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DETECTION OF DIABETIC RETINOPATHY WITH GROUND TRUTH SEGMENTATION USING FUNDUS IMAGE OF EYE IN DEEP LEARNING

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Abstract: The condition of the vascular network of the human eye is an important diagnostic factor in retinopathy. Its segmentation in fundus imaging is a nontrivial task due to the variable size of vessels, relatively low contrast, and potential presence of pathologies like microaneurysm and hemorrhages. The Project proposes the Retinal image analysis through efficient detection of vessels and exudates for retinal vasculature disorder analysis. It plays an important role in the detection of some diseases in their early stages, such as diabetes, which can be performed by comparison of the states of retinal blood vessels. Intrinsic characteristics of retinal images make the blood vessel detection process difficult. Here, we proposed a new algorithm to detect the retinal blood vessels effectively. The green channel will be selected for image analysis to extract vessels accurately. The Daubechies wavelet transform is used to enhance the image contrast for effective vessel detection. To increase the efficiency of the morphological operators by reconstruction, they were applied using multi-structure elements. A simple thresholding method along opening and closing indicates the remained ridges belonging to vessels. The experimental result proves that the blood vessels and exudates can be effectively detected by applying this method to the retinal images.

Keywords: Diabetic retinopathy, Pre-processing, Feature extraction, Classification, Discrete curvelet transform, Global contrast normalization, Digital image processing, Artificial neural network, Neural network classifier.

I. INTRODUCTION

Diabetic retinopathy (DR) is a serious and potentially sight-threatening complication of diabetes. It is caused by damage to the blood vessels in the retina, which can lead to vision loss or blindness if left untreated. Early detection and treatment of DR are crucial for preventing vision loss, but traditional methods of screening are time-consuming and require trained ophthalmologists.

In recent years, deep learning has shown great promise in automating the detection and diagnosis of DR. In particular, the use of fundus images of the eye has become a popular approach for DR detection, as these images provide a non-invasive and easily accessible way to examine the retina.

In this project, we aim to develop a deep learning model for the detection of DR using fundus images of the eye. Our approach will involve the use of ground truth segmentation, which will allow for more accurate detection of DR by identifying the specific regions of the retina that are affected by the disease.

We will train and evaluate our model on a large dataset of fundus images with ground truth segmentation, using state-of-the-art deep learning techniques such as convolutional neural networks (CNNs) and transfer learning. Our goal is to develop a highly accurate and efficient DR detection system that can be used in clinical settings to improve the diagnosis and treatment of this important complication of diabetes.

The proposed system has the potential to improve the accuracy and efficiency of DR screening, leading to earlier detection and treatment, and ultimately improving the quality of life for people with diabetes. This project has significant implications for public health and can have a positive impact on the global burden of diabetic retinopathy.

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II. RELATED WORKS

The previous researchers have conducted research on deep learning techniques related to Diabetic Retinopathy, and highlights a specific related work by authors Safi H, Safi S, Hafezi-Moghadam A, Ahmadieh H (2018). This work provides guidance on identifying the initial symptoms of DR disease with the help of an ophthalmologist. The statement also notes that light-based molecular imaging in rodents has been suggested as an early sign of diabetic retinopathy.[1].

The Deep learning techniques are more commonly used in medical image analysis, and that a review and analysis of recent methods for detecting and classifying diabetic retinopathy using deep learning was conducted by Alyoubi WL in (2020). The study provides insights into the use of deep learning in this domain for improved accuracy and efficiency.[2]. The dataset generated will be useful for ophthalmologists and researchers to work on automatic detection algorithms for diabetic retinopathy. Specifically, it will help to detect Non Proliferative Diabetic Retinopathy (Npdr) and Proliferative Diabetic Retinopathy (Pdr) using fundus image. The author of this statement is Benítez VE and the year of publication is 2021.[3]

The Early Treatment Diabetic Retinopathy Study Research Group, and it suggests that implementing a double grading system can improve reproducibility for most characteristics when measuring various aspects of diabetic retinopathy, such as retinal hemorrhages or microaneurysms, hard exudates, new vessels, fibrous proliferations, macular edema, soft exudates, intraretinal microvascular abnormalities, and venous beading.[4]. Wan S, Liang Y, and Zhang Y (2018) achieved a classification accuracy of 95.68% in diabetic retinopathy image classification using CNNs and transfer learning. This information may be useful in developing an automated system for detecting diabetic retinopathy.[5]

The system proposed by O.Sule and S. Viriri(2020), enhancement techniques are applied to input images at the data pre-processing stage to enhance brightness and visibility before passing them to CNN for segmentation. Additionally, the proposed system aims to enhance retinal images to track blood vessels and measure accuracy, sensitivity, specificity, and the area under the ROC curve.[6]. This paper introduces a new urban point cloud dataset for automatic segmentation and classification acquired by mobile laser scanning (MLS) by Roynard X, Deschaud JE (2018).

