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Prediction of Severity of Diabetic Retinopathy Using Ensemble Learning

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ABSTRACT: Diabetic retinopathy (DR) is a leading cause of blindness among diabetic patients. Early detection is crucial for preventing vision loss. This project investigates the effectiveness of ensemble learning techniques in predicting DR using retinal fundus images from the publicly available APTOS dataset. The project explores three ensemble methods: Random Forest, K-Nearest Neighbors (KNN), and Support Vector Machines (SVM), combined with a majority voting strategy for final prediction. The performance of the ensemble models will be evaluated and compared to individual baseline models. This research aims to assess the potential of ensemble learning to improve the accuracy and robustness of DR prediction compared to single machine learning algorithms.

KEYWORDS: Diabetic retinopathy, Ensemble learning, Random Forest, KNN, SVM, Voting, APTOS dataset

I. INTRODUCTION

Diabetic retinopathy (DR) is a health challenge, increasingly recognized as a leading cause of vision impairment and blindness among adults. As the worldwide prevalence of diabetes mellitus continues to surge, the imperative to understand, diagnose, and effectively manage this relentless complication becomes paramount[3]. This disease is considered as a common comorbidity caused as an eventual resultant complication of diabetes mellitus when left undetected, ill-advised and untreated for a prolonged time period. Diabetic retinopathy is the most frequent cause of new cases of blindness among adults aged 20–74 years. During the first two decades of disease, nearly all patients with type 1 diabetes and 60% of patients with type 2 diabetes have retinopathy.. In the younger-onset group, 86% of blindness was attributable to diabetic retinopathy. In the older-onset group, in which other eye diseases were common, one-third of the cases of legal blindness were due to diabetic retinopathy.

The disease finally leads to visual impairment due to neovascularization from retinal detachment, hemorrhage, retinal capillary nonperfusion and macular edema. DR, essentially a microvascular disease, takes root within the intricate vasculature of the retina, primarily due to the systemic effects of diabetes[4]. Its early stages often progress silently, devoid of overt symptoms, making early diagnosis and intervention imperative. However, the impact of DR is profound, potentially leaving a trail of vision loss in its wake.

The sheer magnitude of DR is indeed alarming. The World Health Organization estimates that 422 million individuals worldwide grapple with diabetes[4]. Of these, it is projected that roughly one in three people with diabetes will develop some form of diabetic retinopathy.

Diabetic retinopathy doesn't manifest as a singular entity but progresses through stages of severity. These stages, which include mild non-proliferative, moderate non-proliferative, severe non-proliferative, and proliferative DR, demarcate the varying levels of retinal damage and the risk of vision loss. Mild non-proliferative DR typically involves the presence of microaneurysms and small retinal hemorrhages[2]. As the condition progresses to moderate non-proliferative DR, more significant retinal damage becomes evident, with moderate haemorrhages and retinal swelling.

Severe non-proliferative DR encompasses widespread retinal damage, including more pronounced haemorrhages and retinal deformation. Proliferative DR is the most advanced stage, marked by the growth of abnormal blood vessels in the retina, a phenomenon that poses a severe risk of severe vision impairment and blindness[5]. Diabetic retinopathy progresses from mild non-proliferative abnormalities, characterized by increased vascular permeability, to moderate

and severe non-proliferative diabetic retinopathy (NPDR), characterized by vascular closure, to proliferative diabetic retinopathy (PDR), characterized by the growth of new blood vessels on the retina and posterior surface of the vitreous. Macular edema, characterized by retinal thickening from leaky blood vessels, can develop at all stages of retinopathy. DR's consequences are far-reaching, extending beyond vision impairment[2]. The loss of sight, even partial, fundamentally alters one's life. Routine tasks become daunting challenges, professional opportunities dwindle, and the ability to fully engage in social, recreational, and familial activities diminishes[1]. The emotional and psychological toll on individuals and their families is immeasurable. The fear, anxiety, and depression stemming from vision loss further compound the condition's impact.

