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REGION BASED SEGMENTATION METHOD IN DIABETIC RETINOPATHY USING RESNET50

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Abstract:

Diabetic retinopathy presents a grave risk to individuals with diabetes, as damaged blood vessels lead to exudate leakage, threatening vision. Early detection of these exudates is vital but challenging due to their small size. Our research proposes an innovative image analysis program combining Region Based segmentation, PCA for feature extraction, and CNN-ResNet 50 for classification. Through extensive testing, we demonstrate the superiority of CNN-ResNet 50 in identifying diabetic retinopathy, offering a reliable tool to aid ophthalmologists in early detection and management, thus reducing the risk of irreversible vision loss in diabetic patients.

***Keywords*—**Diabetic retinopathy, Detection, Region based segmentation, Feature Extraction, PCA, Classification, ResNet50.

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I. INTRODUCTION

Diabetic retinopathy, a complication resulting from high blood glucose levels in diabetes, impacts the eyes significantly.

Image Processing presents a promising avenue for addressing the challenges associated with detecting diseases like diabetic retinopathy. By employing passive methods, it delves into an image's history, capitalizing on subtle traces left by image processing tools. These traces, though often imperceptible, can indicate whether an image has undergone manipulation. Over recent years, a plethora of algorithms has emerged, extracting features from images to classify different types of traces, thus aiding in the computerized analysis of medical images. Given the importance of early detection, various image analysis techniques are utilized for automatic disease detection, particularly in the retina, where pathological changes are first observed. Diabetic retinopathy, a severe complication of diabetes, is a leading cause of blindness, necessitating regular screening of retinal fundus images for early detection. It is a progressive disease, affecting a significant proportion of individuals with diabetes, particularly after several years post-diagnosis. Key indicators of diabetic retinopathy include blood vessel damage and the leakage of protein and fat-based particles, known as exudates, which various detection methods aim to identify. Accurate segmentation of the optic disk early in the detection process is crucial to avoid erroneous results, given its similarity in brightness and contrast to exudates. In our proposed method, we introduce a dynamic approach for calculating optimal thresholds to detect hard exudates in fundus images, aiming to enhance diagnostic accuracy and improve patient outcomes.

II. LITERATURE SURVEY

1.Diabetic Retinopathy Detection Using Prognosis of Microaneurysm and Early Diagnosis System for Non-Proliferative Diabetic Retinopathy Based on Deep Learning Algorithms

[Lifeng Qiao; Ying Zhu; Hui Zhou, IEEE 2023]

The paper "Diabetic Retinopathy Detection Using Prognosis of Microaneurysm and Early Diagnosis System for Non-Proliferative Diabetic Retinopathy Based on Deep Learning Algorithms" published in IEEE

2023 addresses the challenge of predicting microaneurysms in fundus images and identifying diabetic retinopathy at an early stage. Diabetic retinopathy, a consequence of prolonged high blood glucose levels, can lead to irreversible vision loss if not diagnosed early. Leveraging the advancements in deep learning, the proposed system utilizes convolutional neural networks accelerated with GPU for efficient medical image analysis. By employing semantic segmentation algorithms, the system can automatically classify fundus images as normal or infected, aiding ophthalmologists in grading the severity of non-proliferative diabetic retinopathy (NPDR). The system's effectiveness lies in its ability to train deep convolutional neural networks effectively for semantic segmentation, thus enhancing the efficiency and accuracy of NPDR prediction.

2.The Multifocal ERG in Early Detection of Diabetic Retinopathy

[Xu Jin; Hu Guangshu; Huang Tianna; Huang Houbin; Chen Bin, IEEE 2023]

The study, "The Multifocal ERG in Early Detection of Diabetic Retinopathy," published by IEEE in 2023, focused on using multifocal ERG to assess retinal changes in diabetic eyes for early-stage retinopathy detection. Across seven healthy subjects, 16 diabetics without apparent retinopathy (NDR), and nine diabetics with background diabetic retinopathy (BDR), multifocal ERG testing was conducted. Researchers extracted and summed the first slice of the second-order kernel (K21) from the recordings, evaluating three major peaks (P1, N1, and P2) based on their amplitude and implicit time. Linear classifiers were then developed using these features to distinguish between control, NDR, and BDR eyes, leading to a notable reduction in classification error.