This system helps to improve the classification of image using ground truth segmentation techniques in our project.[7]. “A supervised learning-based approach using artificial neural network has been proposed to achieve more accurate diagnoses outcomes for the case of diabetic retinopathy” by Chakraborty S, Jana GC.(2020). The ANN architecture used in this work is feed forward back propagation neural network. Accuracy obtained for the proposed method is found to be 97.13%.[8]. “A novel method to detect hard exudates with high accuracy with respect to lesion level can play an important role in detection or screening of diabetic retinopathy” by K. K. Palavalasa and B. Sambaturu(2018). It helps to a proposed novel method to detect hard exudates with high accuracy with respect to lesion level[9].

Frequency domain transformation methods used widely in Digital Image Compression and Digital Image Watermarking by Asmara RA, Agustina R (2017).

The experiments are comparison analysis of image watermark quality using Peak Signal to Noise Ratio (PSNR), color converting, image resizing, image optical scanning and the noise-tolerant of the image watermarked by giving Gaussian noise.It helps to converts the noisy digital image into different compression as per the requirement.[10]

III. EXISTING SYSTEM

In existing models, Edge detection is a well-developed field on its own within image processing. Region boundaries and edges are closely related, since there is often a sharp adjustment in intensity at the region boundaries. Edge detection techniques have therefore been used as the base of another segmentation technique. The edges identified by edge detection are often disconnected.

To segment an object from an image however, one needs closed region boundaries. Image segmentations are computed at multiple scales in scale-space and sometimes propagated from coarse to fine scales; see scale-space segmentation. Segmentation criteria can be arbitrarily complex and may take into account global as well as local criteria. A common requirement is that each region must be connected in some sense.

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IV. PROPOSED SYSTEM

1. "In our proposed system, we used the second generation of curvelet transform, discrete curvelet transform (DCT), and modified the DCT coefficients by a suitable nonlinear function."
2. "One way to increase the image contrast is to enhance the image ridges, which play an important role in enhancing image contrast.
3. "Then, morphological opening by reconstruction helps to remove the detected ridges not belonging to the vessel tree while preserving the thin vessel edges."
4. "There is a restriction on size of structure elements (SEs) concerning the blood vessels diameter."
5. "In order to act locally, image is decomposed to several tiles and CCA, and length filtering is individually applied to each tile."

