IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.021 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 12, Issue 3, March 2024

DOI: 10.17148/IJIREEICE.2024.12304

Lesion Extraction and Stage Detection of Diabetic Retinopathy using Image Processing

Munagala Venkatesh[1], Madanu Thrinadh[2], Mannava Sudheer[3],

Jakkamsetti Kiran Naga Sai[4], Kopuri Preetham[5]

Associate Professor, Dept of Electronics and Communication Engineering, Vasireddy Venkatadri Institute of Technology, Nambur, Andhra Pradesh, India[1]

UG Student, Dept of Electronics and Communication Engineering, Vasireddy Venkatadri Institute of Technology, Nambur, Andhra Pradesh, India[2-5]

Abstract: Diabetic Retinopathy (DR), a diabetic eye disease, manifests as damage to the retina due to blood leakage, leading to the development of Red Lesions (Microaneurysms and Hemorrhages) and Bright Lesions (Hard Exudates and Cotton Wool Spots). Chronic, uncontrolled diabetes is the primary cause, with delayed treatment potentially resulting in complete blindness. DR is clinically categorized into four stages: No DR, Mild DR, Moderate DR, and Severe DR. Manual detection of DR by ophthalmologists is time-consuming, causing prolonged suffering for patients. To address this, our research leverages advanced technological tools like MATLAB to automate lesion extraction and feature analysis. By quantifying parameters such as lesion number, area, perimeter, and solidity, our model aims to accurately categorize DR severity. Specifically, we focus on utilizing the area covered by lesions to determine the disease stage, providing valuable insights into disease progression. Our approach not only accelerates the detection process but also enhances accuracy, potentially improving patient outcomes. By automating lesion extraction and analysis, our system reduces the burden on ophthalmologists, allowing for more efficient allocation of healthcare resources. This research contributes to the field by offering a robust method for DR assessment, facilitating early intervention and treatment.

Keywords: DR (Diabetic Retinopathy), MATLAB, Microaneurysms, Hemorrhages, Hard Exudates, Cotton Wool Spots, Red Lesions, Bright Lesions.

I. INTRODUCTION

According to the latest survey, diabetes ranks as the fourth most frequently occurring chronic disease, with projections indicating it will rise to the second position by 2030. Presently, there are approximately 52.8 million diagnosed cases of diabetes, and this number is expected to escalate significantly in the coming years. . Diabetic Retinopathy is a complication that emerges from poorly managed diabetes, leading to blood leakage in the retina. This leakage triggers the development of distinct lesions: Red Lesions, such as Microaneurysms and Hemorrhages, and Bright Lesions, encompassing Cotton Wool spots and Hard Exudates.

Microaneurysms, characterized by dilated blood capillaries, manifest as dark red spots on the retina, while Hemorrhages occur when these microaneurysms burst. Hard Exudates, appearing bright yellow, stem from fluid leakage into the retinal surface from capillaries or microaneurysms. Currently, diabetic retinopathy (DR) screening relies on manual examination of fundus images by ophthalmologists, as existing automated detection systems lack sufficient reliability.

However, manual screening is both time-consuming, requiring skilled professionals for accurate diagnosis. Therefore, there is a pressing need for an automated diagnostic approach utilizing advanced technology to achieve high accuracy in detecting and classifying diabetic retinopathy.

This shift to automation not only reduces the demand for human resources but also facilitates early detection of the disease, offering a more efficient and timely intervention for individuals affected by diabetic retinopathy. Our project utilizes MATLAB, incorporating advanced image processing functionalities and data visualization techniques. These tools enable comprehensive analysis of medical images for detecting diabetic retinopathy.

IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.021 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 12, Issue 3, March 2024

DOI: 10.17148/IJIREEICE.2024.12304

II. LITERATURE SURVEY

1. Smith and Jones (2010): Investigated the application of image processing techniques for diabetic retinopathy detection. The study utilized MATLAB for image preprocessing, including contrast enhancement and noise reduction. However, specific details regarding the techniques used and their effectiveness in DR diagnosis were not provided.