3.Pre-diagnosis of Diabetic Retinopathy using Blob Detection

[MEHER MADHU DHARMANA; AISWARYA M.S, IEEE 2023]

In the publication by IEEE in 2023 titled "Pre-diagnosis of Diabetic Retinopathy using Blob Detection," authors Meher Madhu Dharmana and Aiswarya M.S. address the need for efficient screening methods for diabetic retinopathy (DR). Recognizing the time-consuming nature of manual diagnosis, the study proposes a novel approach utilizing blob detection for feature extraction, followed by machine learning classification to distinguish between different stages of DR. This method demonstrates promising results, achieving an accuracy of 83%, thus offering a potential solution for automatic characterization of retina images and aiding specialists in accurately identifying patients' conditions.

4.Exudate detection for diabetic retinopathy with convolutional neural networks

Publisher: IEEE 2023.

[Shuang Yu; Di Xiao; Yogesan Kanagasingam, IEEE 2023]

In the IEEE publication of 2023 titled "Exudate detection for diabetic retinopathy with convolutional neural networks," authored by Shuang Yu, Di Xiao, and Yogesan Kanagasingam, the focus lies on the crucial task of exudate detection for diabetic retinopathy (DR) diagnosis. The study employs a deep convolutional neural network (CNN) for pixel-wise identification of exudates, initially trained with expert-labelled exudate image patches and then utilized as an offline classifier. To enhance computational efficiency without compromising accuracy, potential exudate candidate points are extracted using a morphological ultimate opening algorithm. Subsequently, local regions surrounding these candidate points are inputted into the trained CNN model for classification, resulting in impressive pixel-wise accuracy of 91.92%, sensitivity of 88.85%, and specificity of 96% on the test database.

5. Edge sharpening for diabetic retinopathy detection

[Haniza Yazid; Hamzah Arof; Norrima Mokhtar IEEE-2023]

This paper proposes a technique to enhance the segmentation of cotton wool spots and exudates, common complications of diabetic retinopathy, by sharpening their edges through ramp width reduction. These lesions, characterized by distinct visual features like yellowish-white exudates with well-defined edges and greyish-white cotton wool spots with fluffy edges, often lead to vision loss and blindness in diabetic patients. The proposed method aims to simplify the segmentation process by highlighting the well-defined edges of exudates, aiding in the early detection and management of diabetic eye complications.

6. Transfer Learning Approach for Diabetic Retinopathy Detection using Residual Network

[R.S. Rajkumar; T Jagathishkumar; Divi Ragul; A. Grace Selvarani IEEE-2023]

Diabetic retinopathy, linked to Diabetes Mellitus, is a leading cause of global blindness, especially with prolonged illness increasing the risk. Lack of proper treatment and monitoring contributes significantly to the majority of diabetic retinopathy-related blindness cases. While a cure for advanced stages remains elusive, early detection through automated computer diagnosis, utilizing deep learning methods such as Residual Networks, provides a hopeful solution. Through transfer learning, Residual Network models exhibit notable precision in discerning stages of diabetic retinopathy, enabling timely interventions and effective mitigation of visual impairment risks.

III. PROBLEM STATEMENT & METHODOLOGY

EXISTING SYSTEM

A. CONVOLUTIONAL NEURAL NETWORKS (CNN)

A Convolutional Neural Network (CNN) is a deep learning architecture widely used for analysing visual data, offering applications in image and video recognition, classification, segmentation, medical image analysis, and more. CNNs, characterized by their shared-weights and translation invariance properties, are a regularized version of multilayer perceptron's, mitigating overfitting by leveraging hierarchical patterns to assemble complex features from simpler ones. Inspired by the organization of the animal visual cortex, CNNs mimic the receptive fields of cortical neurons, responding to stimuli within localized regions. Notably, CNNs require minimal pre-processing, learning filters autonomously without hand-engineering, thus offering independence from prior knowledge and human effort in feature design. However, challenges persist in existing systems, including lower accuracy in diabetic retinopathy detection, limited applicability across datasets, high computational time, and complexity of predictive models. Addressing these drawbacks is essential for enhancing the effectiveness and usability of CNNs in various applications.