In the quest to detect and classify DR, the retinal fundus image plays a pivotal role. This non-invasive imaging technique acts as a window into the intricate world of the eye, providing a detailed view of the retina's vascular network. Within these images, healthcare professionals can identify characteristic abnormalities, including microaneurysms, haemorrhages, exudates, and abnormal blood vessels[1]. By scrutinising these images, specialists can accurately classify the severity of DR, enabling timely intervention to preserve vision. The use of deep learning and artificial intelligence in the analysis of these images has the potential to further enhance accuracy and consistency in diagnosis, ensuring that individuals at risk receive the most appropriate care, the "Prediction of Severity of Diabetic Retinopathy Using Ensemble Learning" project aims to harness these advancements, ensuring early diagnosis, enhancing accessibility, and ultimately alleviating the burden of DR on health care professionals.

1.1 Retinal Fundus Image

The Retinal fundus image consists of the interior lining of the eyeball, including the retina (the light-sensitive screen), optic disc (the head of the nerve to the eye), and the macula (the small spot in the retina where vision is keenest). The fundus is the portion of the inner eye that can be seen during an eye examination by looking through the pupil. "Fundus" is the Latin word for the bottom. In medicine, fundus refers to the bottom or base of an organ.

Optic Disc: The circular area in the back of the inside of the eye where the optic nerve connects to the retina. Also called the optic nerve head.

Optic Cup: The optic cup is the white, cup-like area in the center of the optic disc.

Cup to Disc ratio: The ratio of the size of the optic cup to the optic disc (cup-to-disc ratio, or C/D) is one measure used in the diagnosis of glaucoma.

1.2 Phases of Diabetic Retinopathy

Diabetic retinopathy (DR) progresses through several distinct phases, each characterized by specific changes in the retina resulting from damage to the blood vessels caused by diabetes.

Mild Nonproliferative Retinopathy: This initial stage of diabetic retinopathy is characterized by the development of small areas of swelling in the retinal blood vessels, known as microaneurysms. These microaneurysms may leak fluid into the surrounding retinal tissue, leading to mild retinal edema. At this stage, there may be minimal or no visual symptoms, and the condition may be detected during a routine eye examination.

Moderate Nonproliferative Retinopathy: As the disease progresses, the retinal blood vessels may undergo further changes. Blood vessels may become blocked, leading to areas of restricted blood flow. This can result in the appearance of characteristic "dot" and "blot" hemorrhages, which are small areas of bleeding within the retina. Additionally, lipid deposits, known as hard exudates, may accumulate in the retinal tissue due to leakage from damaged blood vessels.

Severe Nonproliferative Retinopathy: In this stage, the retinal blood vessels continue to deteriorate, leading to more widespread ischemia, or oxygen deprivation, in the retina. Areas of ischemia may become evident as areas of capillary dropout on retinal imaging. The lack of oxygen supply to the retina triggers the release of growth factors that stimulate the growth of new blood vessels, a process known as neovascularization.

Proliferative Diabetic Retinopathy (PDR): This is the advanced stage of DR and signifies significant damage to the retinal blood vessels.

- New blood vessel growth: Due to the lack of oxygen reaching the retina, the body attempts to compensate by growing new blood vessels. However, these new vessels are abnormal and fragile, prone to bleeding.
- Bleeding and scarring: Leakage from these new blood vessels can cause blurred vision or floaters (spots in your

vision). Bleeding can also lead to scar tissue formation on the retina, further impacting vision.

- **Macular edema:** Fluid leakage can also accumulate in the macula, the central part of the retina responsible for sharp central vision. This can cause significant vision loss.
- **Detached retina:** In severe cases, bleeding or scar tissue formation can cause the retina to detach from the underlying tissue, leading to permanent vision loss.

1.3 Causes of Diabetic Retinopathy

Chronic Hyperglycemia: Prolonged elevation in blood sugar levels contributes significantly to diabetic retinopathy. High glucose levels induce biochemical changes in retinal blood vessels, leading to structural alterations and increased permeability. This chronic exposure weakens the vasculature, making it more prone to damage and leakage.

Microvascular Changes: Diabetes affects the small blood vessels throughout the body, including those in the retina. Endothelial dysfunction, increased vascular permeability, and abnormal angiogenesis are hallmark microvascular changes that exacerbate diabetic retinopathy. These alterations disrupt normal blood flow and oxygen delivery to the retina, contributing to tissue damage.

