Journal of Image Processing and Intelligent Remote Sensing
ISSN 2815-0953
Vol: 04, No.02, Feb-Mar 2024
http://journal.hmjournals.com/index.php/JIPIRS
DOI: https://doi.org/10.55529/jipirs.42.30.40

Diabetic Retinopathy Detection Using Inception-Resnet-V2 and Densenet121

Gangumolu Harsha Vardhan[1*], Meda Venkata Sai Jyoshna[2], Pamarthi Kasi Viswanath[3], Shaik Zubayr[4], Velaga Sravanth[5]

[1]Jr. Assistant Professor, Department of Information Technology, Vishnu Institute of Technology, Bhimavaram, Andhra Pradesh, India.*
[2,3,4,5]Vishnu Institute of Technology, Bhimavaram, Andhra Pradesh, India.

Email: [2]medajyoshna28@gmail.com, [3]pamarthiviswanath17@gmail.com, [4]Shaikzubayr20@gmail.com, [5]velagasravanth460@gmail.com
Corresponding Email: [1]harshavardhan5905@gmail.com*

Received: 22 October 2023 **Accepted:** 08 January 2024 **Published:** 24 February 2024

Abstract:** This project addresses the global health challenge posed by the prevalence of diabetic retinopathy (DR) by developing an efficient automated diagnostic system. The dataset, consisting of diverse high-resolution retinal images, underwent preprocessing to categorize images into No DR (0) and DR (1-4) classes. The First initial binary classification model using a Convolutional Neural Network (CNN) discriminated between healthy and diseased retinas. Subsequently, The second multi-class CNN model was designed to predict the severity of diabetic retinopathy (DR) across a spectrum from mild (1) to proliferative DR (4), enabling a fine-grained analysis for early identification of cases requiring urgent intervention. To address real-world complexities, potential noise in the dataset, including artifacts and exposure variations, was acknowledged. The CNN models were designed to exhibit resilience to these challenges, ensuring robust performance in clinical settings. Preprocessing is considered the common occurrence of image inversion in retinal imaging by incorporating anatomical features, such as macula position and notches, to correctly identify image orientation and enhance result interpretability. The proposed automated analysis system demonstrated promising results in accurately categorizing retinal images into No DR and DR, as well as assigning severity scores for diabetic retinopathy. This project contributes significantly to computer-aided diagnostics, Supplying a dependable instrument for promptly identifying and addressing cases of diabetic retinopathy.

***Keywords:** Diabetic Retinopathy, Convolutional Neural Network, proliferative DR, Preprocessing, Image Augmentation, InceptionResNetV2.*

Journal of Image Processing and Intelligent Remote Sensing
ISSN 2815-0953
Vol: 04, No.02, Feb-Mar 2024
http://journal.hmjournals.com/index.php/JIPIRS
DOI: https://doi.org/10.55529/jipirs.42.30.40

1. INTRODUCTION

Diabetic Retinopathy (DR) stands as a debilitating complication arising from diabetes, impacting the retina and potentially resulting in vision impairment or blindness if not addressed promptly. The criticality of early detection and precise grading of DR cannot be overstated, as it serves as a linchpin in enabling timely intervention to forestall irreversible damage. The objective of this project is to leverage Convolutional Neural Networks (CNNs) to develop an automated analysis system capable of accurately assessing the severity levels of diabetic retinopathy.

Our dataset encompasses a varied assortment of high-resolution retina images, which comprehensively capture the intricacies of real-world imaging scenarios. Each image undergoes meticulous annotation by clinicians, utilizing a scale spanning from 0 to 4 to denote the severity of diabetic retinopathy. This multi-class grading system classifies images into five distinct categories: No DR, Mild, Moderate, Severe, and Proliferative DR. The nuanced gradation within this scale facilitates a thorough comprehension of the disease's progression.

Furthermore, the dataset introduces challenges associated with variations in imaging perspectives. Some images follow the anatomical orientation of the retina, while others are presented in an inverted manner typical of a live eye exam. To address this, our algorithm incorporates sophisticated techniques to identify inversion cues, such as the relative positioning of the macula and optic nerve, as well as the presence of notches on the image borders.

In the real-world context, images may exhibit imperfections, such as artifacts, focus issues, or exposure irregularities. Tackling these challenges is paramount to developing a robust and clinically applicable solution. Hence, this competition emphasizes the creation of algorithms resilient to noise and variations, mirroring the conditions encountered in actual clinical settings.

