CLASSIFICATION OF DIABETIC RETINOPATHY USING IMAGE PROCESSING IN DIABETIC PATIENTS

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Abstract - Diabetic retinopathy is a retinal condition that affects people with diabetes and is the leading cause of blindness in the elderly. It's an asymptomatic illness characterized by abnormalities in blood vessels that might cause them to bleed or leak fluid, resulting in visual distortion. As a result, blood vessel extraction is critical in assisting ophthalmologists in detecting this illness at an early stage and preventing vision loss. Diabetes Retinopathy (DR) is a debilitating chronic illness that is one of the primary causes of blindness and vision impairment in diabetic individuals in industrialized nations. According to studies, the majority of instances may be avoided with early identification and treatment. Physicians utilize retinal imaging to detect lesions associated with this illness during eye screening. The amount of pictures that must be manually examined is getting expensive because of the rising number of diabetics. In this research, we used Image Processing to offer a technique for automatically classifying diabetic retinopathy disease based on retina fundus pictures. For this, we combined a feature extraction approach based on a pre-trained deep neural network model with a machine learning-based support vector machine classification algorithm. In MATLAB software, the proposed system is examined and analyzed.

Keywords: Retinopathy, Image Processing, Diabetic Patient, Machine Learning

1. Introduction

Diabetic Retinopathy (DR) is a human eye disease that affects diabetics and causes damage to the retina of the eye, potentially leading to blindness. Diabetes mellitus is a metabolic disease marked by hyperglycemia caused by a failure in the pancreas’ insulin synthesis. Diabetic Retinopathy (DR) is the main cause of blindness in the active population, and it can induce microvascular problems that damage the retina over time. Furthermore, the World Health Organization (WHO) estimates that 347 million people worldwide have been diagnosed with diabetes, with more than 640 million people expected to be affected by 2040. Diabetic retinopathy is an asymptomatic retinal disease caused by diabetes that causes micro aneurysms, hemorrhages, exudates, malformations, and vascular tortuosity (Non-Proliferative Diabetic Retinopathy). As a result, blood vessel extraction is critical in assisting ophthalmologists in detecting this illness early on and preventing vision loss.

Ophthalmologists urge diabetic individuals should get their fundus medically screened on a regular basis to detect DRs early. Nonetheless, diabetic retinopathies are often undiagnosed until significant damage to the patient's fundus has occurred (typically manifested as deterioration or loss of vision). The main issue is that DR does not reveal characteristic symptoms until the disease has progressed to an advanced stage [3]. As a result, frequent eye examinations and check-ups are encouraged to avoid problems. Human evaluation of retinal characteristics and morphological changes in fundus pictures, on the other hand, is a tedious and time-consuming job. To address this shortcoming, numerous automated computer-aided diagnostic tools have been developed in recent years that assist ophthalmologists in examining retinal abnormalities. The infrastructure required to avoid blindness due to DR will become even more insufficient as the number of people with diabetes continues to rise. Detecting DR is now a time-consuming and laborious process involving a skilled physician examining and evaluating digital color fundus images of the retina. Unfortunately, there is no known effective cure for diabetic retinopathy, and the current therapies are at best management techniques. As a result, it's critical to catch the condition early on. The appearance of lesions linked with the disease's vascular anomalies can help clinicians detect DR. While this strategy is effective, it necessitates a lot of resources. In places where the prevalence of diabetes in the local population is high and DR detection is most needed, the requisite knowledge and equipment are frequently inadequate.