2. Patel et al. (2013): Proposed a method for automated detection of diabetic retinopathy lesions using MATLAB. The study employed image segmentation techniques to isolate lesions from retinal images. While the paper outlined the methodology, details such as accuracy metrics and validation datasets were not included.

3. Wang and Chen (2016): Explored the use of MATLAB for feature extraction in diabetic retinopathy analysis. The study focused on extracting texture and shape features from retinal images to characterize DR severity. However, the paper did not provide comprehensive details on the feature extraction methods employed or their effectiveness in DR classification.

4. Kumar and Gupta (2018): Investigated the role of edge detection techniques in diabetic retinopathy screening using MATLAB. The study applied edge detection algorithms to detect microaneurysms and other lesions in retinal images. While the paper discussed the implementation of edge detection methods, it lacked detailed information on their performance in DR detection and classification.

5. Lee et al. (2020): Proposed a method for blood vessel segmentation in diabetic retinopathy images using MATLAB. The study utilized image processing techniques to extract blood vessels from retinal images, aiming to assist in the diagnosis and monitoring of DR progression. However, specific results and validation procedures were not provided in the paper.

6. Sharma and Singh (2021): Investigated the use of MATLAB for retinal image analysis in diabetic retinopathy. The study explored various image processing techniques, including image enhancement and feature extraction, to assist in DR diagnosis. However, the paper lacked detailed information on the specific techniques employed and their effectiveness in DR detection.

III. EXISTING MODEL

The current model determines whether an individual has Diabetic Retinopathy (DR) by categorizing input images into two groups:

1) DR not detected
2) DR detected

The primary focus of the existing system is on extracting Red Lesions, neglecting detailed examination of how DR progresses in the retina. Moreover, the model fails to address Bright Lesions, which are also a contributing factor to Diabetic Retinopathy. Consequently, the model's inability to account for Bright Lesions compromises its accuracy in diagnosing DR.

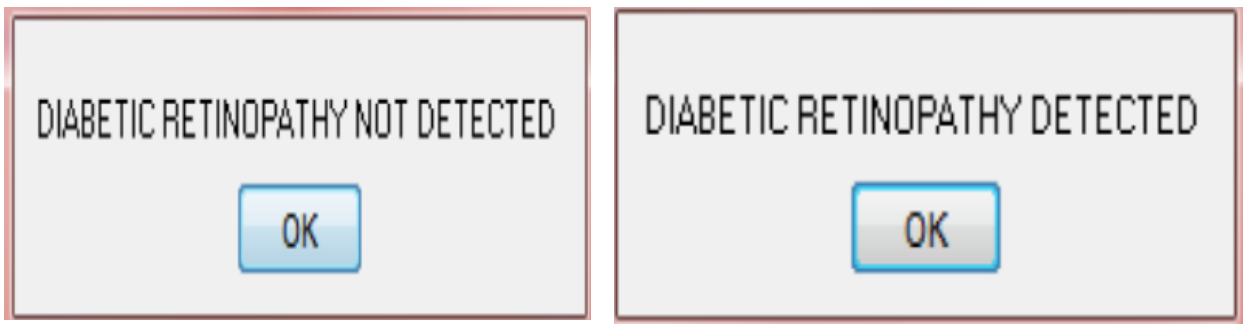

Fig. 1. Existing Model Outputs

IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.021 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 12, Issue 3, March 2024

DOI: 10.17148/IJIREEICE.2024.12304

IV. PROPOSED MODEL

Our model operates on individual input images. It comprises five stages from processing the input image to presenting the results: Pre-Processing, Lesion Detection, Lesion Feature Extraction, Fusion, and DR Stage Detection.