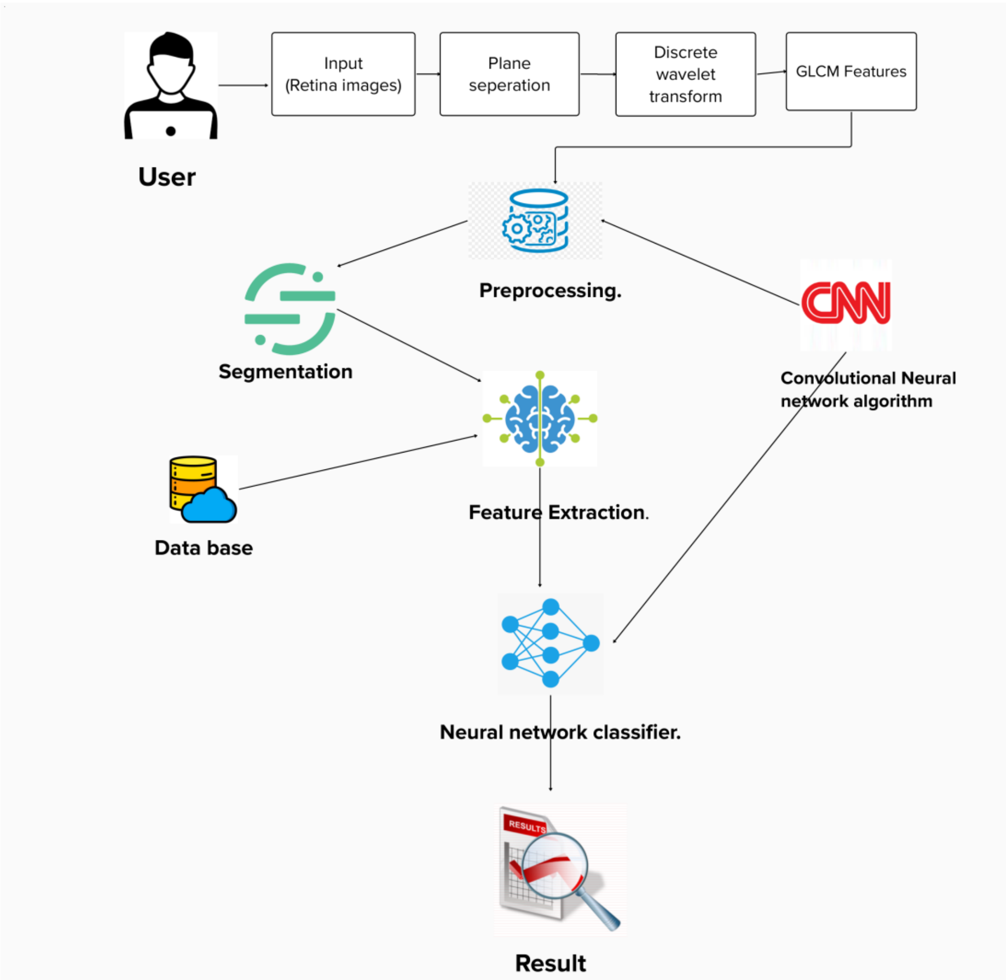

Fig 1. System Architecture Diagram

V. MODULES

1. Pre-processing
2. Feature Extraction
3. Discrete Wavelet Transform
4. Segmentation
5. Neural Network classifier

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Pre-processing

Image pre-processing is the general name for image processing at the lowest level of abstraction. Its input and output are using images. The purpose of pre-processing is to improve image data, limit distortion, or improve some important image features for further processing. Image correction is the process of taking a bad/noisy image and guessing the original image. Corruption can take many forms, including business blur, noise, and camera misfocusing.Image restoration differs from image enhancement, which aims to highlight the features of the image and make it interesting to the observer, but does not necessarily constitute actual data from a scientific point of view. Image enhancement methods provided by image processing packages, such as enhancing contrast or deblurring nearest-neighbor processes, do not use a predefined model of the process that produced the image. Image enhancement noise can be effectively eliminated at the cost of some resolution, but this is unacceptable for many applications. The resolution in the z direction in fluorescence microscopy is poor. To process objects, more rendering methods must be used. An example of image processing is deconvolution. It can increase resolution, remove noise, and improve contrast, especially in the axial direction

Feature Extraction

Feature extraction is a critical step in deep learning-based approaches for image analysis tasks such as diabetic retinopathy (DR) detection. It involves transforming the raw image data into a set of relevant features that capture the important characteristics of the image. This is achieved through the use of pre-trained convolutional neural networks (CNNs) that have been trained on large datasets of images for different tasks. The pre-trained CNNs are fine-tuned on a smaller subset