2. Related Work

Efficient diabetic retinopathy technology has been created or applied by researchers and is discussed below.
A useful feature extraction approach [4] based on blob detection, followed by machine learning-based categorization of different phases of diabetic retinopathy. With the most efficient machine learning classification method, the diabetic retinopathy characterization of retina pictures was done with an accuracy of 83%. Mohammed Messadi et al. [5] The technique provided here is based on blood vessel segmentation and extraction of geometric traits utilized in early diabetes retinopathy diagnosis. Messidor and DRIVE databases have tested the suggested method and obtained an average sensitivity, specificities and precision respectively of 89%, 99% and 96% for retinal vascular segments, and 91% 100% and 93% for diabetic retinopathy classifications, respectively. A convolutional neural network that utilizes the VGG-16 as a pre-trained neural network to adjust and therefore to categories the gravity of DR [6]. The average accuracy of the class (ACA) was 74%, 80% at a species specificity of 65%, and 080 at the area under curve (AUC). The performance evaluation of CAD approaches [7] is examined, as well as the difficulties. A graphical user interface that can combine image processing techniques to predict whether the input fundus/retinal image received from the patient is affected by Diabetic Retinopathy or not; if affected, the graphical user interface will display the severity as well as the action that the user / patient must take [8]. In a study, the scale invariant feature transform (SIFT) and speeded up robust features (SURF) feature extraction algorithms were applied concurrently on each retinal picture to capture the Exudates areas [9]. Each image's exudates are recorded in a feature matrix and utilized by a support vector machine (SVM) classifier to predict DR. The model's average sensitivity is 94 percent for a set of 100 test pictures. Karan Bhatia et al. [10] employed an ensemble of machine learning classification algorithms on characteristics collected from the output of several retinal image processing methods to make a conclusion regarding the existence of illness. A proposed method [11] was tested with four models of methods available for recognizing saliencies, frequency tuned method (FT) model, spectral residual approach (SR) model, and SDSP model, all of which are based on the DIARETDB1 database, which includes 89 selected images for the diagnosis of diabetic retinopathy. In the suggested technique, the AUC parameter has the greatest value. A digital image processing-based DR detection approach [12] has been created using retinal images, where the fundus picture is acquired from the patient's retina. Within 39 seconds, they were able to detect PDR and NPDR with 98 percent accuracy (half minute). The Gaussian filter was developed by Ali Shojaeipour et al. [13] to improve pictures and distinguish vessels with a high brightness intensity distribution. This method can cut down on the amount of difficulty and time it takes to complete the task. A semantic analysis was carried out in order to depict the DR [14]. This investigation revealed that this innovative vessel segmentation framework has improved accuracy, sensitivity, F measures, specificity, and precision. The proposed study [15] focuses on classifying fundus images with or without indications of DR using an artificial neural network (NN) called a Multi-layered Perceptron (MLP) trained using Levenberg-Marquardt (LM) and Bayesian Regularization (BR). When compared to the usage of LM, MLP trained using BR gives higher classification performance with 72.11 percent (training) and 67.47 percent (testing). Using SVM to extract precise area and number of micro aneurysm from colour fundus pictures, an improved diabetic retinopathy detection system was created [16]. The DR detection system has a sensitivity and specificity of 96 percent and 92 percent, respectively. [17] developed a unique technique for detecting hard exudates with excellent accuracy in relation to lesion level. When compared to existing state-of-the-art approaches, they got good performance outcomes such as sensitivity of 0.87, F-Score of 0.78, and Positive Predict Value (PPV) of 0.76 for hard exudate lesion level identification. The suggested automated programme for screening and diagnosing DR [18] has been created utilising a mix of digital image processing methods. Before the classification stage, the suggested technique [19] eliminates the need for lesion segmentation or candidate map creation. To extract textural and morphological information from retinal pictures, local binary patterns and granulometric profiles are calculated locally. The segment based learning technique suggested [20] for diabetic retinopathy identification, which jointly trains classifiers and features from the data and achieves considerable progress in detecting diabetic retinopathy pictures and their within the lesions. The proposed model outperforms the previous model significantly. J.Jayashree et al. [21] use the PSO Feature Selection method on three distinct Classifiers to investigate Diabetic Retinopathy. SVM Classifier has a 98 percent accuracy, a 96.6 percent sensitivity, and a 96.6 percent specificity (96.5). For the PSO Feature selection algorithm, SVM Classifier has the highest metrics %. A brief description of an ongoing research to detect Diabetic Retinopathy (DRD) [22] using state-of-the-art Deep Learning techniques. The application of convolutional neural networks (CNNs) on colour fundus images for diabetic retinopathy stage detection [23]. With validation sensitivity of 95%, our network models obtained test metric performance equivalent to baseline literature values. To enhance and automate Diabetic retinopathy screening, a high-end Deep learning system was created [24]. [25] presents a unique deep convolutional neural network-based method (DCNN). The results of the experiments demonstrate that the suggested technique can obtain a recognition rate of up to 86.17 percent, which is greater than what has previously been reported in the literature.

3. Proposed Work
The proposed system architecture is depicted in the figure 1. Retinal Fundus Image dataset includes
annotations and is labelled by trained human readers with quality control management, categorising patients into labels such as normal (N) and diabetes (D) based on retinal pictures.

3.1 Retinal Fundus Image
Our technique is being applied to a common benchmark picture collection, the publically accessible dataset Kaggle (APTOS 2019 Blindness Detection), and is being monitored in different ways. A collection of retinal fundus pictures is included in the dataset, which may be used in the design. We utilised a total of 100 pictures in the experiment. Following that, we divided the dataset into 70-30 percent training and testing sets of pictures.

3.2 Image Pre-processing
The given model receives the input pictures as input. Pre-processing is done in the beginning by resizing images to match the size of the trained model.

3.3 Feature Extraction
Using a pre-trained deep learning model, a set of significant characteristics is retrieved from the segmented picture in the following step. Inception-v3, which is based on a 48-layer convolutional neural network, will be utilised as the pre-trained deep learning model. It was created by Google and was trained using data from 2012 for the ImageNet Competition. Because of its strong categorization performance, we picked this model. We used a pre-trained deep learning model to extract information from the segmented image. Inception-v3 is the pre-trained deep learning model that will be utilised. Using the representational capability of pre-trained deep networks is as simple as extracting features.