Hypertension: High blood pressure commonly coexists with diabetes and exacerbates retinal vascular damage. Elevated blood pressure increases the stress on retinal blood vessels, accelerating their deterioration and amplifying the risk and severity of diabetic retinopathy. Hypertension management is critical for mitigating retinal complications.

Dyslipidemia: Abnormal lipid levels, including high cholesterol and triglycerides, are prevalent in individuals with diabetes. Dyslipidemia promotes atherosclerosis, narrowing and hardening retinal blood vessels. Reduced blood flow and compromised vascular integrity worsen retinal damage and contribute to diabetic retinopathy progression.

Duration of Diabetes: The longer an individual has diabetes, the greater their risk of developing diabetic retinopathy. Chronic exposure to elevated blood sugar levels amplifies vascular damage and retinal changes over time. Disease duration is a significant predictor of retinopathy severity and progression.

1.4 Diagnosis and Treatment

Diagnosis of Diabetic Retinopathy: Regular eye screenings, including dilated eye examinations by eye care professionals, are essential for early diabetic retinopathy detection. These comprehensive assessments enable the identification of characteristic signs such as microaneurysms, hemorrhages, exudates, and neovascularization. Visual acuity testing measures the severity of retinopathy and its impact on vision, guiding treatment decisions.

Fluorescein Angiography: This diagnostic procedure involves injecting a fluorescent dye into a vein, which travels through retinal blood vessels. Specialized imaging captures the dye's flow, revealing areas of leakage, ischemia, and abnormal blood vessel growth. Fluorescein angiography provides critical information for treatment planning and disease monitoring.

Optical Coherence Tomography (OCT): OCT imaging produces high-resolution cross-sectional images of the retina, enabling visualization and measurement of retinal thickness, fluid accumulation, and structural abnormalities associated with diabetic retinopathy. OCT plays a vital role in disease staging, guiding treatment selection, and monitoring therapeutic response.

Treatment of Diabetic Retinopathy: Lifestyle modifications are foundational for managing diabetic retinopathy. Tight glycemic control, blood pressure and lipid management, weight control, and adopting a balanced diet and regular exercise regimen are fundamental for disease control and progression prevention.

Intravitreal Injections: Anti-vascular endothelial growth factor (anti-VEGF) agents or corticosteroids may be administered via intravitreal injections to treat diabetic macular edema and proliferative diabetic retinopathy. These injections reduce retinal swelling, inflammation, and abnormal blood vessel growth, preserving vision and preventing further complications.

Laser Photocoagulation: Laser therapy is a standard treatment for diabetic retinopathy, particularly in cases of proliferative disease and diabetic macular edema. Laser photocoagulation aims to seal leaking blood vessels, reduce

macular edema, and induce regression of abnormal vessels. This intervention preserves central vision and prevents vision loss.

Vitreotomy: In advanced cases of diabetic retinopathy with vitreous hemorrhage or tractional retinal detachment, vitrectomy may be necessary. This surgical procedure involves removing blood, scar tissue, and abnormal vitreous gel from the eye, restoring visual function and preventing further complications. Vitrectomy is typically reserved for cases unresponsive to other treatments.

1.5 Ensemble learning

Ensemble learning revolutionizes machine learning by amalgamating predictions from multiple models to yield a more accurate and resilient final prediction. By leveraging the diversity of models, ensemble learning mitigates individual weaknesses and magnifies collective strengths. In the method of Voting, predictions from various base models undergo a majority vote or weighted average, applicable to both classification and regression tasks. Bagging, exemplified by Random Forest, entails training diverse models on bootstrapped subsets of data and averaging their predictions. Boosting, including AdaBoost and Gradient Boosting Machines, sequentially refines models to focus on challenging examples. Stacking integrates base model predictions through a meta-model, adapting weights to optimize the final prediction. Despite its advantages—enhanced performance, robustness, and generalization—ensemble learning necessitates meticulous base model selection, parameter tuning, and may incur higher computational costs and interpretability challenges. Nonetheless, its proven efficacy across diverse machine learning problems underscores its significance in the field. Ensemble Learning