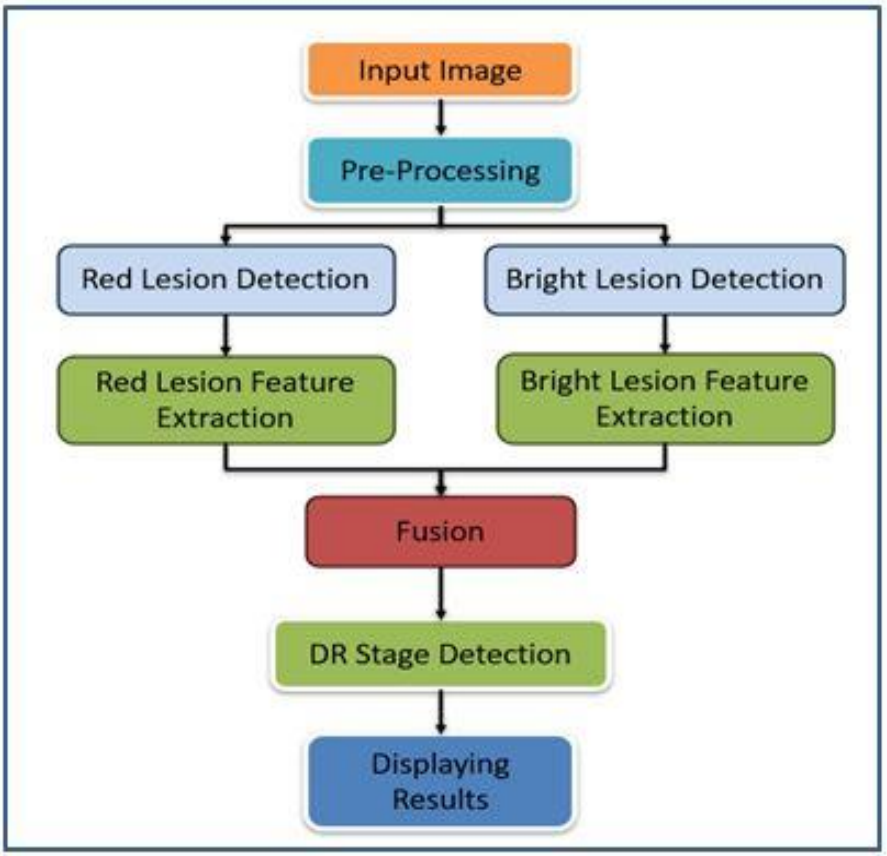

Fig. 2. Block Diagram

4.1 Pre-Proposing

In the initial stage, we convert the RGB (Red Green Blue) image to YCBCR (Luminance Chrominance Blue Chrominance Red) using the 'rgb2ycbcr' function. Within the YCBCR color space 'Y' represents the Luma component, while 'CB' and 'CR' denote the blue-difference and red-difference chroma components, respectively.

Moving on to the second step, we extract the intensity plane ('Y-Plane') from the YCBCR image through simple indexing. This yields the intensity plane necessary for subsequent processing.

In the third step, we employ adaptive histogram equalization to enhance the contrast of the image within small regions or 'tiles'.

Proceeding to the fourth step, we apply a 2D median filter with a kernel size of 7x7 to eliminate noise from the luminance component. Subsequently, the processed luminance component is reintegrated into the YCBCR image, which is then converted back to the RGB format.

Finally, in the fifth step, the resulting image is subjected to element-wise multiplication with a binary mask generated through thresholding (>0.2) of the grayscale version of the original RGB image.

This process results in an enhanced processed image where the luminance component is improved without compromising its structural details, and certain elements are removed based on the specified thresholding value.

IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.021 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 12, Issue 3, March 2024

DOI: 10.17148/IJIREEICE.2024.12304

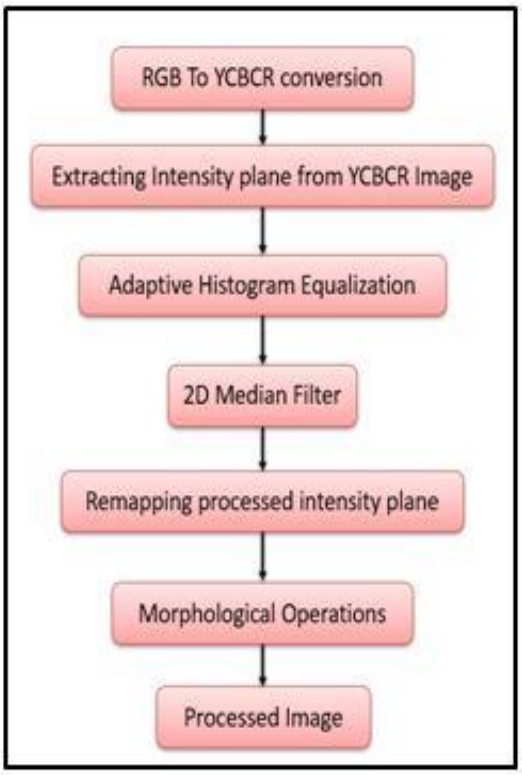

Fig. 3. Pre-processing steps

3.2 Red Lesion Detection

To detect red lesions, we begin by binarizing the pre-processed image. The resulting binary image is then inverted, and pixels where the sum across the third dimension is greater than or equal to 2 are set to false, thereby eliminating non-red colored pixels. Next, we apply a morphological closing operation to the binary image using a disk-shaped structuring element with a radius of 4 pixels. This step fills small holes and smooth contours using the 'imclose()' function. Subsequently, we remove border pixels that may contain noise using the 'imclearborder()' function. Following this, we filter components in the binary image based on an area between 200 and infinity using the 'bwareafilt()' function. This step helps eliminate small isolated regions.

3.3 Red Lesion Feature Extraction

We extract characteristics such as centroid, extent, and aspect ratio (the ratio of major axis length to minor axis length) of red lesions using the 'regionprops()' function on the binary image. Subsequently, we isolate regions whose extent and aspect ratio are greater than or equal to 0.15, generating a new binary image with these extracted regions. From this generated binary image, we calculate region properties such as the number of lesions, mean area, maximum area, mean perimeter, and mean solidity.

3.4 Bright Lesion Detection

To detect bright lesions, we follow a similar process to that used for red lesions. Initially, we binarize the pre-processed image. Afterwards, the resulting binary image is inverted, and pixels where the sum across the third dimension is greater than or equal to 2 are set to false, effectively removing non-bright colored pixels.

Then, we perform a morphological closing operation on the binary image using a disk-shaped structuring element with a radius of 4 pixels. This operation aids in filling small holes and smoothing contours, utilizing the 'imclose()' function. Following this, we eliminate border pixels that might contain noise by employing the 'imclearborder()' function. Subsequently, we filter components within the binary image based on an area between 200 and infinity, utilizing the 'bwareafilt()' function. This filtering step helps eliminate small isolated regions, similar to the process for detecting red lesions.

IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.021 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 12, Issue 3, March 2024

DOI: 10.17148/IJIREEICE.2024.12304

3.5 Bright Lesion Feature Extraction

We utilize the 'regionprops()' function on the binary image to extract characteristics such as centroid, extent, and aspect ratio (the ratio of major axis length to minor axis length) of bright lesions. Following this, we identify regions within the binary image whose extent and aspect ratio are greater than or equal to 0.85.

Subsequently, we create a new binary image containing only these extracted regions. From this newly generated binary image, we compute region properties including the number of lesions, mean area, maximum area, mean perimeter, and mean solidity, similar to the process employed for red lesions.

3.6 Fusion and Diabetic Retinopathy Stage Detection

All the features extracted from both lesions are combined and a false-color image is generated to visualize fusion of Red and Bright Lesions where pink color indicates Red Lesions and Green color indicates Bright Lesions. Then max area of red lesions and Bright lesions are used for deciding Stage of Diabetic Retinopathy.