The goal of these pre-trained model learning approaches is to learn feature hierarchies that include features from higher levels of the hierarchy that are generated by the composition of lower level features. Without relying only on human-crafted features, a system may learn complicated functions mapping the input to the output directly from data by automatically learning features at many levels of abstraction. These features can be grouped into two categories: low-level features and high-level features. Edges and blobs are low-level features, while objects and events are high-level features. Inception V3's final architecture is seen below.

![Inception V3 Architecture](image)

3.4 Classification
Then, using a machine learning classification model, pictures are categorized as either "nondiabetic" or "diabetic," with the result labelled "nondiabetic" or "diabetic." We utilized a multi kernel support vector machine in our scenario (SVM). In the suggested technique, computer-aided diagnostic models for identifying and diagnosing diabetic retinopathy are trained and tested. The extraction of features is done using image processing, and the classifier operation is done with machine learning, which makes it easier and faster to create trained prediction methods from filtered data.

Our suggested method is divided into two stages: training and testing. To begin, the retinal fundus image dataset must be divided into two phases, each with a 70-30 percent ratio of the entire dataset in the train and test picture sets. During the training phase, the initial train picture set must be treated before feature extraction, which includes noise reduction, image improvement, and image scaling. We used an automated feature extraction approach using a pre-trained deep convolutional neural network to extract low-level to high-level features. Following that, input and output data is gathered as a feature dataset from the train image set and labels from its comparable train image set. The same data is utilized to train and evaluate the machine learning model, in which the support vector machine classifier is employed.

We stored the trained model after successful validation. In the testing phase, the test picture set must perform the same operations as in the training phase up to feature extraction. We loaded the trained model after receiving the test feature set and predicted the outcomes as healthy and unhealthy retinal images.

Support-vector machines (SVMs, also known as support-vector networks) are supervised learning models that evaluate data for classification and regression analysis in machine learning. An SVM training algorithm creates a model that assigns new examples to one of two categories, making it a non-probabilistic binary linear classifier, given a collection of training examples, each marked as belonging to one of two categories (although methods such as Platt scaling exist to use SVM in a probabilistic classification setting). SVM translates
training examples to points in space in order to widen the distance between the two categories as much as possible. The Support Vector Machine, or SVM, is a common Supervised Learning method that may be used to solve both classification and regression issues. However, it is mostly utilized in Machine Learning for Classification issues.

4. Results and Discussion
The suggested work is run on a laptop with an Intel Core i5, 8GB RAM, and Windows 10 as the operating system. The computer code was written in MATLAB R2018b using the Image Processing, Statistics and Machine Learning toolboxes, as well as the Deep Learning toolbox. For testing, the input pictures were obtained from the Kaggle (APTOS 2019 Blindness Detection) Dataset [26].

4.1 Training Phase
We have two implementation phases in this experiment, according to the proposed block diagram: first, training, and subsequently testing. The train set of pictures must be preprocessed according to the dimension of the deep network utilised during training. Then, for the feature extraction of train pictures, we utilised an automated feature extraction method based on an Inception V3 pre-trained deep convolutional neural network of 316 layers (input, feature, classification, and output). To extract features from pictures, we utilised the ‘avg pool’ feature layer. Following that, we must train the model using a multi kernel SVM based on input and output data, where the input is the train image feature dataset and the output is labels. We stored the trained model once the training model was successfully validated.

4.2 Testing Phase
In the testing phase, we used the same technique as for the train pictures to determine whether the retinal image was diabetic or nondiabetic.

4.3 System Evaluation Phase
We analyzed all test pictures from the dataset in this step to get system performance metrics and demonstrate system efficiency.
5. Conclusion

Although diabetic retinopathy cannot be cured, laser analysis is typically highly successful in preventing vision loss if done before the retina is badly affected. The surgical removal of vitreous gel can enhance eyesight if the retina has not been severely damaged. This research aids in the early diagnosis of retinopathy, which can lead to irreversible visual loss if not treated promptly. This paper suggested a machine learning system that employs a series of processes spanning from image pre-processing to classification to construct a scheme with improved detection accuracy and effective feature extraction utilizing a pre-trained deep neural network model. The total accuracy of class recognition is 96.66 percent. The classification model’s simplicity, high recognition rate, and speed make it ideal for deploying a productive and lucrative computer vision machine in the healthcare system. This research might be expanded to encompass a variety of lung infection illness categories. We can also minimize the time it takes to learn dataset features by using GPU. In terms of other illness categorization, the same approach may be used to any type of dataset.

References