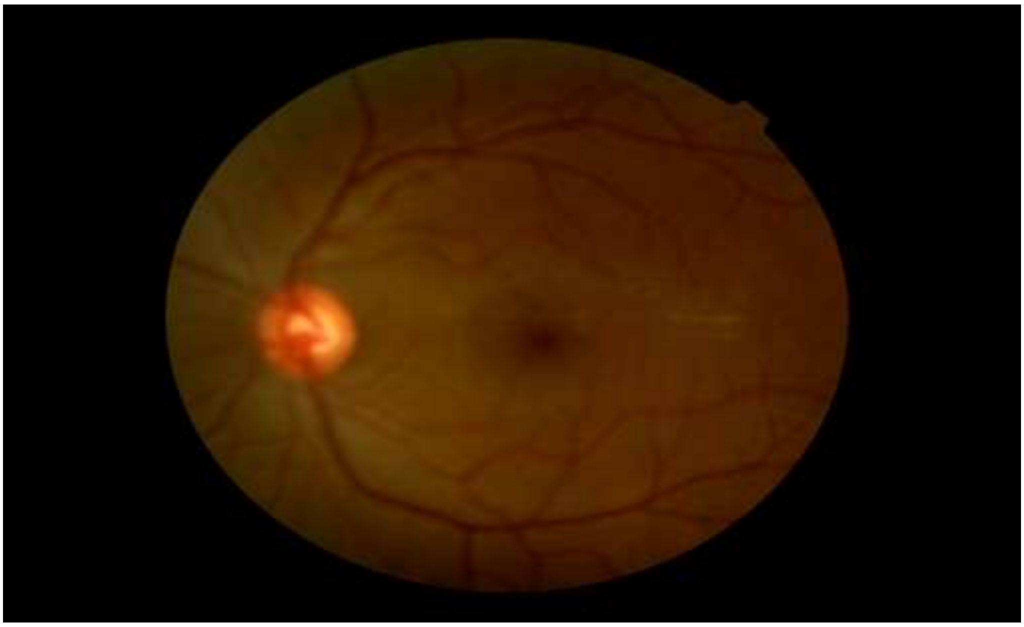
With this endeavor, our aim is to make strides in the field of diabetic retinopathy diagnostics by offering an automated and dependable tool tailored for ophthalmologists. By incorporating cutting-edge CNNs alongside inventive image analysis methods, we not only seek to boost the accuracy of disease detection but also to establish a pathway for a more widely accessible and scalable solution in combating diabetic retinopathy.

In the contemporary landscape marked by an escalating prevalence of diabetes, the significance of an Automated Diabetic Retinopathy Detection System employing Convolutional Neural Networks (CNN) cannot be overstated. This system assumes a pivotal role in the timely identification and intervention of diabetic retinopathy by analyzing high-resolution retina images and assigning a diabetic retinopathy score ranging from 0 to 4. This aids healthcare practitioners in accurately gauging the severity of the condition. Through the utilization of sophisticated image analysis methodologies, the system not only discerns the presence of retinopathy but also adeptly maneuvers through variations in image quality and diverse camera types.

This initiative empowers healthcare providers by offering a rapid and unbiased evaluation of diabetic retinopathy, facilitating prompt intervention and averting potential complications. With its intuitive interface, it ensures accessibility for both ophthalmologists and general practitioners, positioning it as an invaluable resource for regular screenings and proactive

Journal of Image Processing and Intelligent Remote Sensing
ISSN 2815-0953
Vol: 04, No.02, Feb-Mar 2024
http://journal.hmjournals.com/index.php/JIPIRS
DOI: https://doi.org/10.55529/jipirs.42.30.40

diabetic management. Ultimately, this automated platform plays a pivotal role in the early detection and treatment of diabetic retinopathy, thereby safeguarding the vision of individuals living with diabetes.



2. RELATED WORKS

1. This study focuses on the automation of diabetic retinopathy (DR) diagnosis using deep learning techniques, specifically deep convolutional neural networks (CNNs). The paper introduces a CNN model accelerated by GPU processing capable of classifying high-resolution retinal images into five stages of DR severity. The dataset used consists of 35,126 labeled images from EyePACs, categorized into five stages of DR. The proposed CNN architecture, comprising multiple convolutional and pooling layers, shows promising results, achieving a quadratic weighted kappa metric score of 0.3996 through ensemble learning.
2. The paper introduces a novel approach for diagnosing diabetic retinopathy using retinal fundus images, integrating image processing and deep learning techniques. This hybrid method combines histogram equalization and contrast limited adaptive histogram equalization for image enhancement, followed by classification through a convolutional neural network (CNN). Evaluation conducted on 400 retinal fundus images from the MESSIDOR database demonstrates the method's high performance, achieving impressive metrics such as accuracy (97%), sensitivity (94%), specificity (98%), precision (94%), FScore (94%), and GMean (95%).
3. This literature review delves into the utilization of deep learning methodologies for the timely detection and categorization of Diabetic Retinopathy (DR) through the analysis of color fundus images. It explores the diverse lesions and stages associated with DR, alongside the datasets commonly employed for model training and evaluation. The significance of automated systems over manual diagnosis is underscored, owing to their enhanced efficiency and diminished risks of misdiagnosis. Moreover, the survey delineates the prevailing challenges

Journal of Image Processing and Intelligent Remote Sensing
ISSN 2815-0953
Vol: 04, No.02, Feb-Mar 2024
http://journal.hmjournals.com/index.php/JIPIRS
DOI: https://doi.org/10.55529/jipirs.42.30.40

and charts out prospective avenues for further research in this domain. In sum, the integration of deep learning techniques in DR detection underscores promising strides towards enhancing early diagnosis and averting vision loss.