of labeled data to adapt them to the specific task of DR detection and segmentation. The fine-tuned CNN is then used to extract features from the fundus images, producing a high-dimensional representation of the image known as the feature map. This feature map is used as input for subsequent classification and segmentation stages.The advantage of using pre-trained CNNs is that they can extract powerful features that have been learned from a large dataset of images, which reduces the need for hand-crafted features. Fine-tuning the pre-trained CNN allows it to adapt to the specific task of DR detection and segmentation. The resulting feature map captures the relevant information in the image for the task at hand, which improves the accuracy of the subsequent classification and segmentation stages. The use of CNNs and fine-tuning for feature extraction has shown promising results in detecting and segmenting DR from fundus images.

Discrete Wavelet Transform

The Discrete Wavelet Transform (DWT) is a mathematical tool that is used to decompose a signal into different frequency bands. Unlike the Fourier Transform, which decomposes a signal into a set of sinusoidal basis functions, DWT decomposes a signal into a set of wavelets that are localized in both time and frequency domains. This localization property of wavelets makes them particularly useful in signal processing applications. The DWT is implemented using a filter bank. The signal is passed through a set of filters, which separate the signal into different frequency bands. The resulting signals are then down-sampled to reduce their size. This process is repeated iteratively until the desired level of decomposition is achieved. DWT has found numerous applications in signal processing, image processing, and data compression. In signal processing, DWT is used for noise reduction, signal denoising, and feature extraction. In image processing, DWT is used for image compression, image denoising, and edge detection. In data compression, DWT is used for compressing audio and video signals.