PROPOSED SYSTEM

A) REGION BASED SEGMENTATION

Region-based segmentation methods, such as region-growing and Statistical Region Merging (SRM), operate under the assumption that neighbouring pixels within a region exhibit similar values. In region-growing, pixels are compared with their neighbours, and if similarity criteria are met, they are assigned to the same cluster. Seeded region growing requires predefined seeds to mark objects, while unseeded region growing iteratively considers neighbouring pixels without explicit seeds. Haralick and Shapiro proposed a variant based on pixel intensities, computing test statistics to determine region membership. Connected segmentation assesses pixel connectivity based on intensity and linking paths. Split-and-merge segmentation, employing a quadtree partition, recursively splits non-uniform regions and merges homogeneous ones until no further segmentation is possible, often achieving optimal time complexity with specialized data structures.

B) PRINCIPAL COMPONENT ANALYSIS

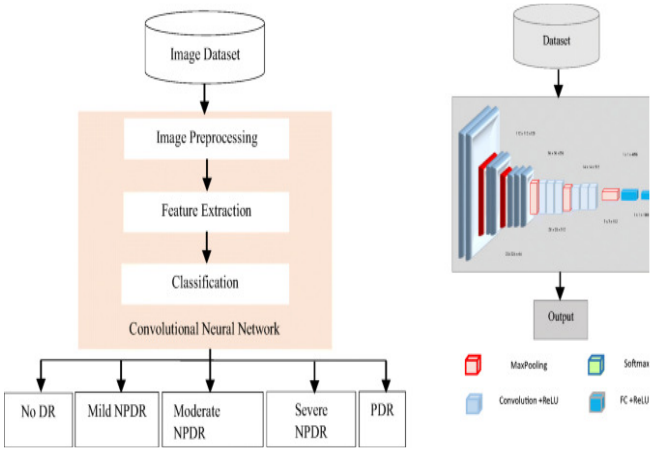
Principal Component Analysis (PCA) serves as a valuable linear dimensionality reduction technique utilized in exploratory data analysis, visualization, and data preprocessing. By transforming the data onto a new coordinate system, PCA enables the identification of principal components—unit vectors representing directions capturing the largest variation in the data. These principal components form an orthonormal basis, with each dimension being linearly uncorrelated. Often, the first two principal components are employed to plot data in two dimensions, facilitating the visual identification of closely related data clusters. In various fields such as population genetics, microbiome studies, and atmospheric science, PCA finds applications in elucidating underlying patterns and reducing the dimensionality of complex datasets for further analysis.

C) ResNet50 Architecture:

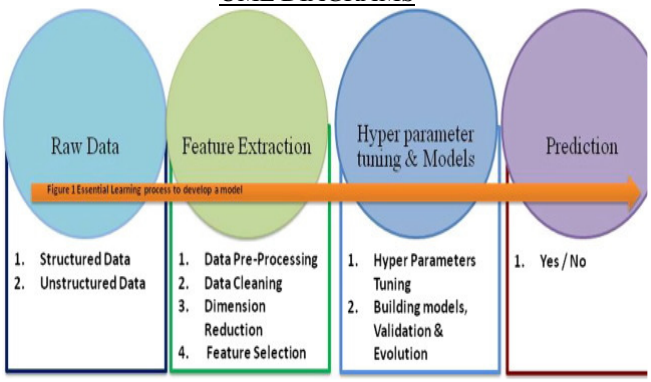
A residual neural network (ResNet) enhances traditional artificial neural networks by incorporating skip connections, enabling information to bypass certain layers. These connections, commonly implemented with double- or triple-layer skips, mitigate vanishing gradient and degradation problems, where deeper models suffer from increased training errors. During training, weights adjust to dampen the effect of preceding layers and amplify the skipped layers, facilitating faster learning and improved feature exploration. Residual networks progressively reintroduce skipped layers, leading to efficient learning and robust feature

representation, compared to non-residual networks, which are more susceptible deviations from the feature space and require additional training data for recovery.