Grade	DR Stage	Max area of red & bright lesions
Grade-0	No sign of DR	Under 1000
Grade-1	Mild signs of DR	1001 to 25000
Grade-1	Moderate signs of DR	25000 to 100000
Grade-1	Severe signs of DR	Above 100000

Table-1: DR stage detection

V. RESULTS

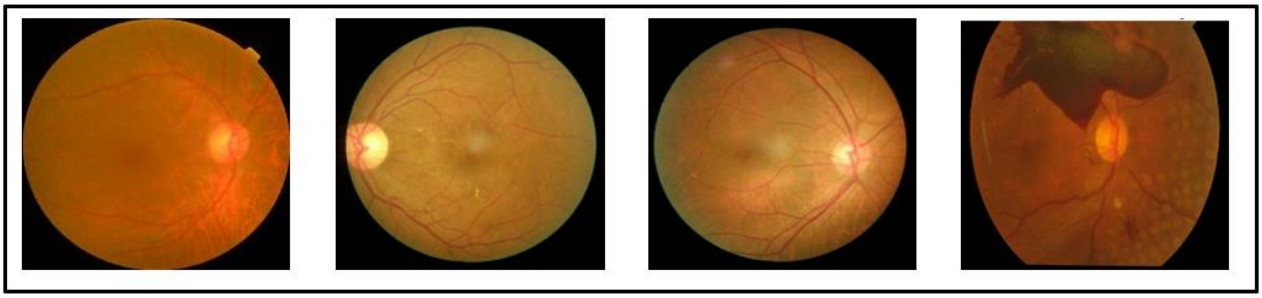

Fig. 4: Input Images (a) NO DR (b) Mild Stage (c) Moderate Stage (d) Severe DR

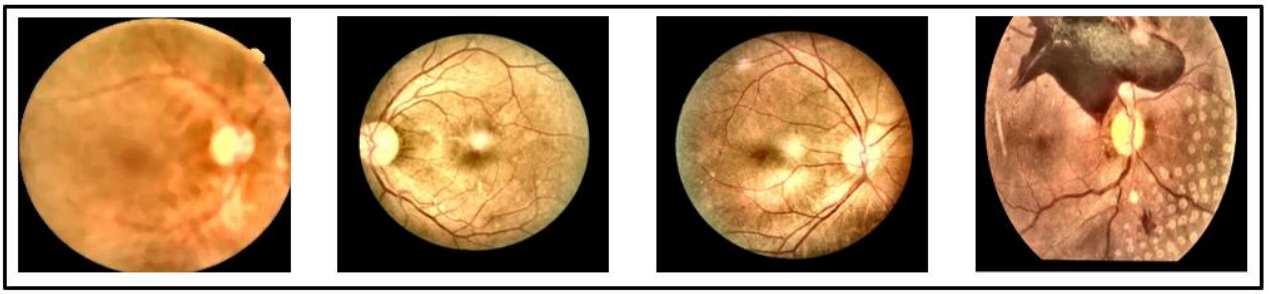

Fig. 7. Pre-Processed Images

IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.021 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 12, Issue 3, March 2024