Segmentation

In computer vision, segmentation refers to the process of dividing a virtual image into segments (groups of pixels, also known as superpixels) . The purpose of segmentation is to simplify the representation of an image and/or replace it with something more meaningful and easy to define. Image segmentation is mainly used to find objects and obstacles (lines, curves, etc.) in pixels. More precisely, image segmentation is the process of assigning a label to each pixel in an image such that pixels with the same label have a particular appearance.The result of image segmentation is a hard and fast segment that together covers the entire image or a set of subtracted images (see the detection section). Each pixel in a scene is similar to a specific or included feature, including color, density, or texture. Neighborhoods are different but work the same way.

Neural Network Classification

The classifier module is an essential component of the proposed approach for detecting Diabetic Retinopathy (DR) using ground truth segmentation of fundus images. It uses a deep neural network, which is trained on a large dataset of labeled fundus images, to classify the presence and severity of DR based on the segmented regions of interest.

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The architecture of the deep neural network used in the classifier module is typically a convolutional neural network (CNN), which is well-suited to image classification tasks due to its ability to learn spatial hierarchies of features. The training of the deep neural network involves optimizing the network's weights to minimize the difference between the predicted output and the ground truth labels, using a loss function such as cross-entropy loss.Once the deep neural network is trained, it can be used to classify new fundus images by feeding the segmented regions of interest as input and computing the output probability scores for the presence and severity of DR. The accuracy and reliability of the classifier module's results depend on the deep neural network's architecture and training, making these critical factors in the overall success of the proposed approach.

VI. RESULTS AND DISCUSSION

The goal of this study is to employ Matlab technology and deep learning approaches to identify diabetic retinopathy. In the suggested method, retinal blood vessels and lesions in fundus pictures are automatically segmented using a convolutional neural network (CNN). The network architecture's main purpose is to predict the presence of diabetic retinopathy by learning characteristics from the input image. The trained image is subjected to many degrees of sorting, such as scaling the image to make it fit into a specified format and size. To make it easier to calculate the features of the retina image, the RGB color image is converted to a grayscale image.The mathematical method known as DWT is frequently employed in the analysis of digital signals and images. In this project, the fundus image is broken down into its many frequency components using DWT. The high-frequency components, which reflect the image details, are eliminated while the low-frequency components, which describe the image's overall structure and shape, are used for further processing. The extraction of image characteristics using DWT is more effective and efficient than standard approaches, which can increase the precision of diabetic retinopathy segmentation and identification. The preprocessing module's job is complete, and segmentation work is now moving forward. The vessels have been classified as abnormal and have the color white (damaged vessel).

An Artificial Neural Network (ANN) classifier is employed in this project to categorize fundus images as normal or pathological. The Convolutional Neural Network (CNN) algorithm is used to build the classifier. This algorithm has been trained with a set of input photos to learn the features associated with diabetic retinopathy. Depending on the presence or absence of specific traits, the model can accurately predict whether a new image is normal or abnormal once it has been trained. This method makes it possible to automatically and precisely identify diabetic retinopathy in fundus pictures, which can aid in the early detection and treatment of the condition.