4. This paper tackles the critical challenge of early detection of diabetic retinopathy (DR) through the application of a deep learning methodology. DR, a complication of diabetes leading to vision impairment, typically necessitates expert interpretation of fundus images for diagnosis. The proposed approach utilizes a deep convolutional neural network (CNN) to automatically identify different stages of DR from single fundus photography. By incorporating a multi-target learning strategy, which includes ordinal regression, the model's capability to predict various stages of DR is augmented. The method exhibits promising outcomes, boasting a sensitivity and specificity of 0.99, and attains a commendable ranking on the APTOS 2019 Blindness Detection Dataset. This study underscores the importance of streamlining detection processes to facilitate early diagnosis, underscoring the potential of deep learning in the realm of DR detection.

5. This study addresses the pressing concern of detecting Diabetic Retinopathy (DR) using a combination of five deep Convolutional Neural Network (CNN) models. DR, a leading cause of blindness, progresses through five distinct stages, underscoring the significance of early detection. Current computer vision techniques face challenges in identifying the initial stages, particularly the Mild stage. The proposed ensemble model, trained on a dataset from Kaggle, surpasses existing methods by successfully identifying all DR stages, including the difficult Mild stage. The research underscores the importance of balanced datasets and investigates the influence of hyperparameter tuning. Evaluation criteria encompass a range of metrics such as accuracy, sensitivity, specificity, precision, F1-score, ROC, and AUC. The findings showcase exceptional performance, pushing forward DR classification endeavors and offering potential for early intervention and enhanced patient outcomes.

6. The paper introduces a novel VGG-NiN model designed for the detection and classification of diabetic retinopathy (DR) stages through deep learning techniques. DR stands as a significant contributor to blindness, where manual assessment of fundus images often proves prone to errors. The VGG-NiN model amalgamates VGG16, spatial pyramid pooling layer (SPP), and network-in-network (NiN) components to construct a highly nonlinear, scale-invariant deep architecture. Its primary objective is to categorize DR stages with minimal learnable parameters, thereby facilitating quicker training and convergence. Experimental results demonstrate its superior accuracy and computational efficiency when compared to existing state-of-the-art methods. The proposed architecture harnesses the power of transfer learning, SPP for spatial information extraction, and NiN for capturing nonlinear features, presenting a comprehensive solution for the classification of DR.

7. This research paper delves into the utilization of deep learning, specifically DenseNet-169, to detect diabetic retinopathy (DR) in its early stages through fundus images.The study utilizes datasets sourced from Kaggle, specifically the Diabetic Retinopathy Detection 2015 and Aptos 2019 Blindness Detection datasets. The proposed model demonstrates a commendable 90% accuracy in categorizing the severity levels of DR. The paper thoroughly examines the global prevalence of diabetes, the inherent challenges in early DR detection, and conducts a comprehensive review of related literature in the field, with a focus on the paradigm shift from manual feature extraction to the use of deep learning techniques.

Journal of Image Processing and Intelligent Remote Sensing
ISSN 2815-0953
Vol: 04, No.02, Feb-Mar 2024
http://journal.hmjournals.com/index.php/JIPIRS
DOI: https://doi.org/10.55529/jipirs.42.30.40

