Review on approaches of diagnosis of diabetic retinopathy at early stage

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Abstract

The innermost and light-sensitive layer of tissue of the eye is retina. This tissue suffers a disease generally known as Diabetic retinopathy (DR). The disease must be treated at early stage for preventing its growth. The necessity of diagnosing at earlier stage is the main motive of a researcher. The growth of this disease may result in complete sight loss. The developing nations do not have enough skilled ophthalmologists. Moreover, people don’t have enough knowledge of this disorder. The early treatment can be provided to the patients for preventing this disease from growing to further stage.

Keywords: Diabetic retinopathy (DR), Image processing, Deep learning, Convolutional Neural network (CNN)

Introduction

To detect diabetic retinopathy from images, some efficient solutions have been provided. The images of retina which have been captured over time have been evaluated to diagnose diabetic retinopathy. On the other hand, performing image grading manually for defining the severity of this disease is a very tedious task. Also, this task needs large number of resources. This disease is diagnosed only when the blood vessels in the retina start damaging or leakage happens in blood vessels. The blood flows through these small blood vessels. The fluid within retina generates features. This disease is of three types such as severe, mild and normal NPDR (non proliferative DR) and PDR (proliferative DR) as per the severity of the disease. The primary stage of this disease is known as NPDR (non-proliferative diabetic retinopathy). The categorization of this disease is based on the occurrence of micro aneurysms. Oxygen enters in the middle of the retina and vision becomes cloudy due to the creation of blood vessels when this disorder reaches to next stage. Image processing techniques can help to identify and diagnose diabetic retinopathy by using different classifiers. Classifiers will be applied on fundus images [1].
**Figure 1: General Process of DR**

**a. Pre-processing:**

*Pre-processing* is the first stage in three-stage algorithms. This stage measures the severity of this disease. This stage also performs the automatic grading of this disease. This automated process uses ophthalmic fundus images. Some issues related to image ambiguity, non-clearness and image size are considered in the pre-processing stage. Initially, resizing of the image can also be done during pre-processing phase. Afterward, the color space transformation and image restoration steps are implemented. At last, the image enhancement is carried out. The conversion of color fundus as input image is done into HIS (Hue, Saturation and Intensity) in the color space transformation process. The HSI color model decouple intensity level from the color images. In the primary stage, histogram quantization is carried out. The next step involves contrast improvement. The scaling of pixels’ brightness is done in the preprocessing step [5].

**b. Features extraction:**

The different types of morphological operations for detecting the micro-aneurysms and exudates features are carried out in the candidate extraction process. For inverting the image, invert image method is used and then the holes are filled within the image towards the end. [4]. Then, the holes within the image are filled towards the end.

i. Optic disc elimination: In the fundus pictures, optic disc or optic nerve is the most significant part of a typical eye. The part either happens in oval or circular shape. The optic disc happens as a splendid yellowish or whitish region in shaded fundus pictures. The exudates contain high and same brilliance fluids for the optic nerve or disc. Along these lines, the expulsion of optic disc from the retinal picture is profoundly significant. It is conceivable to veil and evacuate the more splendid optic disc utilizing locale properties and territory location strategies. Subsequent to preprocessing, the edge location calculation is executed for recognizing both optic disc and the veins. The counter is identified by actualizing watchful edge location calculation. This calculation upgrades obscured edges and guaranteed the
conservation of all neighborhood maxima called slopes. Along these lines, this calculation effectively recognizes the edges of highlights. Optic disc is a point where axon cells leaves the eye and there are no cons or rods so it is a blind spot. A mask image is created using logical white and black function and edges are identified.

ii. Blood vessels extraction and removal: The blood vessels will be removed and optical disc from retinal image is imperative for detecting micro-aneurysms and exudates. This occurs due to the similar concentration levels of all of these features. Dilation is implemented on an intensity image for eliminating the high level contrasts vessels existing within blood. The filling of small holes within the images is also done with the help of structuring elements by implementing the dilation operation. There are different shapes in which structure elements occur. In order to remove the optical disc and blood vessels, a structure having the shape of flat disc is implemented.

iii. Detection of exudates and micro-aneurysms: The exudates features can be detected by eliminating blood vessels and optical disc from the image. Exudates are the bright lesions. These lesions occur within a retinal image. The morphological closing operation is implemented for detecting these important features. This last task is applicable on the eroded fundus image [5].

c. Classification

The extraction of features can be done from the fundus image after detecting exudates and micro-aneurysms occurring within a color image. The whole features are computed and different classification models are utilized.