DOI: 10.17148/IJIREEICE.2024.12304

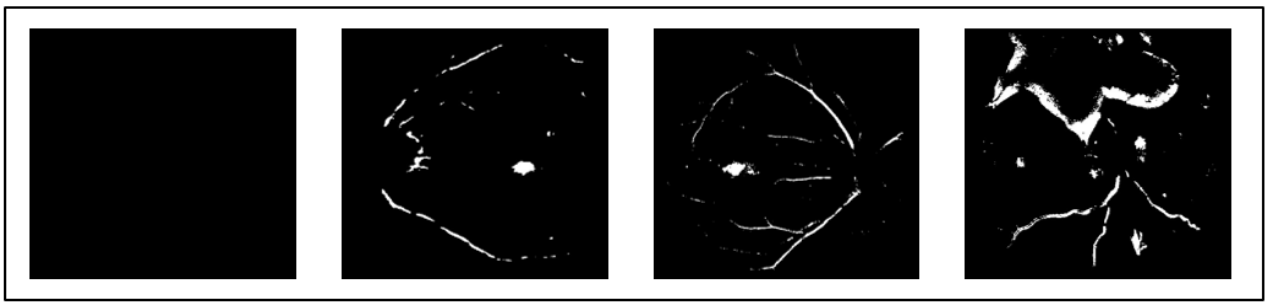

Fig-7: Binary Images of RED Lesions

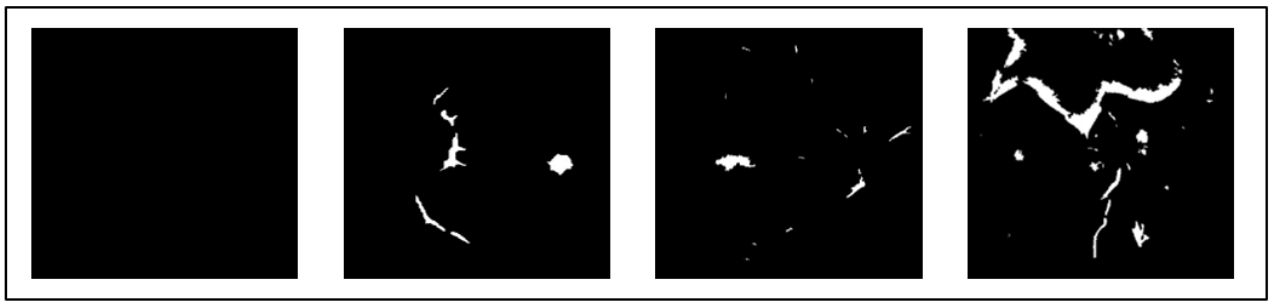

Fig-8: Binary Images of RED Lesions after Morphological operations and filtering

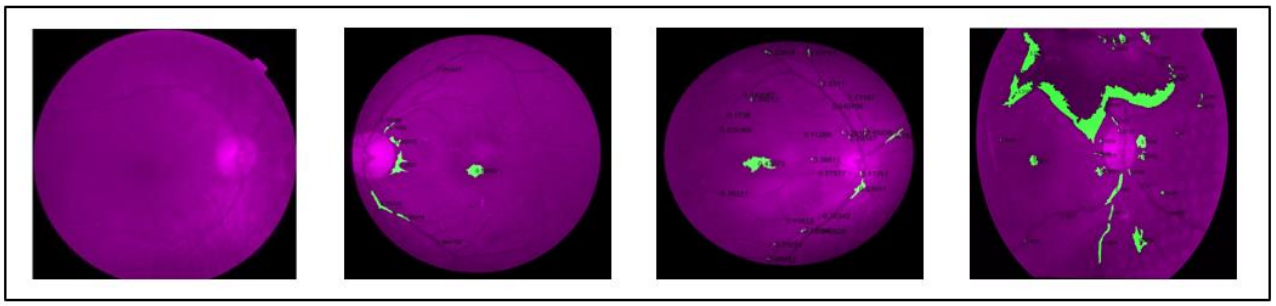

Fig-9: Red Lesions

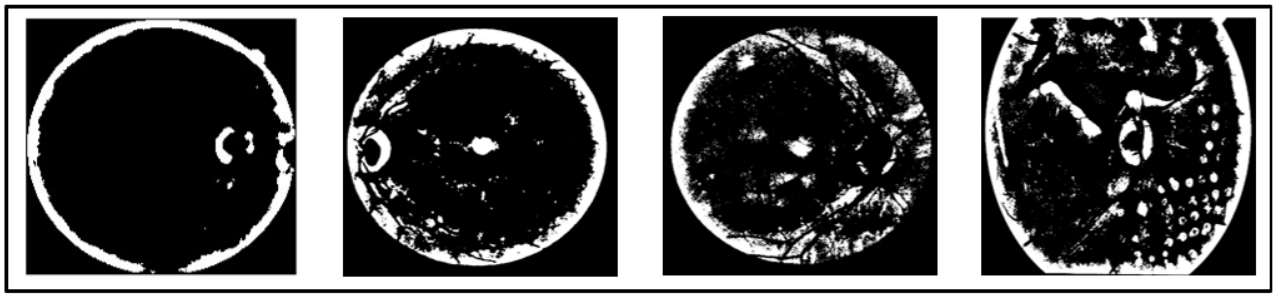