8. This paper delves into the impact of Diabetes Mellitus (DM) on vision, specifically through Diabetic Retinopathy (DR), and presents a novel automated knowledge model aimed at early detection of DR using fundus images. The study employs three distinct neural network architectures: back propagation NN, Deep Neural Network (DNN), and Convolutional Neural Network (CNN). These models are trained on a variety of features such as blood vessels, fluid leakage, exudates, hemorrhages, and microaneurysms. Utilizing Fuzzy C-means clustering, the study determines class thresholds for precise DR severity classificationThe proposed model integrates image preprocessing, statistical feature extraction, and neural networks to enhance DR detection accuracy. This research significantly contributes to the field by providing a comparative analysis of the effectiveness of various neural network models in identifying critical DR indicators.
9. This review article extensively examines the utilization of deep learning methodologies in the detection and classification of diabetic retinopathy (DR) using fundus images. The paper delves into datasets, preprocessing methodologies, and a spectrum of deep learning models deployed across various stages of DR detection. It underscores the pivotal role of AI in mitigating the manual workload associated with DR diagnosis, particularly in regions grappling with a scarcity of ophthalmologists. The review accentuates the strides made in artificial intelligence, with a focal point on deep learning models developed post-2016, and offers valuable insights for future research trajectories in this dynamically evolving domain. The discourse encompasses models spanning from classification to lesion segmentation, addressing multifaceted facets of DR diagnosis. By presenting a comprehensive examination of datasets, preprocessing strategies, and practical clinical applications, the review fosters a holistic comprehension of the present landscape and challenges in the field.
10. This study investigates the application of deep convolutional neural networks (DCNNs) for diagnosing diabetic retinopathy (DR) and introduces a new dataset comprising 4,476 DR fundus images annotated with treatment method information. These images were collected from three distinct clinical departments, and DCNN models were trained to classify DR severity. The proposed Inception-V3 model achieves an accuracy of 88.72% in a four-degree classification task. Additionally, an Inception@4 model, optimized for larger images, further enhances grading accuracy and recall rates. Clinical assessment demonstrates a consistency rate of 91.8% with the judgments of ophthalmologists across multiple hospital settings. This research underscores the potential of automated DR diagnosis using DCNNs, addressing the challenges arising from the significant diabetic population and the limited availability of ophthalmologists.

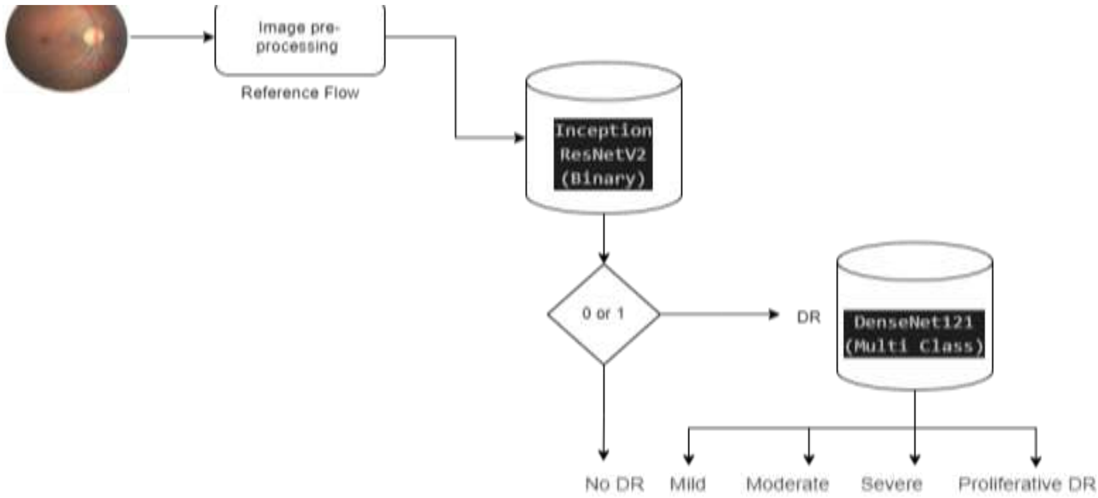
3. METHODOLOGY

CNN

In this project, we utilized transfer learning with Convolutional Neural Networks (CNNs) to create an automated system for detecting diabetic retinopathy (DR). Utilizing an extensive dataset of high-resolution retina images annotated with DR severity levels, our approach involved two primary phases. Initially, we transformed the dataset into a binary classification task, distinguishing between "No DR" and "DR" cases. This step facilitated the creation of a robust CNN model capable of identifying the presence or absence of diabetic retinopathy with

Journal of Image Processing and Intelligent Remote Sensing
ISSN 2815-0953
Vol: 04, No.02, Feb-Mar 2024
http://journal.hmjournals.com/index.php/JIPIRS
DOI: https://doi.org/10.55529/jipirs.42.30.40

high accuracy. Subsequently, we extended the model to handle the multi-class classification of DR severity levels—Mild, Moderate, Severe, and Proliferative DR. This refined CNN model exhibited the capacity to precisely categorize the severity of diabetic retinopathy, providing clinicians with valuable insights for tailored patient care. Our approach not only accommodated variations in image quality and artifacts but also addressed challenges posed by different imaging conditions. By strategically utilizing transfer learning, we harnessed the knowledge embedded in pre-trained CNN models, enhancing the efficiency of our system in handling complex visual data. The outcome is an automated analysis system that aids clinicians in swiftly assigning accurate DR severity scores, fostering timely and personalized patient intervention.