II. LITERATURE REVIEW

Diabetic Retinopathy (DR) is a leading cause of vision loss in diabetic patients, resulting from microvascular damage to the retina. Early detection is crucial to prevent irreversible blindness, but it often requires expensive and time-consuming expertise from ophthalmologists. Automatic detection systems have been developed to address this challenge, but their accuracy has been limited due to inadequate datasets. To improve accuracy, we proposed an ensemble-based learning approach that combines multiple classification algorithms. By selecting the top features from the Messidor dataset using InfoGainEval. and WrapperSubsetEval., we achieved high accuracy rates of 70.7% and 75.1% on subdatasets containing the top 5 and top 10 features, respectively. These results demonstrate superior performance compared to other common classification algorithms, suggesting a promising avenue for more effective and efficient DR diagnosis.

This paper [2] presents a novel method for automated diabetic retinopathy (DR) diagnosis using decision tree-based ensemble learning with features extracted from fundus images. The study focuses on the APTOS 2019 BD dataset, enhancing it for machine learning applications through various processing steps. With a classification accuracy of 94.20% and an F-measure of 93.51%, the method demonstrates robustness and reliability in DR detection. Detailed descriptions of image processing, feature extraction, and selection techniques are provided for reproducibility. This approach holds promise for mass retinal screening, potentially reducing vision loss associated with DR on a large scale. This paper proposes an augmented bioinspired multidomain feature extraction and selection model for estimating the severity of diabetic retinopathy (DR) using ensemble learning. The approach involves segmenting retinal images to identify DR severity levels and extracting multidomain features such as frequency, entropy, cosine, gabor, and wavelet components. A Modified Moth Flame Optimization-based feature selection method is then applied to select optimal features. Finally, an ensemble model comprising various machine learning algorithms is used for severity classification. Experiments on multiple datasets demonstrate superior performance, with an accuracy of 96.5% in identifying DR severity levels, outperforming conventional methods.

The paper titled "A Comparison of Two-Stage Classifier Algorithm with Ensemble Techniques on Detection of Diabetic Retinopathy" was presented at the 2021 1st International Conference on Artificial Intelligence and Data Analytics (CAIDA). It compares a two-stage classifier algorithm with ensemble techniques for the detection of diabetic retinopathy. The study explores various machine learning algorithms, including Neural Networks, Support Vector Machines (SVM), Logistic Regression, K-Nearest Neighbors (KNN), Naïve Bayes, Decision Tree, Multilayer Perceptron (MLP), Gradient Boosting Classifier, and Random Forest. The research aims to evaluate the performance of these algorithms in detecting diabetic retinopathy and highlights the potential of ensemble techniques in improving classification accuracy.