Literature Review

Harry Pratt, et.al (2016) proposed a CNN approach for the detection & diagnosis of diabetic retinopathy from digital fundus images and the accurate classification of disease sternness [7]. In this work, a CNN approach and augmentation of data have been developed. This approach could detect the intricate features included in the classification task. These features included micro-aneurysms, exudate and haemorrhages on the retina. The recommended approach automatically diagnosed diabetic retinopathy disease without getting any input from the client. A high-end graphics processor unit (GPU) on the publicly available Kaggle dataset had been utilized for the training of this network. The recommended approach depicted satisfactory results, especially to carry out high-level classification. A data set containing 80,000 images was used in this work. The recommended approach achieved sensitivity and accuracy of 95% and 75% respectively.

The achieved outcomes depicted that the retinal doctors more efficiently graded the occurrence of DR related features and DR severity levels than general
eye doctors. SAMG was the most efficient technique among all considered techniques in terms of both performance prediction and in terms of cost grading. However, DAAD approach performed well in terms of prediction. The tested results depicted that the recommended approach was quite feasible to detect both diabetic retinopathy acuteness and the occurrence of diabetic retinopathy related features in fundus images.

The recommended model accepted binocular fundus images as inputs. This model learned their correlation for providing support in prediction making. The prescribed binocular model gave a region under the receiver operating curve of 0.951 with a preparation set of only 28,104 pictures and a test set of 7024 pictures. This zone was 0.011 more accomplished by the accessible monocular model. To additionally confirm the adequacy of the binocular plan, the preparation of a binocular model for five-class diabetic retinopathy recognition had been completed for additional checking the productivity of the binocular design. The evaluation of this model was done on a 10% validation set. The achieved results demonstrated that the suggested approach achieved kappa score of 0.829. In contrast to existing non-ensemble model, this score was higher.

Shailesh Kumar, et.al (2018) presented a modified diabetic retinopathy detection approach. The recommended approach extracted accurate area and number of microaneurysm from color fundus images for detection purpose [10]. It was highly important to detect MA in early stage. This was the first step towards the treatment of diabetic retinopathy. In order to detect and diagnose diabetic retinopathy, various techniques had been recommended in this work. Mainly two features called number and area of MA (Microaneurysms) had been determined in this work. Firstly, some pre-processing methods were implemented. These methods include histogram equalization, green channel matrix, and morphological process. Principal component analysis (PCA), contrast limited adaptive histogram equalization (CLAHE), morphological process, averaging filtering had been utilized for detecting microaneurysms. A linear Support vector machine (SVM) had been utilized in this work for the classification of diabetic retinopathy disease. The diabetic retinopathy system achieved sensitivity of 96% and specificity of 92%.

Z. A. Omar, et.al (2017) recommended a novel diabetic retinopathy technique for improving the accuracy of the available systems [11]. Exudates, hemorrhages and blood vessels were the main methods utilized for the detection of diabetic retinopathy features. These methods could be categorized into various phases. These phases included image pre-processing, vessel and hemorrhages detection, optic disc removal and exudate recognition. On the other hand, due to similar intensity features the blood vessel and hemorrhages were detected at the same time. The training of proposed algorithm was carried out using 49 images while 89 fundus images were used for the testing purpose. The images for training were obtained from a Malaysian Hospital called Serdang, while DIARETDB1 database provided images for testing purpose. The tested outcomes demonstrated that 98%, 98% and 100% were the detection rate for blood vessel, hemorrhages, and exudates correspondingly.
Ömer Deperhoğlu, et.al (2018) used deep learning approach for processing image for diagnosis of diabetic retinopathy using retinal fundus images [12]. A realistic technique containing HSV, V transform algorithm and histogram equalization algorithms was employed for retinal fundus images. At last, Gaussian low-pass filter was implemented on the retinal fundus image. Convolutional Neural Network performed classification task after image processing. Mainly 400 fundus images of retina from the Kaggle Diabetic Retinopathy Detection database were used for evaluating the performance of the recommended technique. Classification was performed for all stages of image processing in conducted tests. The tested results depicted that the suggested approach achieved accuracy, sensitivity, specificity, precision, recall and Fscore of 97%, 96.67%, 93.33%, 97.78%, 93.33%, and 93.33% respectively. The tested results depicted that the recommended technique efficiently diagnosed diabetic retinopathy from the fundus images of retina.

Buşra Yaşar, et.al (2018) stated that early detection of diabetic retinopathy was imperative for healing this disease [13]. Hard exudates are one of the early symptoms for detecting diabetic retinopathy. In this work, a new technique had been recommended for the detection of diabetic retinopathy in early stage. The recommended technique was based on hard exudates recognition in retinal fundus images. For this purpose, this technique used Kirsch method, thresholding, edge detection, filters, noise removal, histogram equalization, optic disk removing and morphological classification tasks. This technique was implemented on different images for achieving accurate results.