Encoding Categorical Data

For encoding categorical data in the Diabetic Retinopathy Detection project, a systematic approach was employed to ensure optimal model performance. The initial step involved transforming the dataset into a binary classification task by categorizing images into 'No DR' and 'DR' classes. This enabled the development of a specialized Convolutional Neural Network (CNN) tailored for the purpose of distinguishing between the presence and absence of diabetic retinopathy.

Subsequently, another CNN model was created specifically for multi-class classification, with an emphasis on categorizing the severity levels of diabetic retinopathy, namely: 'Mild,' 'Moderate,' 'Severe,' and 'Proliferative DR.' Each severity level was encoded as a distinct class to enable precise scoring based on the clinician-rated scale.

This dual-model approach allowed for a nuanced analysis, accommodating the intricacies of the diabetic retinopathy severity spectrum. The utilization of CNNs in both binary and multi-class scenarios ensures the system's adaptability to diverse imaging conditions and varying degrees of pathology, making it robust against noise and dataset variations.

Class Weights

DenseNet121, a convolutional neural network architecture, is employed for the task. To tackle

Journal of Image Processing and Intelligent Remote Sensing
ISSN 2815-0953
Vol: 04, No.02, Feb-Mar 2024
http://journal.hmjournals.com/index.php/JIPIRS
DOI: https://doi.org/10.55529/jipirs.42.30.40

the inherent class imbalance within the dataset, class weights are employed. These classes signify varying severity levels of DR: 0 for Mild, 1 for Moderate, 2 for Severe, and 3 for Proliferative DR. The determination of class weights is based on the inverse proportion of samples within each class. Subsequent to defining the class weights, the DenseNet121 model is constructed, incorporating additional layers for fine-tuning purposes. The model is compiled utilizing the Adam optimizer and categorical cross-entropy loss function. Throughout the training process, metrics such as accuracy and area under the curve (AUC) are monitored. The summary of the DenseNet121-based model architecture reveals its constituent layers and parameters.

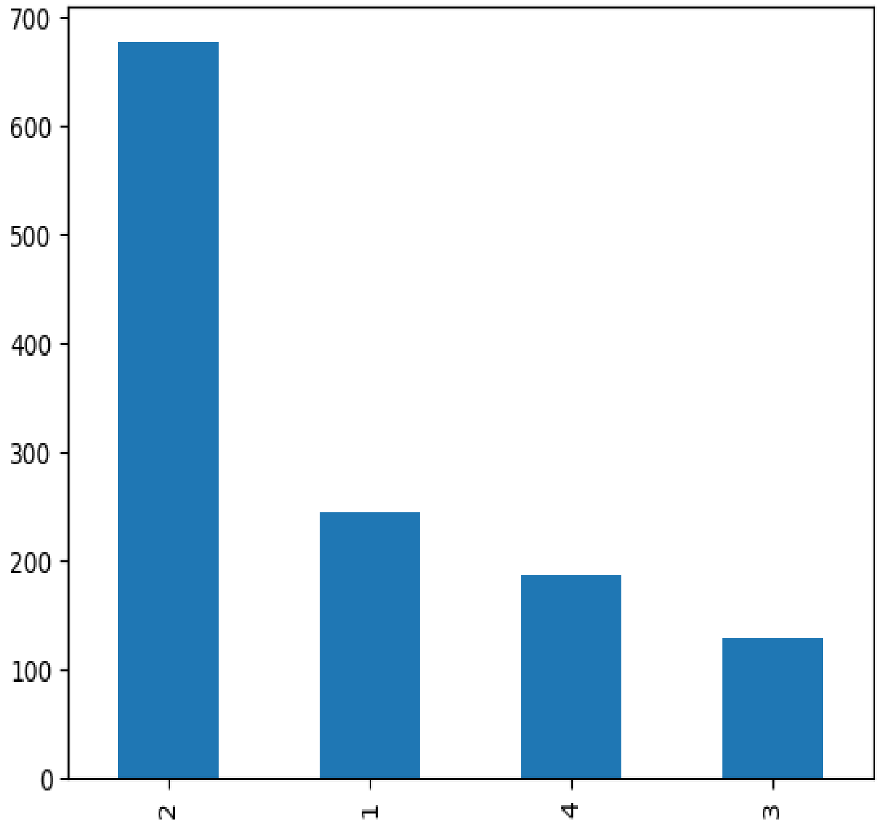
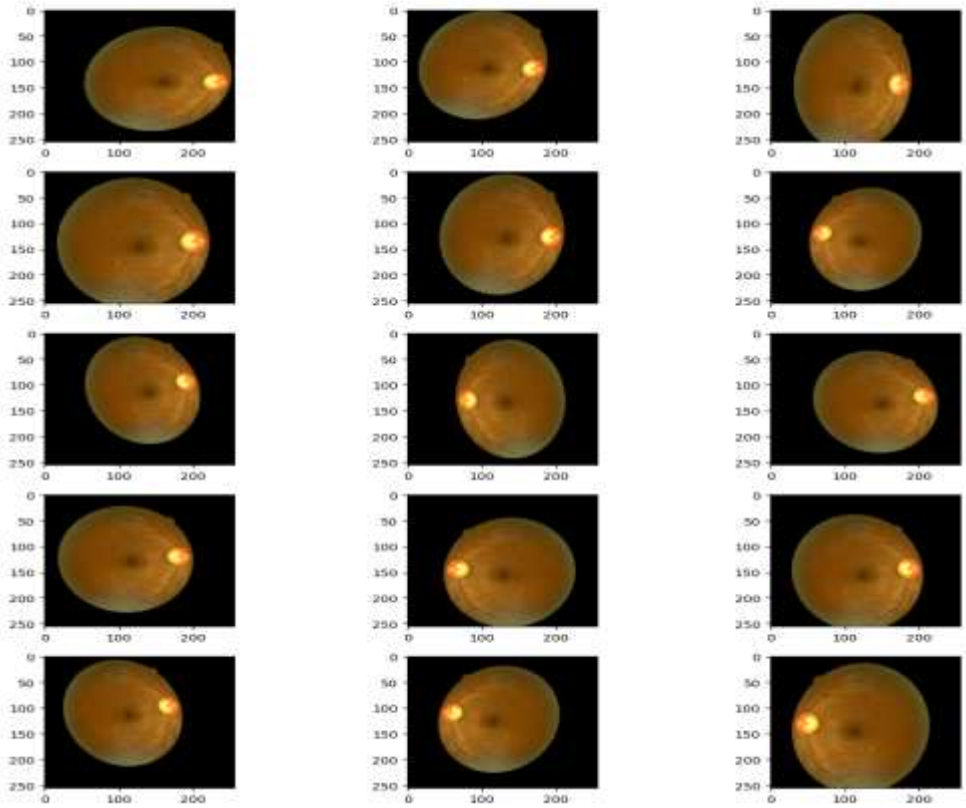