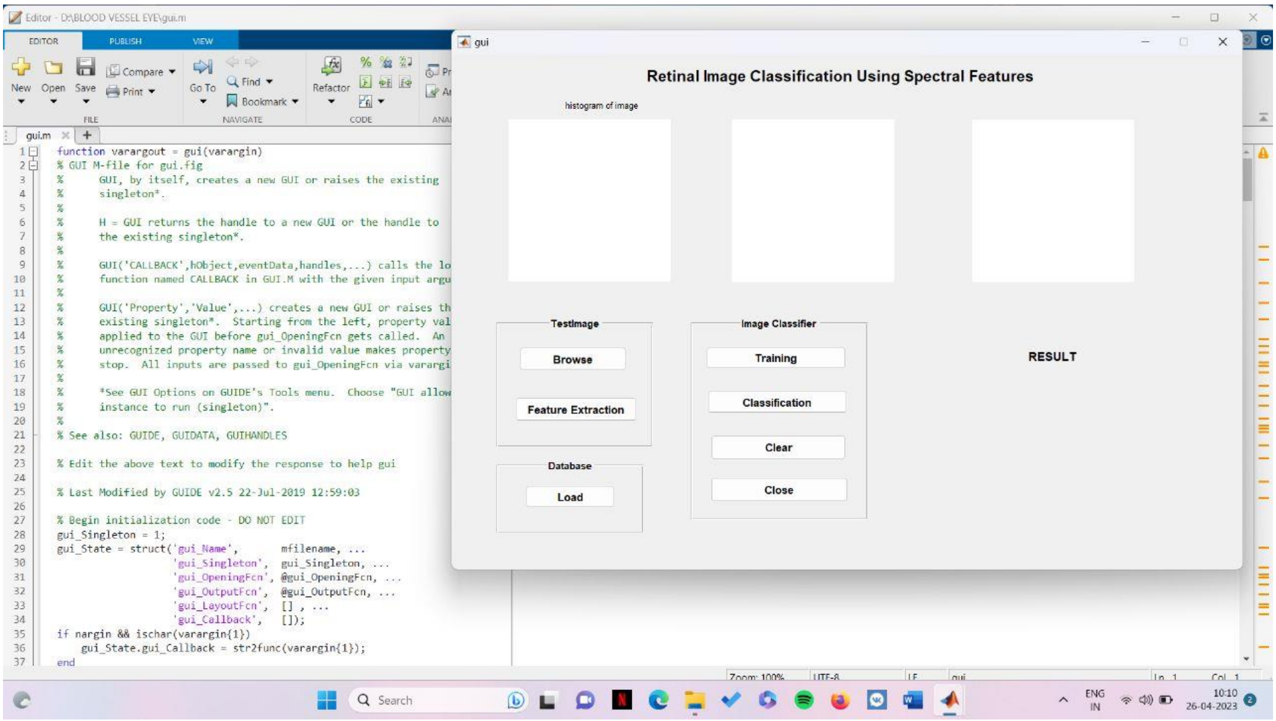

Fig. 2 User Interface for the detection of the diabetic retinopathy

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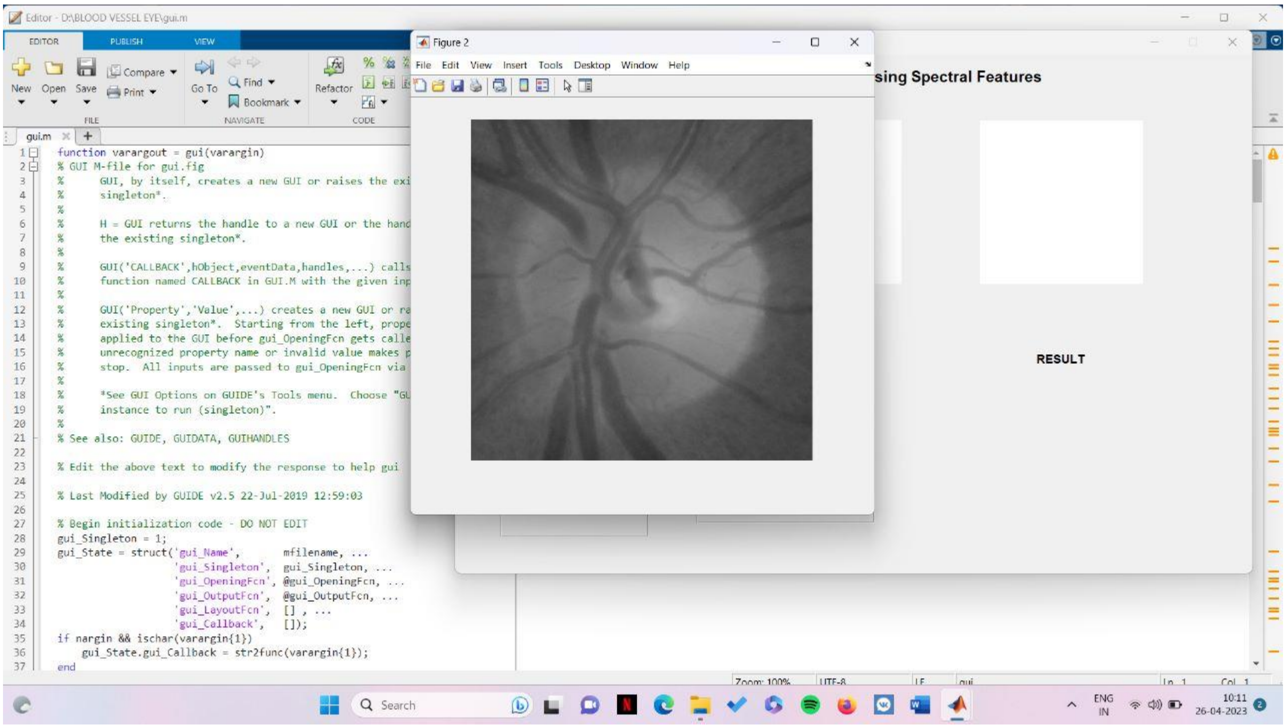