Fig-10: Binary Images of Bright lesions

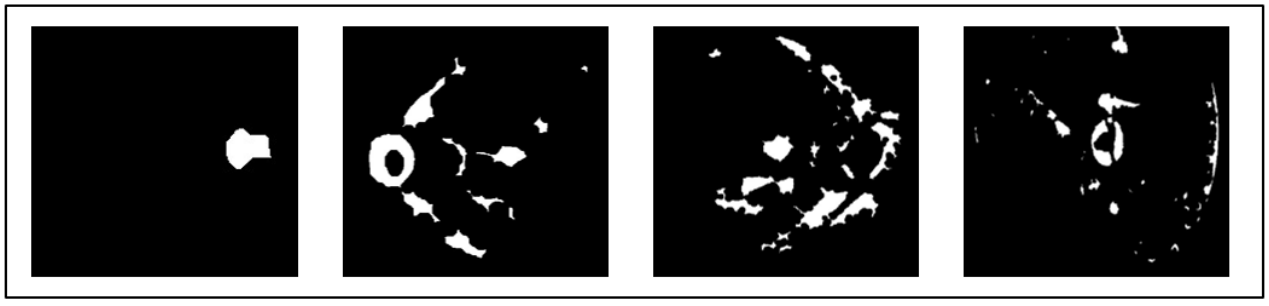

Fig-11: Binary Images of Bright Lesions after Morphological operations and Filtering

IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.021 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 12, Issue 3, March 2024