Image Augmentation

For effective Diabetic Retinopathy Detection using CNN, a robust Image Augmentation strategy is crucial. The train_datagen employs various transformations to diversify the dataset, enhancing model generalization. Rotation_range introduces image rotations up to 20 degrees, while width_shift_range and height_shift_range perform horizontal and vertical shifts, mimicking real-world variations. Shear_range introduces shearing effects, and zoom_range enables random zooming, both helping the model adapt to different perspectives. Horizontal_flip adds horizontal flipping for symmetry exploration. Fill_mode ensures pixel filling in case of transformations.

Journal of Image Processing and Intelligent Remote Sensing
ISSN 2815-0953
Vol: 04, No.02, Feb-Mar 2024
http://journal.hmjournals.com/index.php/JIPIRS
DOI: https://doi.org/10.55529/jipirs.42.30.40

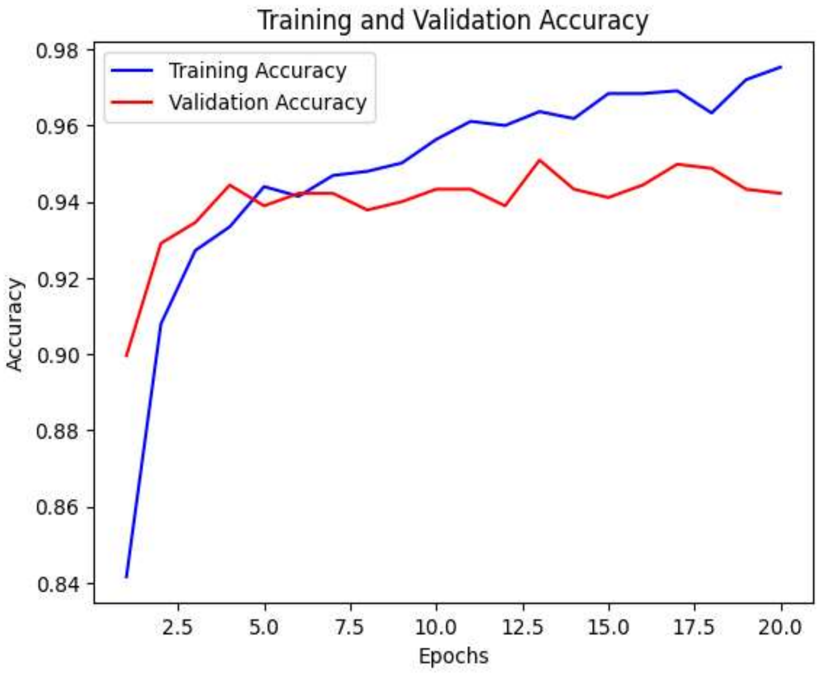


4. RESULTS AND DISCUSSION

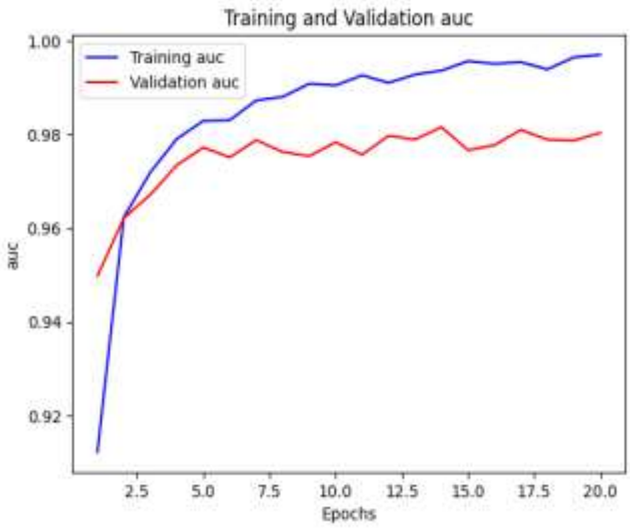
Model	Type	Train Accuracy	Test Accuracy	Train AUC	Test AUC
InceptionResNetV2	binary	0.9782	0.9421	0.9968	0.9853
DenseNet121	Multi class	0.7911	0.7511	0.8466	0.8037

The model architecture is founded on InceptionResNetV2 for detecting diabetic retinopathy (DR). It incorporates pre-trained layers with fine-tuning applied to the last 10 layers. The input shape is defined as (75, 75, 3). Following the convolutional layers, there's a Flatten layer utilized for feature extraction, accompanied by Dropout regularization set at a rate of 0.5 to mitigate overfitting risks. Deeper representation learning is facilitated through