IV. SYSTEM ARCHITECTURE



UML DIAGRAMS



The above diagrams depicts the way of implementing the process of the proposed system that involves various aspects and its structure.

V. SYSTEM IMPLEMENTATION

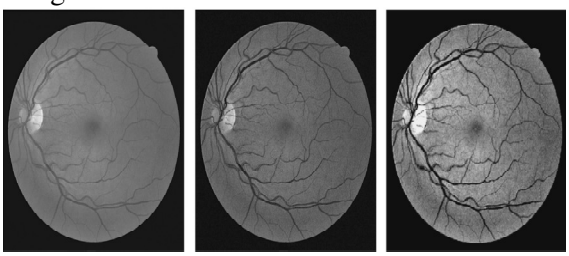
A. Image Acquisition Image

Image Acquisition is the process of collection of images. These images are downloaded from the online dataset provider called Kaggle.com. In each data set we are having some hundreds of images which undergo segmentation process.

B. Image Preprocessing

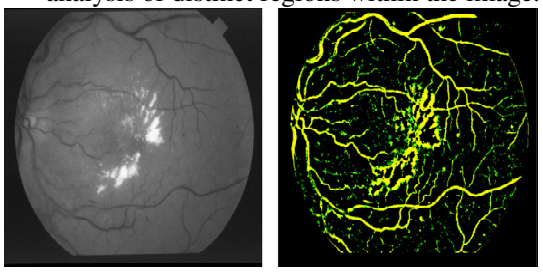
Image preprocessing involves several steps to prepare images for further analysis. One crucial step is converting RGB images to grayscale, which simplifies the dataset by representing images in black and white. This conversion enhances accuracy by reducing noise and making the background neutral. Additionally, grayscale images improve brightness and facilitate more effective image analysis. Another important technique is data augmentation, which creates new data from existing images to prevent overfitting and increase the diversity of the dataset. Overall, image preprocessing plays a vital role in optimizing image data for subsequent processing and analysis.

Image Enhancement



C. Image Segmentation
[Region Based Segmentation]

Image segmentation is an essential aspect of image processing, focusing on breaking down an image into significant and coherent segments. This division helps streamline the image's depiction, enabling easier analysis by separating foreground objects from the background. Often conducted on grayscale images, segmentation utilizes techniques like K-means clustering to group pixels with similar intensities. Through segmentation, specific areas of interest can be isolated, allowing for detailed scrutiny and analysis of distinct regions within the image.



D. Feature Extraction
[Principal Component Analysis (PCA)]

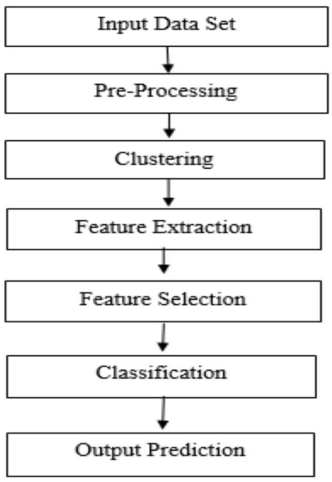
Feature extraction is a crucial step in image processing, involving the extraction of relevant information from segmented image regions to facilitate classification tasks. This process aims to highlight distinctive characteristics that aid in

distinguishing between different images or objects.Feature extraction is a fundamental component of machine vision algorithms, serving to transform segmented objects into descriptive representations that capture their essential features and attributes. Through this process, the complexity of the data is reduced, making it easier to classify and analyse the segmented regions effectively.

