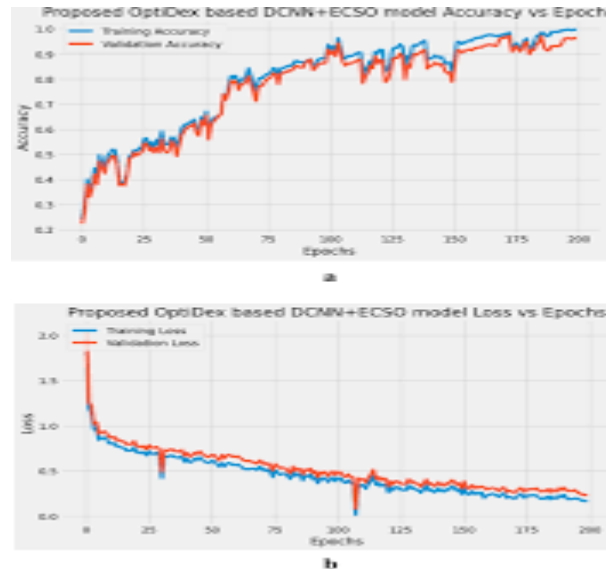


Fig 3: Diabetic retinopathy detection and severity classification using optimized

RegNet is a network design approach developed by Facebook AI Research (FAIR) that focuses on creating network architecture spaces rather than designing individual network instances. The core idea behind RegNet is to parametrize a low-dimensional design space of simple, regular networks. This is based on the observation that effective networks can be described by a quantized linear function that determines their widths (the number of channels) and depths (the number of layers). What makes the RegNet approach distinctive is its emphasis on simplicity and interpretability, along with the goal of identifying general design principles that apply to well-performing networks across various settings. This stands in contrast to traditional manual network design and neural architecture search (NAS).

## V. CONCLUSION WITH FEATURE WORK

In this proposed method hemorrhages, exudates and microaneurysms are detected. For exudate detection green channel extraction, masking, smoothing, bitwise AND are done which results in better calculation and extraction of exudates. For detection of hemorrhages and micro aneurysms, morphological operations are performed like opening. Dilation and erosion operators are performed here. For diabetic retinopathy detection, count the number for MA occurred, count the number of hemorrhages occurred and count the number of exudates occurred in the image so we can decide the condition of image. Then features are calculated and feed to both SVM, KNN, Random Forest classifier. Voting of three classifiers are chosen as final prediction . So from the extracted feature it directly concludes the disease grade as normal or abnormal. So earlier detection and diagnosis of diabetic retinopathy help the patients from blindness and also the severe effects of disease can be decreases.

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