the addition of three dense layers comprising 512, 128, and 64 units, respectively. Each dense layer is followed by BatchNormalization and ReLU activation. The output layer is a Dense layer with softmax activation, producing probabilities for binary classification. The model is compiled leveraging the Adam optimizer with a learning rate set to 0.0001. Impressively, it achieves notable metrics such as an accuracy of 97.52% and an AUC of 0.9970 on the training set, along with an accuracy of 94.21% and an AUC of 0.9804 on the validation set after 20 epochs.

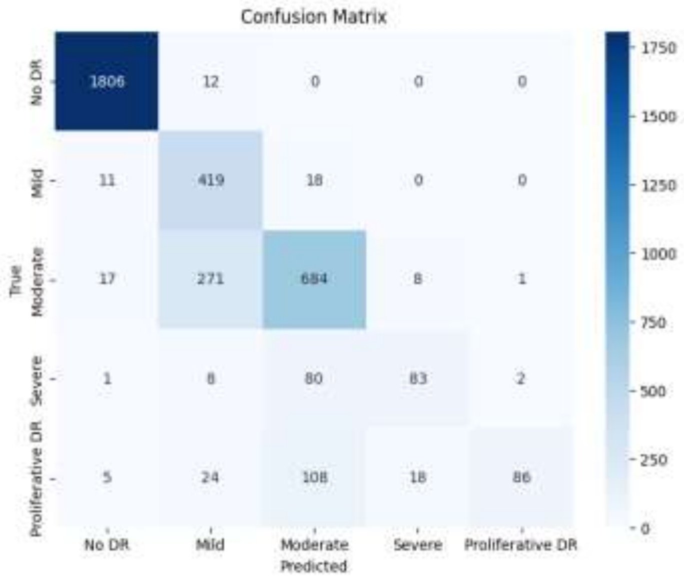
Journal of Image Processing and Intelligent Remote Sensing
ISSN 2815-0953
Vol: 04, No.02, Feb-Mar 2024
http://journal.hmjournals.com/index.php/JIPIRS
DOI: https://doi.org/10.55529/jipirs.42.30.40



The diabetic retinopathy severity classification model utilizes the DenseNet121 architecture, initialized with pre-trained weights and excluding the top classification layer. Global Average Pooling is employed for feature extraction, followed by Dropout regularization to curb overfitting. A dense layer with 256 units and ReLU activation precedes the softmax output layer with four units representing severity classes. The model is compiled with the Adam optimizer using a learning rate of 0.001 and categorical cross-entropy loss. After 150 epochs, it achieves a training accuracy of 79.11%, validation accuracy of 75.11%, training AUC of 84.66%, and validation AUC of 80.37%. Despite its relatively high performance, further fine-tuning or data augmentation could enhance its generalization capability.