Fig. 3 Browsing the Fundus image of the eye

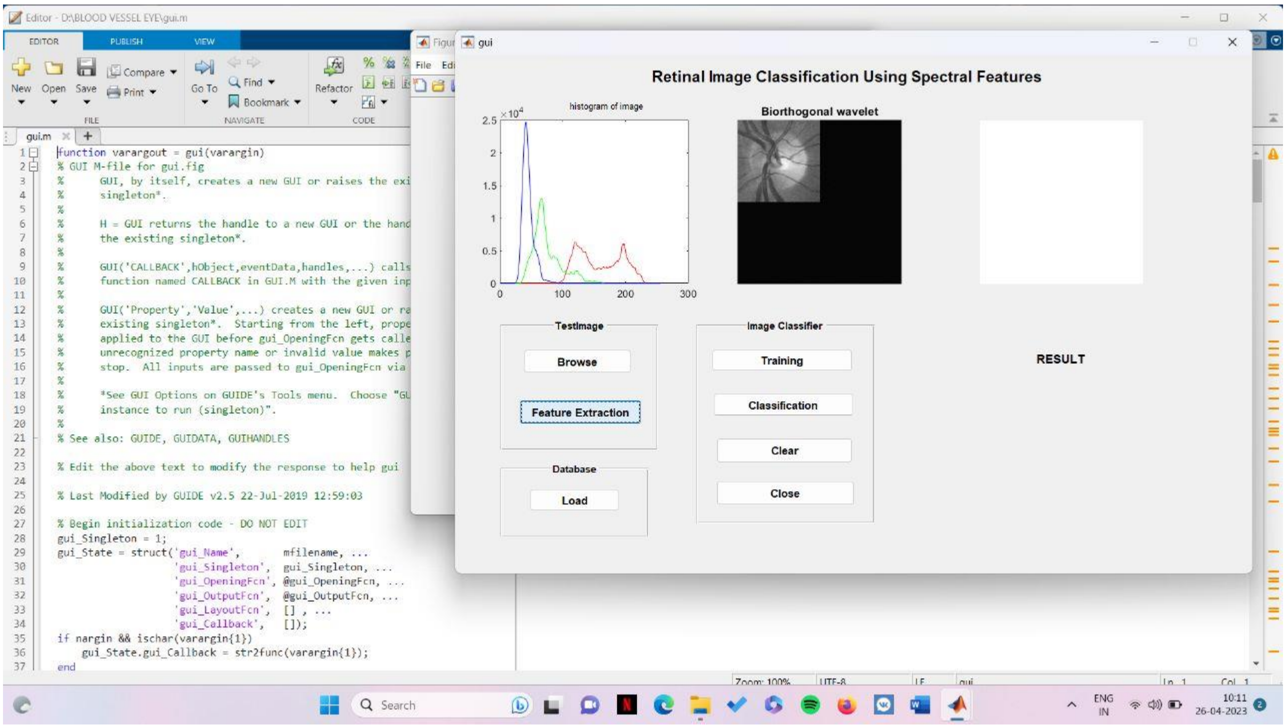

Fig. 4 Implementing the Feature Extraction

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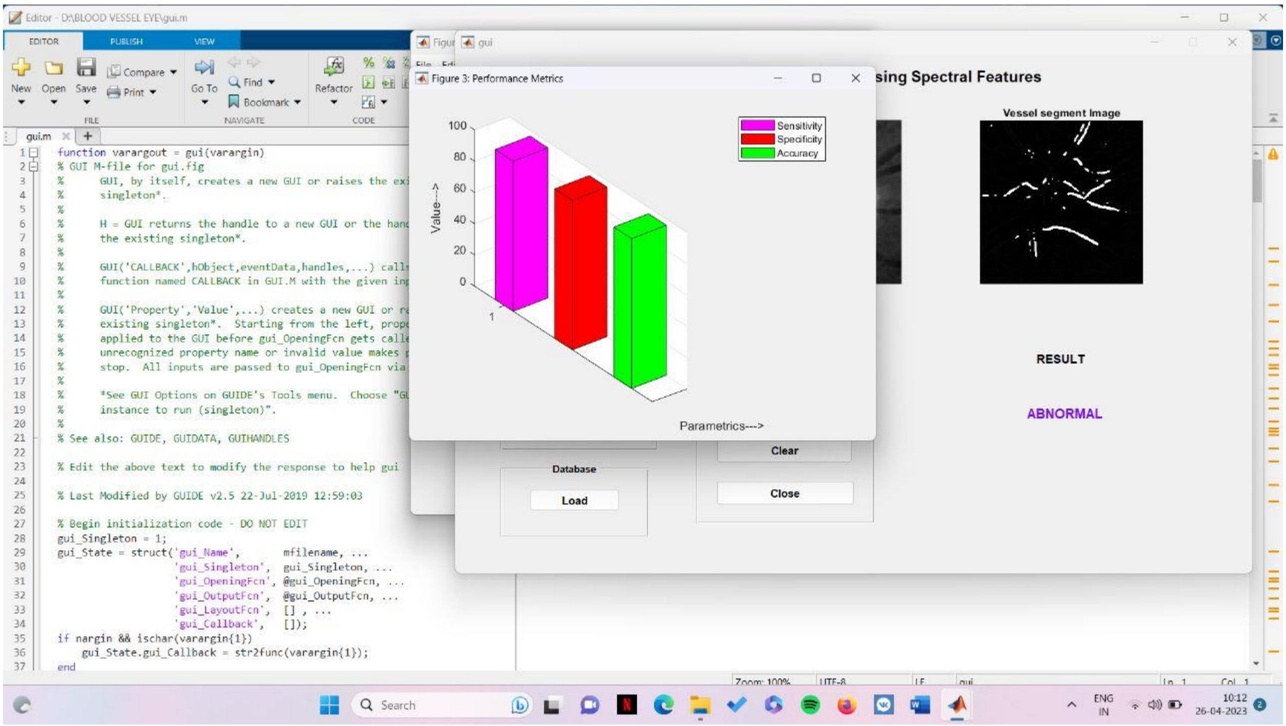