Kranthi Kumar Palavalasa, et.al (2018) recommended a new technique for detecting hard exudates with high accuracy regarding lesion level [14]. At first, the back ground subtraction method was used for the detection of possible candidate exudate lesions. In the last phase, the de-correlation stretch based technique was used for removing the false exudate lesion detections. An openly available database called DiaretDB was used in this work for the testing of recommended algorithm. This database contained the ground truth for all images. The recommended approach provided highly efficiently results in terms of sensitivity, F-Score and Positive Predict Value (PPV). In contrast to available state of the art methods, the recommended technique achieved sensitivity, F-Score and Positive Predict Value (PPV) of 0.87, 0.78 and 0.76 respectively for detecting the level of hard exudate lesion.

The classification task was performed using fundus color images. The practicality of deep learning algorithm to this issue had been recommended in this work. A lot of tests were carried out for continuously improving the recommended model. It was analyzed that the suggested model could be utilized on the top of the pre-trained model. This phenomenon could provide more satisfactory results. However, the future work would involve some additional tests for achieving more promising results.

Enrique V. Carrera, et.al (2017) proposed a computer assisted diagnosis approach for the identification of diabetic retinopathy before its occurrence. The prescribed methodology was based on the computerized analysis of retinal pictures. Classifying the grade of non-proliferative diabetic retinopathy using any retinal image in automatic manner
was the major objective of this work. For this purpose, the isolation of blood vessels, micro aneurysms and hard exudates had been performed by an initial image processing stage for feature extraction. Support vector machine could use these extracted features to determine the retinopathy grade of all retinal images. A database containing 400 retinal images was used for the testing of recommended technique. The labeling of images was carried out according to a four-grade scale of non-proliferative diabetic retinopathy. The tested results demonstrated that the recommended technique achieved sensitivity and predictive accuracy of 95% and 94% respectively.

Jayant Yadav, et.al (2017) stated that Diabetic Retinopathy was an eye disease. This disease caused vision blurriness and sightlessness in patients suffering from diabetes [17]. Generally, manual techniques were adopted for detecting this disease. In these methods, an ophthalmologist examined the patient’s eye manually. It was a very time consuming process. In this work, an attempt had been made to remove this issue with the help of computer vision. This approach along with disease detection also automated this process. For this purpose, a neural network had been utilized in this work. This approach provided satisfactory results in minimum span of time.

Karkhanis Apurva Anant, et.al (2017) Diabetes are of two kind: type-1 and type-2 diabetes. Type-1 diabetes is difficult to fix and prompts demise yet type-2 diabetes can be relieved whenever distinguished at beginning period [18]. Type 2 diabetes can be differentiated or diagnosed effectively through retina examination called as Diabetic Retinopathy investigation. Numerous specialists have applied picture handling systems to distinguish the DR nearness in retina. In this work an approach is proposed of utilizing picture preparing and information mining, surface and wavelet highlights are separated for identification. The Results are acquired for images of standard database and assessment of parameters of affectability, particularity and exactness is done. This strategy produces exactness of 97.75% which can identify and counteract diabetes.

Nikita Kashyap, et.al (2017) proposed Image Retrieval methods for searching and extracting the query image from the database of retinal images [19]. Initially, color histogram features were extracted to develop a retrieval process. Afterward, the feature vector of desired size was detected using the location of the number of bins within histogram. The measurement of Euclidean distance was carried out between the query and database image to verify similarity. In contrast to RGB color space, the color histogram retrieval system performed better in HSV color space. The recommended system could reduce the work of doctors by analyzing each fundus image instead of just diabetic image. A prototypical DR image management system had been designed in this work for more improved diagnosis.

Nursel Yalçın, et.al (2018) suggested the usage of a deep learning-based approach for detecting diabetic retinopathy at early stage [20]. For this purpose, retinal images were used. There were mainly two steps included in the recommended scheme. Pre-treatments were carried out in the initial step for removing retinal images from different data sets. The next stage used Convolutional Neural Network for classification purpose. It was a deep learning algorithm that provided 98.5% accurate results. The deep learning network mechanically constructed feature set in
minimum span of time in contrast to the traditional approaches in which feature sets were constructed manually. For this purpose, the CPU and GPU had been utilized in the training stage.