E. Classification

In the classification stage, machine learning techniques, specifically utilizing TensorFlow, are employed to categorize segmented image features. TensorFlow, an open-source library for numerical computation in Python, facilitates efficient implementation of machine learning algorithms. It enables the creation of dataflow graphs, where nodes represent mathematical operations and edges denote data arrays or tensors. Through TensorFlow, developers can construct sophisticated models that efficiently process and classify image data, making the classification process faster and more accessible.

FLOW CHART

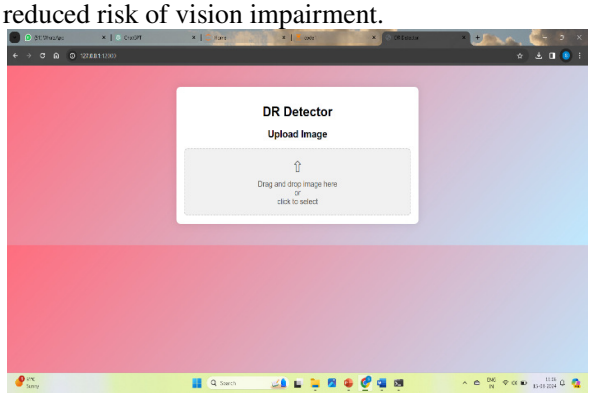


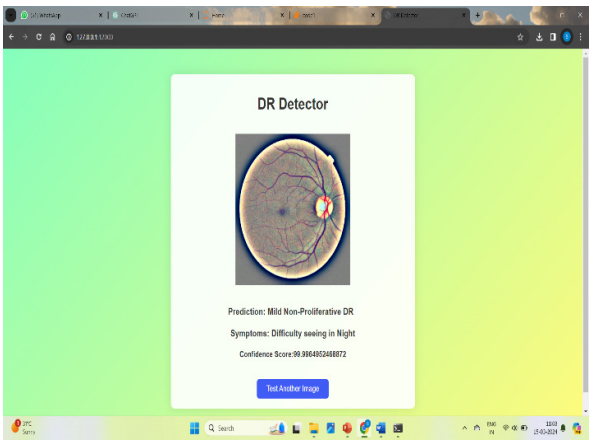
VI. RESULTS AND DISCUSSIONS

The results and discussion of diabetic retinopathy detection using ResNet50, region-based segmentation, and principal component analysis (PCA) showcase promising outcomes in accurately identifying and classifying retinal abnormalities associated with diabetic retinopathy (DR).

The application of ResNet50, region-based segmentation,and PCA in diabetic retinopathy detection demonstrates significant advancements in accurately identifying and categorizing retinal abnormalities linked to the condition. ResNet50, leveraging its deep CNN architecture and residual learning features, excels in discerning intricate patterns within retinal images, facilitating precise classification of various DR stages. Region-based segmentation techniques further enhance diagnostic accuracy by isolating specific pathological features like exudates and microaneurysms, crucial indicators of DR.

PCA complements these methods by effectively reducing dimensionality and extracting discriminative features, streamlining computational processes while preserving diagnostic efficacy. Together, the integration of ResNet50, region-based segmentation, and PCA offers a comprehensive approach, synergistically combining the strengths of deep learning, image processing, and feature extraction. This integrated framework holds promise for early DR diagnosis and management, contributing to improved patient outcomes and reduced risk of vision impairment.





VII. CONCLUSION AND FUTURE SCOPE

In our project, we have developed a method for detecting hard exudates in digital retinal fundus images, achieving high sensitivity validated with a dataset of images. We conducted a comprehensive review of segmentation algorithms, revealing the absence of a universal solution for retinopathy detection. Utilizing morphological filters, we focused on the green channel of RGB images for vessel segmentation, leveraging its sensitivity to vessel appearance. Morphological operations like dilation, erosion, opening, and closing were employed to enhance vessel features effectively. Our algorithm demonstrates potential for diabetic retinopathy detection and vessel diameter measurement in practical applications, showcasing promising results for everyday use.

For future work, the methods studied in this project will be extended to online learning models. In addition, other online learning models will be investigated. The use of online learning will enable rapid detection of cases, potentially in real-time.

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