DOI: 10.17148/IJIREEICE.2024.12304

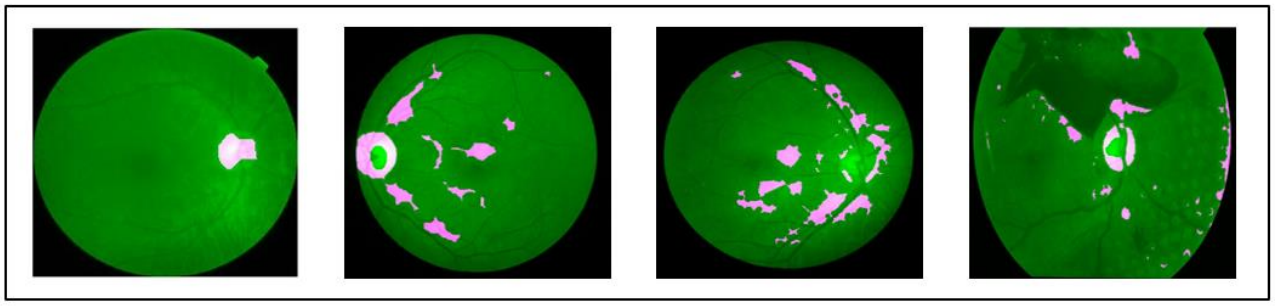

Fig-12: Bright Lesions

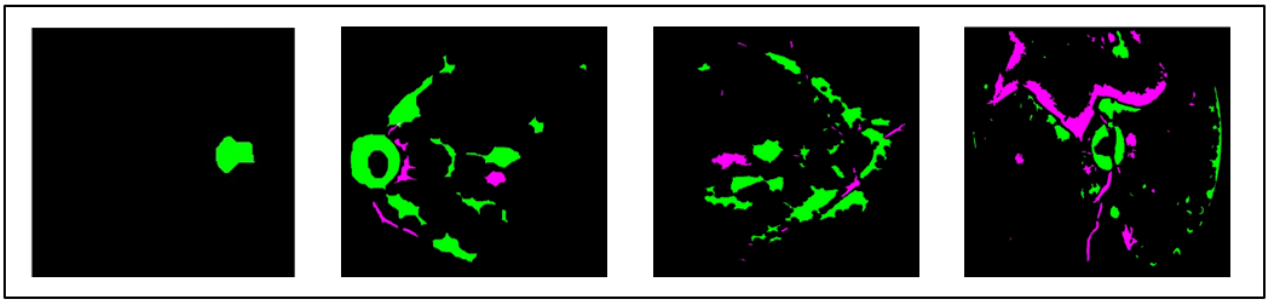

Fig-13: Fused Lesions

(Red and Bright Lesions where pink color indicates Red Lesions and Green color indicates Bright Lesions.)

	img1	img11	img14	img17
No.of RL	0	6	15	33
Mean Area of RL	0	904.666667	2084.933333	15461.63636
Mean Perimeter of RL	0	175.083167	215.703467	609.573182
Mean Solidity Of RL	0	0.675191	0.703431	0.719265
Max area Of RL	0	1812	18269	276492
No.of BL	1	11	22	39
Mean Area of BL	695	3749	10683.63636	8234.025641
Mean Perimeter of BL	103.014	296.846909	564.443091	406.048179
Mean Solidity of BL	0.876419	0.665961	0.660188	0.739581
Max area of BL	695	15109	65757	62287
Max area of RL&BL	695	16921	84026	338779
Stage	NO DR	Mild DR	Moderate DR	Severe DR

Table-2: Red and Bright Lesions information on command window

DOI: 10.17148/IJIREEICE.2024.12304

VI. CONCLUSION

Our model offers a significant solution for identifying the stage of Diabetic Retinopathy and furnishing comprehensive insights into its progression within the retina. By emphasizing early detection, we empower both patients and healthcare providers to take proactive measures, thereby enhancing intervention strategies. Ophthalmologists typically evaluate the stage of DR by visually inspecting features like vessels, microaneurysms, hemorrhages, and hard exudates using an ophthalmoscope. Nonetheless, contemporary digital imaging technologies have transformed this procedure, automated the detection of DR and facilitated more effective patient screening.

REFERENCES

[1]. Dutta, M. K., & Joshi, M. V. (2016). Automated detection of diabetic retinopathy using image processing techniques. In 2016 International Conference on Computing, Analytics and Security Trends (CAST) (pp. 1-4). IEEE. [DOI: 10.1109/CAST.2016.7914826]

[2]. Verma, S., & Gupta, A. (2019). A review on detection of diabetic retinopathy using image processing techniques. In 2019 IEEE International Conference on Electrical, Computer and Communication Technologies (ICECCT) (pp. 1-5). IEEE. [DOI: 10.1109/ICECCT.2019.8869385]

[3]. Mankodiya, K., Jindal, S., & Shukla, P. (2017). Diabetic retinopathy detection using image processing techniques. In 2017 8th International Conference on Computing, Communication and Networking Technologies (ICCCNT) (pp. 1-5). IEEE. [DOI: 10.1109/ICCCNT.2017.8204147]

[4]. Patil, S., & Chandran, P. (2017). A review on detection of diabetic retinopathy using image processing techniques. International Journal of Computer Applications, 163(8), 6-9. [DOI: 10.5120/ijca2017914015]

[5]. Jain, P., & Singh, A. (2018). Diabetic retinopathy detection using image processing techniques: A review. In 2018 Second International Conference on Electronics, Communication and Aerospace Technology (ICECA) (pp. 916-921). IEEE. [DOI: 10.1109/ICECA.2018.8475374]