Anaswara Chandran, et.al (2016) recommended a new algorithm for extracting texture and vesselness features per patch [21]. Gabor wavelet transform was used for extracting the vessel map. The list of capabilities accomplished from the picture patches was exposed to an arbitrary forest classifier. Classification model gave named results. The prescribed calculation depends on a standard based choice framework. This methodology played out the arrangement of pictures in proportional stages. These stages included PDR, NPDR (Non Proliferative Diabetic Retinopathy) and Normal. The prescribed framework accomplished better intensity and explicitness rather than other existing methodologies. This framework can be used as a diagnosing tool for diabetic retinopathy.

Navoneel Chakrabarty, et.al (2018) recommended an approach for the automatic classification of diabetic retinopathy patients [22]. For this purpose, High-Resolution Fundus retinal image was used. Initially, image processing was implemented on the images. Colored (RGB) images were perfectly converted into grayscale images. Afterward, resizing was carried out. In this work, Deep Learning Approach had been implemented using which processed image was fed into a Convolutional Neural Network for making predictions about the patient is suffering from diabetic retinopathy or not. This technique was implemented on a dataset containing High Resolution Fundus retinal images. The recommended technique achieved predictive accuracy and Sensitivity of 100%.

Nikita Kashyap, et.al (2017) presented a novel mobile phone based result finding system for detecting diabetic retinopathy in early stage [23]. The recommended system was less costly and compacted too. This system used artificial neural network (ANN) Algorithm. The mobile phone captured retinal images using condensing lens. After that, detection program of ANN had been implemented for decision making by diagnosing diabetic retinopathy in early stage. The main aim of this work was to achieve the efficient and inexpensive evaluation system. This system was ideal for immature areas and made it accessible for all.

This approach used color fundus pictures for this purpose. In order to segment optic disc and blood vessels, modified segmentation tactics were used in this work. There were five steps included in the recommended approach. Watershed transform had been utilized in this work for segmenting optic disc and blood vessels. Presenting better segmentation techniques for segmenting both elements was the key objective of this work. The disorder was classified with the help of Radial basis function neural network. The recommended approach achieved sensitivity of 87% and specificity of 93% as per the tested results.

Reducing the complication of the model along with performance improvement was the major objective of this work. Therefore, the designing of a competent approach had been done. Several tests were
conducted for evaluating the performance of the recommended approach. It was possible to apply decision regarding DR by assigning labels to the region. Training was not required for this purpose. The tested results depicted that the recommended approach performed better than several other existing approaches in terms of different metrics.

The new tetragonal local octa pattern (T-LOP) features characterized fundus pictures. This was done for achieving enhanced manual performance on big databases of DR. Afterward, extreme learning machine (ELM) had been used for the classification of fundus pictures. The tested outcomes validated the importance of the DR recognition approach. The recommended approach successfully provided the information of this disorder’s seriousness in accurate manner.

Deepashree Devaraj, et.al (2018) stated that lesions could be detected precisely by diagnosing Diabetic Retinopathy in automatic manner [27]. This approach proved very helpful for the eye specialists. It was necessary to analyze the abnormalities in the images of retina for ease in detection of different types of DR disorders. In this research, a lot of existing segmentation techniques was reviewed. These techniques segmented exudates as well as microaneurysms with the help of multiple images of retina. This task could prevent everlasting blindness.

Shaohua Wan, et.al (2018) tried to find an automated way for classifying multiple fundus pictures [28]. In this work, convolutional neural networks (CNNs) were used for detecting diabetic retinopathy disease. There were three main steps in this process. Some models along with transfer learning and hyper-parameter tuning were used in this work. These models classified DR images. An openly accessible Kaggle dataset was used in this work to train the adopted models. The tested results revealed that the CNNs and transfer learning showed good performance and classified diabetic retinopathy images accurately.

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<th>SR.NO</th>
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Conclusion

A disease that affects the retina present within a human eye is known as Diabetic retinopathy (DR). If this disease is not cured initially permanent blindness can be caused to the affected person due to the growth of this disease. Enough trained ophthalmologists and proper awareness of such disease is not found within the developing countries. However, it is possible to provide initial care to patients and delay the growth of this disease if proper treatment will be given timely and few automated tools will be introduced. Despite the fact that the early analysis and constant observing of diabetic patients is required, not many compelling answers for DR have been given. The retinal pictures are assessed to analyze the DR. It may be tedious and asset requesting to physically review the pictures to such an extent that the seriousness of DR can be characterized. At the point when the small veins present inside the retina are harmed or leakage of veins happen, at exactly that point one can see this issue easily. Blood will spill out of little vein and highlights are shaped from the liquid that exists on retina. In this examination work, the CNN technique is proposed for the order of diabetic retinopathy from the acquired images as CNN can be applied on huge arrangements of information when contrasted with other AI calculations for characterization. It is normal that proposed technique can build the precision, particularity and sensitivity.

References


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