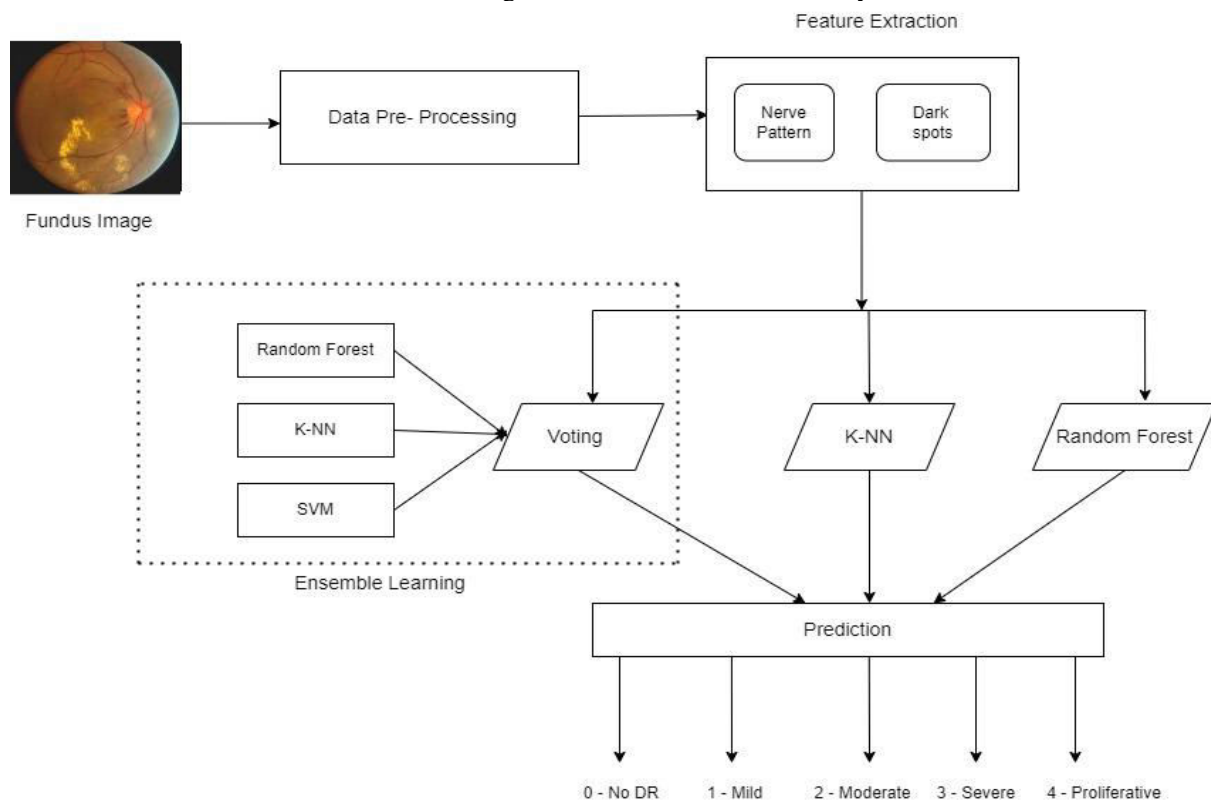
III. EXISTING SYSTEM

The current system for diagnosing and managing diabetic retinopathy (DR) primarily operates on manual assessments conducted by eye care specialists, such as ophthalmologists. This traditional approach is characterised by a set of key limitations and challenges.

The cornerstone of the existing system is manual evaluation, necessitating the careful scrutiny of retinal fundus images. This approach is inherently time-intensive and fraught with interobserver variability. Variations in interpretation across different specialists introduce subjectivity, compromising the consistency and reliability of DR assessments. Consequently, these diagnostic disparities can significantly influence the treatment strategies and, ultimately, the clinical outcomes experienced by patients.

IV. METHODOLGY

The project focuses on developing a methodology for determining the severity level of diabetic retinopathy by analyzing eye images. This involves the extraction of two key features from the images: *nerve patterns* and *dark spots*. These features are used to train a machine learning model that classifies the severity of the condition.



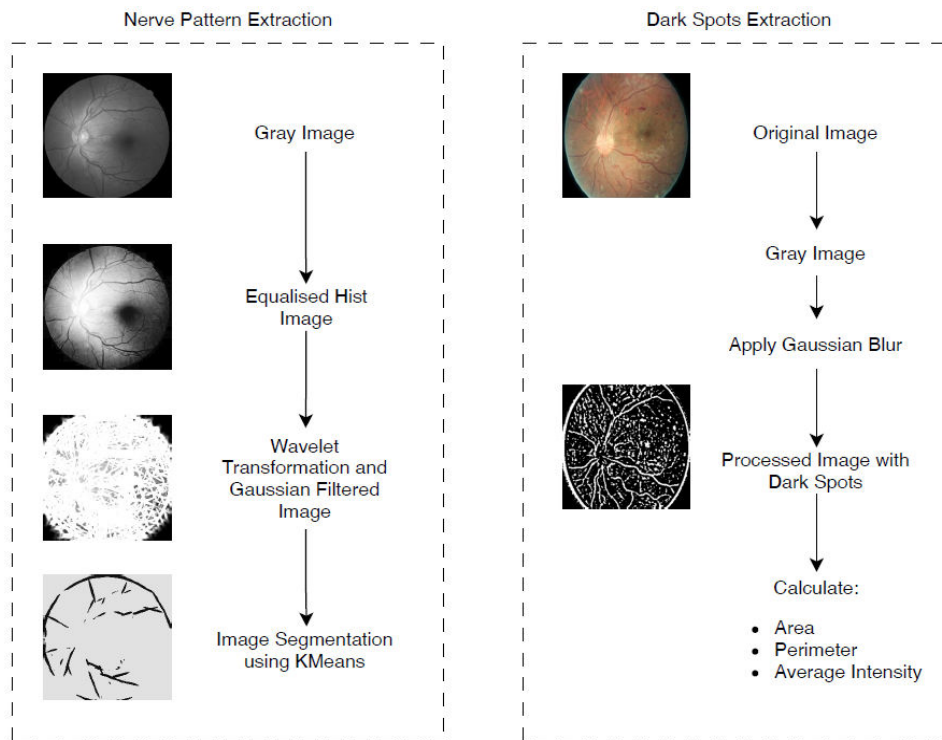
1. Data Acquisition and Preprocessing of Eye images used in the study are first collected from a reliable dataset that includes various stages of diabetic retinopathy. Each image undergoes preprocessing to enhance quality and detail, which is crucial for effective feature extraction. The preprocessing steps include:

Histogram Equalization: To improve the contrast of the images, making features more distinguishable.

Wavelet Transformation: To decompose the image into its frequency subbands, helping in highlighting features like nerve fibers.

Gaussian Filter: To reduce noise and blur out high-frequency components which are not required for feature extraction.

2. Feature Extraction



Nerve Feature Extraction: Image Segmentation using K-Means: This step segments the image into clusters representing different regions of interest, particularly focusing on nerve patterns. The output from the previous preprocessing steps serves as input here, facilitating the accurate identification of nerve structures in the retina.

Dark Spot Feature Extraction:

- **Gaussian Blur:** Applied to soften the image, this step helps in distinguishing the dark spots from the rest of the eye components by reducing detail and noise around these spots.
- **Masking and Contour Detection:** Post-blurring, the image is masked to isolate dark spots, and contours are detected around these areas. The detected contours aid in calculating the area, perimeter, and average intensity of each dark spot, providing quantitative data for analysis.

3. ML model

The extracted features (nerve patterns and metrics related to dark spots) are utilized as inputs for a machine learning model. The following steps outline the model training and prediction process:

Random Forest Classifier: A supervised learning model known for its high accuracy and robustness against overfitting. The model is trained using a dataset of labeled eye images, where each label corresponds to a severity level of diabetic retinopathy.

KNN: K-Nearest Neighbours(KNN) is a non-parametric classification algorithm that assigns a class label to a new data point based on the majority class of its K nearest neighbours in the feature space. It's simple to understand and implement, but computationally expensive for large datasets due to its reliance on calculating distances between data points. The choice of K and the distance metric significantly affect its performance.

Voting : Voting in machine learning refers to combining predictions from multiple models to make a final decision. It can be done through majority voting, where the most common prediction among the models is selected, or weighted voting, where the models' predictions are weighted based on their performance. Ensemble methods like Random Forest and Gradient Boosting utilize voting strategies to improve predictive accuracy and robustness.



4. Model Validation and Testing

The performance of the trained model is validated using a separate validation set. Metrics such as accuracy, sensitivity, specificity, and F1-score are computed to assess the model's capability in correctly classifying the severity levels. Prediction: For new eye images, the same preprocessing and feature extraction steps are applied. The trained Random Forest model then uses these features to predict the severity level of diabetic retinopathy in the image.

5. Evaluation The methodology's effectiveness is evaluated through a series of tests using unseen data. The evaluation focuses on the accuracy and reliability of the predictions in real-world scenarios. Additionally, the system's performance is benchmarked against existing methods to establish its comparative effectiveness.