Journal of Image Processing and Intelligent Remote Sensing
ISSN 2815-0953
Vol: 04, No.02, Feb-Mar 2024
http://journal.hmjournals.com/index.php/JIPIRS
DOI: https://doi.org/10.55529/jipirs.42.30.40



The combined model integrates the strengths of both InceptionResNetV2 and DenseNet121 architectures for diabetic retinopathy (DR) detection and severity classification. Leveraging transfer learning, features from InceptionResNetV2 and DenseNet121 are extracted and concatenated. This fused representation enhances the model's ability to capture diverse visual patterns associated with DR. The concatenated features are passed through dense layers for further abstraction and classification. The model attains a notable accuracy rate of 84.05%, showcasing its effectiveness in precisely recognizing cases of DR. Furthermore, it demonstrates an F1 score, recall, and precision hovering around approximately 83.50%, the model showcases balanced performance in both correctly identifying positive cases and minimizing false positives. The error rate is approximately 15.95%, indicating a relatively low misclassification rate. This combined approach effectively combines the strengths of both architectures, leading to robust DR detection and severity classification.

5. CONCLUSION

The creation of a highly effective automated diagnostic system for diabetic retinopathy (DR) represents a substantial advancement in addressing global health challenges. Utilizing transfer learning with Convolutional Neural Networks (CNNs) enhances the potential of this development.g, this project successfully addressed the complexity of DR detection and severity classification using diverse high-resolution retinal images. The methodology employed a dual-model approach, initially focusing on binary classification to distinguish between healthy and affected retinas, followed by multi-class classification to predict DR severity levels. Encoding categorical data and applying class weights ensured optimal model performance, particularly in handling imbalanced datasets and classifying severity accurately.
The fusion of InceptionResNetV2 and DenseNet121 architectures demonstrated remarkable outcomes, with the amalgamated model attaining an accuracy rate of 84.05% alongside well-balanced performance metrics like F1 score, recall, and precision, all hovering around the

ISSN 2815-0953
Vol: 04, No.02, Feb-Mar 2024
http://journal.hmjournals.com/index.php/JIPIRS
DOI: https://doi.org/10.55529/jipirs.42.30.40

83.50% mark. Notably, the system demonstrated resilience to real-world complexities, including image artifacts and exposure variations, ensuring robust performance in clinical settings.

In conclusion, this project's automated analysis system offers a reliable tool for early detection and intervention in diabetic retinopathy cases. By accurately categorizing retinal images into DR and severity levels, clinicians can make timely and personalized interventions, thus potentially preventing vision loss and improving patient outcomes. The integration of various CNN architectures, alongside thorough preprocessing and encoding methodologies, highlights the effectiveness and transformative potential of the system in revolutionizing the diagnosis and management of DR worldwide. Continued refinement and validation of this approach hold promise for further enhancing its clinical utility and impact in combating diabetic retinopathy's global burden.

6. REFERENCES

1. Doshi, Darshit, et al. "Diabetic retinopathy detection using deep convolutional neural networks." 2016 international conference on computing, analytics and security trends (CAST). IEEE, 2016.
2. Hemanth, D. Jude, Omer Deperlioglu, and Utku Kose. "An enhanced diabetic retinopathy detection and classification approach using deep convolutional neural network." Neural Computing and Applications 32 (2020): 707-721
3. Alyoubi, Wejdan L., Wafaa M. Shalash, and Maysoon F. Abulkhair. "Diabetic retinopathy detection through deep learning techniques: A review." Informatics in Medicine Unlocked 20 (2020): 100377
4. Tymchenko, Borys, Philip Marchenko, and Dmitry Spodarets. "Deep learning approach to diabetic retinopathy detection." arXiv preprint arXiv:2003.02261 (2020)
5. Qummar, Sehrish, et al. "A deep learning ensemble approach for diabetic retinopathy detection." Ieee Access 7 (2019): 150530-150539.
6. Khan, Zubair, et al. "Diabetic retinopathy detection using VGG-NIN a deep learning architecture." IEEE Access 9 (2021): 61408-61416.
7. Mushtaq, Gazala, and Farheen Siddiqui. "Detection of diabetic retinopathy using deep learning methodology." IOP conference series: materials science and engineering. Vol. 1070. No. 1. IOP Publishing, 2021.
8. Dutta, Suvajit, et al. "Classification of diabetic retinopathy images by using deep learning models." International Journal of Grid and Distributed Computing 11.1 (2018): 89-106
9. Tsiknakis, Nikos, et al. "Deep learning for diabetic retinopathy detection and classification based on fundus images: A review." Computers in biology and medicine 135 (2021): 104599.
10. Gao,Zhentao, et al. "Diagnosis of diabetic retinopathy using deep neural networks." IEEE Access 7 (2018): 3360-3370