Fig 5. Performance metrics of the Diabetic retinopathy

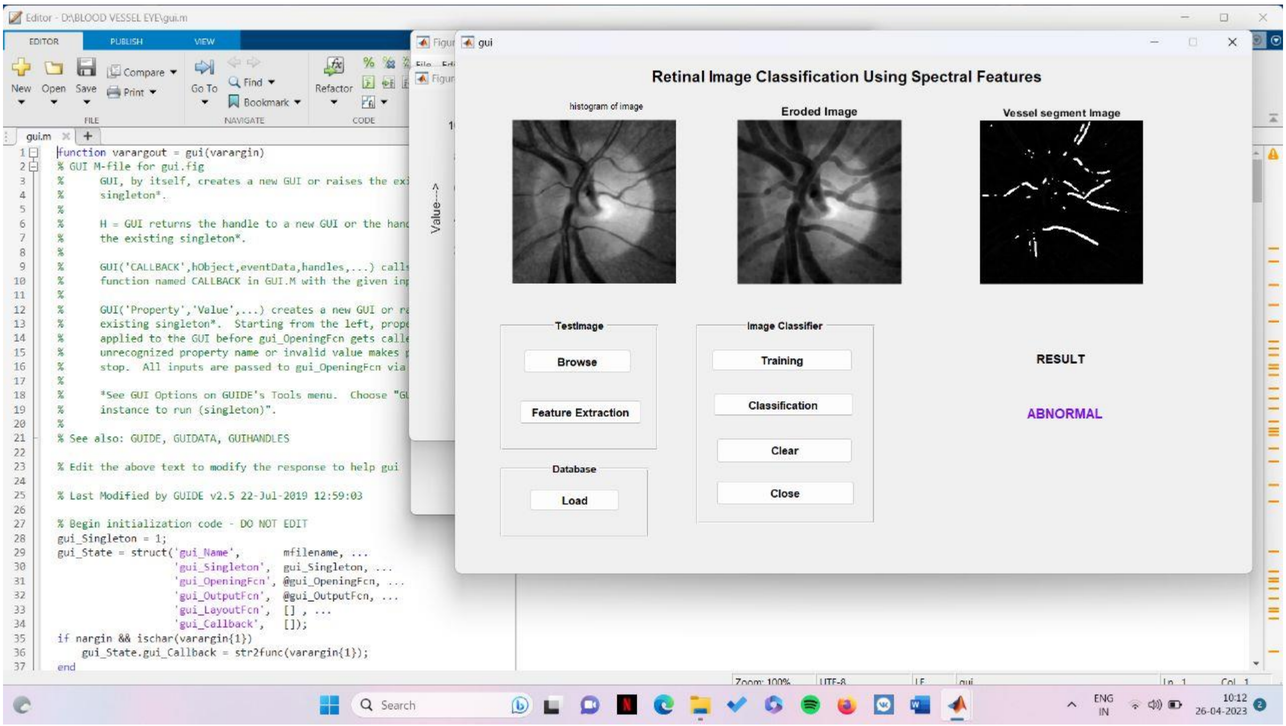

Fig 6. User interface for the detection

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VII. CONCLUSION

The project focuses on detecting and extracting features of diabetic retinopathy, including red lesion, exudates, blood vessel, and optic nerve, to determine if a patient is normal or abnormal. A novel CNN model with a Siamese-like architecture is used to automatically detect RDR using binocular fundus images, achieving high performance with an AUC of 0.951 and a sensitivity of 92.2%. The presented model has potential for detecting other ophthalmic diseases, but further improvements can still be made.

REFERENCES

[1] Safi H, Safi S, Hafezi-Moghadam A, Ahmadieh H. Early detection of diabetic retinopathy. Survey of ophthalmology. 2018 Sep 1;63(5):601-8.
[2] Alyoubi WL, Shalash WM, Abulkhair MF. Diabetic retinopathy detection through deep learning techniques: A review. Informatics in Medicine Unlocked. 2020 Jan 1;20:100377.
[3] Benítez VE, Matto IC, Román JC, Noguera JL, García-Torres M, Ayala J, Pinto-Roa DP, Gardel-Sotomayor PE, Facon J, Grillo SA. Dataset from fundus images for the study of diabetic retinopathy. Data in brief. 2021 Jun 1;36:107068.
[4] Early Treatment Diabetic Retinopathy Study Research Group. Grading diabetic retinopathy from stereoscopic color fundus photographs—an extension of the modified Airlie House classification: ETDRS report number 10. Ophthalmology. 2020 May 1;98(5):786-806.
[5] Wan S, Liang Y, Zhang Y. Deep convolutional neural networks for diabetic retinopathy detection by image classification. Computers & Electrical Engineering. 2018 Nov 1;72:274-82.
[6] O.Sule and S. Viriri, "Enhanced Convolutional Neural Networks for Segmentation of Retinal Blood Vessel Image," 2020 Conference on Information Communications Technology and Society (ICTAS), Durban, South Africa, 2020, pp. 1-6,
[7] Roynard X, Deschaud JE, Goulette F. Paris-Lille-3D: A large and high-quality ground-truth urban point cloud dataset for automatic segmentation and classification. The International Journal of Robotics Research. 2018 May;37(6):545-57.
[8] Chakraborty S, Jana GC, Kumari D, Swetapadma A. An improved method using supervised learning technique for diabetic retinopathy detection. International Journal of Information Technology. 2020 Jun;12:473-7.
[9] K. K. Palavalasa and B. Sambaturu, "Automatic Diabetic Retinopathy Detection Using Digital Image Processing," 2018 International Conference on Communication and Signal Processing (ICCSP), Chennai, India, 2018, pp. 0072-0076, doi: 10.1109/ICCSP.2018.8524234.
[10] Asmara RA, Agustina R. Comparison of discrete cosine transforms (DCT), discrete Fourier transforms (DFT), and discrete wavelet transforms (DWT) in digital image watermarking. International Journal of Advanced Computer Science and Applications. 2017;8(2).