V. SNAPSHOTS

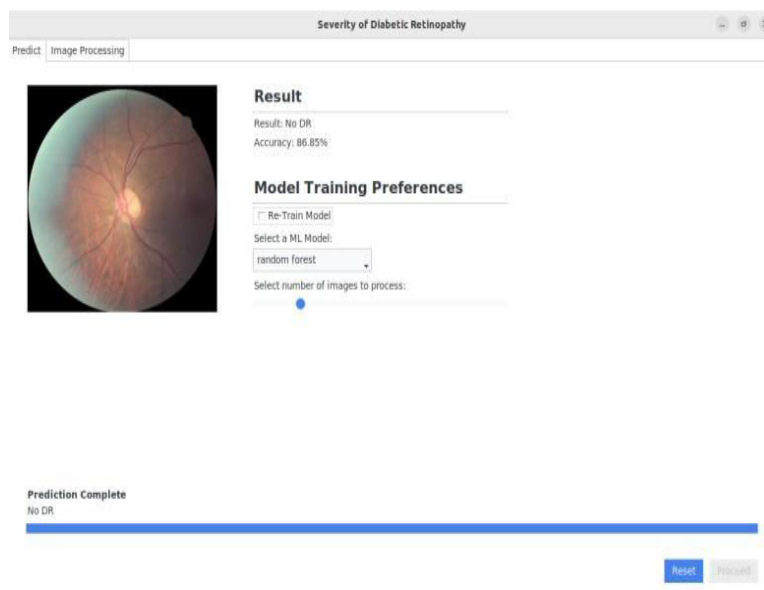


Fig 5.1: Displaying No DR

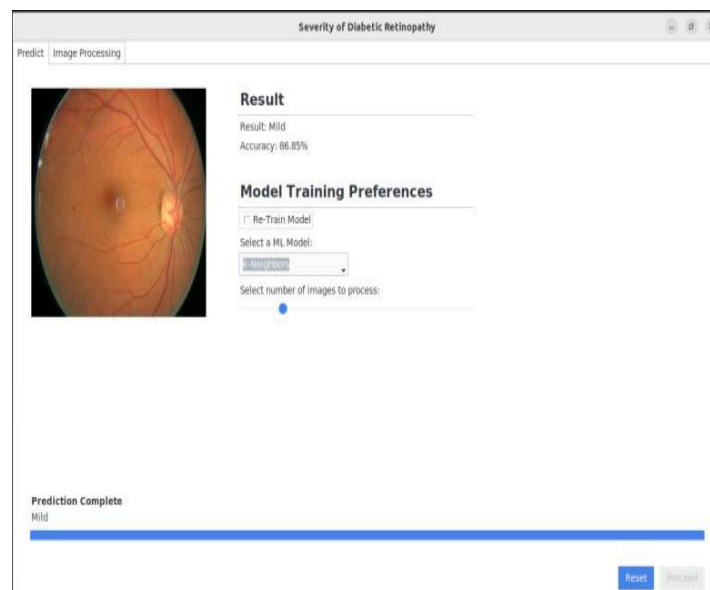


Fig 5.2 : Displaying Mild DR

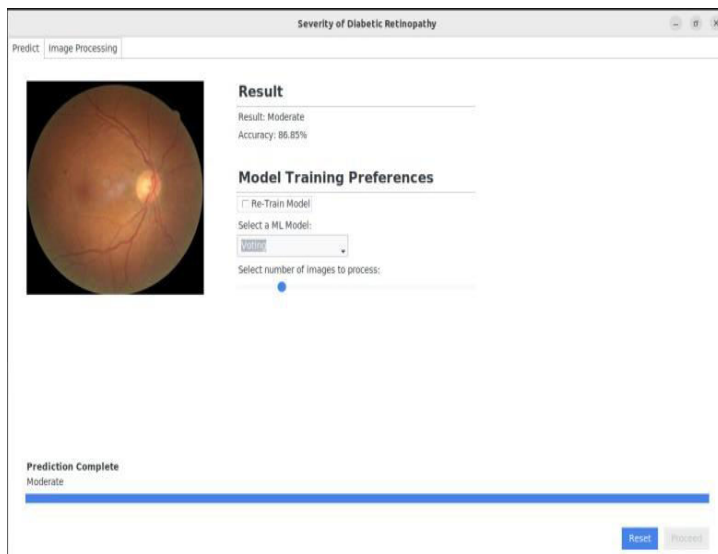


Fig 5.3: Output Displaying Moderate DR

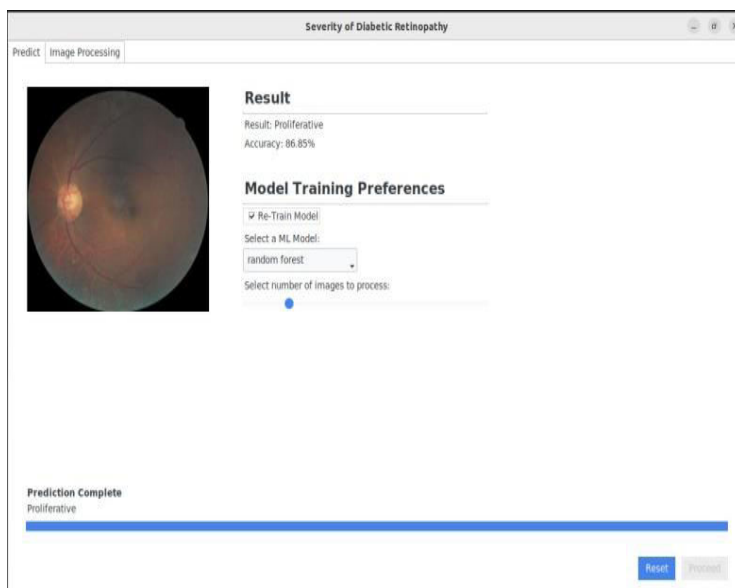


Fig 5.4: Output Displaying Proliferative DR

VI. DISCUSSION

The future of DR holds for integrating predictive models into real-time applications to aid ophthalmologists. Portable retinal imaging devices equipped with embedded predictive algorithms could revolutionize point-of-care screening, particularly in remote or underserved areas, where access to ophthalmic care is limited. Moreover, seamless integration with telemedicine platforms would enable remote consultations and screening, extending the reach of specialized care to a wider patient population. Clinical decision support systems, integrated with electronic health records, could automate the analysis of retinal images during routine examinations, alerting ophthalmologists to high-risk cases for prompt intervention. Continuous refinement and validation of these predictive models, guided by feedback from ophthalmologists and ongoing research, will be essential to ensure their accuracy and effectiveness across diverse patient demographics and clinical contexts.



VII. RESULTS

In conclusion, our ensemble learning methodology, integrating KNN, Random Forest, Voting, and SVM model, offers a significant advancement in diabetic retinopathy severity prediction using the APTOS dataset. By providing accurate and reliable assessments, this approach can empower healthcare professionals with timely insights, aiding in proactive intervention. Moreover, its potential to reduce interoperability issues and enhance diagnostic precision underscores its value as a tool for improving healthcare outcomes. This study marks a critical step forward in leveraging machine learning for the benefit of both patients and clinicians in managing diabetic retinopathy.

REFERENCES

- [1] Odeh, M. Alkasassbeh and M. Alauthman, "Diabetic Retinopathy Detection using Ensemble Machine Learning," *2021 International Conference on Information Technology (ICIT)*, Amman, Jordan, 2021
- [2] Sikder, Niloy, et al. "Severity classification of diabetic retinopathy using an ensemble learning algorithm through analyzing retinal images." *Symmetry* 13.4 (2021): 670.
- [3] Uppamma, P., Bhattacharya, S. A multidomain bio-inspired feature extraction and selection model for diabetic retinopathy severity classification: an ensemble learning approach. *Sci Rep* 13, 18572 (2023).
- [4] Nagi, Ali Tariq, et al. "A comparison of two-stage classifier algorithms with ensemble techniques on detection of diabetic retinopathy." *2021 1st International Conference on Artificial Intelligence and Data Analytics (CAIDA)*. IEEE, 2021
- [5] Bhardwaj, C., Jain, S. & Sood, M. Deep Learning Based Diabetic Retinopathy Severity Grading System Employing Quadrant Ensemble Model. *J Digit Imaging* 34 , 440 457 (2021).
- [6] A. T. Nagi, M. Javed Awan, R. Javed and N. Ayesha, "A Comparison of Two Stage Classifier Algorithm with Ensemble Techniques on Detection of Diabetic Retinopathy," *2021 1st International Conference on Artificial Intelligence and Data Analytics (CAIDA)* , Riyadh, Saudi Arabia, 2021.
- [7] Jain, S., Saxena, S., & Sinha, S. (2022). Ensemble Architecture for Prediction of Grading of Diabetic Retinopathy. *Cybernetics and Systems* , 119.
- [8] Kale, Y., Sharma, S. Detection of five severity levels of diabetic retinopathy using ensemble deep learning model. *Multimed Tools App* 18 2 , 19005 19020 (2023)



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