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Convolution Neural Network for Diabetic Retinopathy Detection

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Abstract*: Diabetes-Retinopathy (DR) condition detection based on machine learning and image processing techniques makes use of the diabetic portion from the set of input images. Textural feature analysis is adopted for feature extraction. CNN is used to classify the extracted features. The execution of the proposed technique is carried out in MATLAB, and the analysis is based on the accuracy, sensitivity, specificity. In the light of analytic outcomes, it can be said that the introduced method performs better than the existing technique in terms of all the mentioned parameters.

***Keywords*: CNN, Retinopathy, CNN, Sensitivity, Specificity, Accuracy**

I. INTRODUCTION

A digital image is composed of a range of pixels. In this image, a value is assigned to every pixel. Conventionally, the value of each pixel signifies the status of the respective part of the organ in clinical images in terms of different features such as colour, intensity etc. Efficient processing, objective evaluation and availability of digital images is possible at multiple locations simultaneously using apt communication networks and protocols. The popularity of medical imaging is growing in the field of research since the devices generated are high-speed, more accurate and less invasive. This has generated the requirement for the respective software development. This provision has paved the way for new algorithmic approaches in both signal as well as image processing. A significant number of these algorithm depends on partial differential equations and curvature driven flows. Various mathematical models have been used to develop biomedical computing. Based on the models newly designed, which perform tasks using the data extracted from images, it is possible to determine the scientific progress of various fields [1]. At present, there are numerous techniques using which images can be captured athwart all biological levels. Present-day medical images can be thought of as arrays of data patterns organized in a geometrical manner. These images perform the quantification of different physical phenomenon. The widening scale of imaging as an opportunity of organizing our observations of the biological world has dramatically increased our aptitude to implement novel processing methods and fuse many channels of data into classy and compound mathematical models of physical function and disfunction. Hence, there is the need to devise versatile software approaches that can be incorporated into wide-ranging treatment providing schemes.

The retina appears as the inner lining at the back of the eye. The retina after sensing light turns it into signals [2]. The brain decodes these signals and able a person to see the world around. Damaged blood vessels may damage the retina. This causes a disease referred to as diabetic retinopathy. Diabetic retinopathy is one of the critical causes of blindness in diabetic patients. The timely detection and treatment of this disease may decrease the risk of vision loss by 95 per cent. With time, a lot of research works has been carried out for developing the competent techniques of DR detection by means of images. However, the efficiency of these techniques depends to a great extent on the early-stage detection and constant observation of people with diabetes. Generally, the acquired image of eye retina is evaluated to detect this disease. Also, a lot of time and assets are required for the grading of retina images manually. The role of grading is quite important for deciding the risk level of this disease. The most important factors which are considered while studying this issue are the ones involved in the outflow of fluid and blood from the blood vessels. Based on the severities, DR is categorized as normal, NPDR (non-proliferative DR) and PDR (proliferative DR). NPDR is the initial stage of DR which is categorized based on the presence of microaneurysms. In the next stage of this disease, some blood vessels block off, which causes fresh blood vessels to grow or proliferate, on the retina surface. Ophthalmologists, with the help of a CAD approach, can easily observe the retinal part of the patients [3]. Up till now, specialists make use of retinal fundus images for the quantification and detection of diabetic retinopathy.

II. LITERATURE REVIEW

Rao, et al. (2016) introduced a novel scheme for detecting the diabetic retinopathy (DR) disorder [7]. This was a hybrid scheme composed of by combining the FCM and MIP (Morphological Image Processing) together. There are a lot of tasks involved in the retinal image pre-processing. This work made use of SVM classification model to classify the chosen retinal attributes.

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This classifier achieved accuracy, specificity and sensitivity of 96.67%, 95.83%, and 100% respectively. Yadav, et.al (2016) performed a comparison study of fundus image improvement methods so that the DR (Diabetic Retinopathy) disorder could be detected [8].

This work compared four popular image pre-processing methods such as HE, ADHE, CLACHE and ESIHE for the diagnosis of the diabetic retinopathic disorder. This work implemented these methods in MATLAB software. This work considered four main fundus image features such as PSNR, SNR, entropy, and histogram for analyzing these methods.

Gupta, et.al (2016) described that an algorithm was developed and performed on the human retinal fundus image for detecting the DR disease [9]. The blood veins that were present in the retinal fundus image had also discovered using this algorithm. This disease affected diabetic patients and led to the loss of vision when this disease was not cured earlier. This technique assisted the doctors in finding out the phase of the disease that had occurred in the blood veins image was evaluated from Retinal fundus image. For the future work, the edge values were made autonomous of picture properties for the more improvement of accuracy of this suggested work.

Seoud, et.al (2016) discussed a new technique for detecting the microaneurysms and haemorrhages in colour fundus images automatically, and the validation of this technique was also performed in this paper [10]. Six databases were utilized from which four were publicly available database for the validation of this technique per-lesion and per-image. The robustness of this technique had demonstrated in terms of variability in image resolution, quality and acquisition system. This technique had acquired FROC score on retinopathy online database of challenge that was computed 0.420, at fourth rank. The presented technique had obtained an area under the ROC of 0.899 while detecting the images with DR on the Messidor database. The presented technique had performed better than modern approaches.

Karami, et.al (2017) recommended a DL-based technique to detect the diabetic retinopathy automatically in digital fundus images [11]. This detection technique was planned on the basis of learned dictionaries through the K-SVD algorithm. The atomic demonstration of images in each class had done by achieving the best discriminative atoms. The rule of classification was prepared on the basis of the best sparse demonstration. This implied that the test image has belonged to the class which had the minimum number of best specific atoms. Thirty colour fundus images had employed for testing the recommended technique. The acquired accuracy from normal images was computed 70% and 90% for the diabetic images.

Carrera, et.al (2017) suggested a computer-assisted diagnosis that was planned on the basis of the digital processing of retinal images for the detection of DR at the initial phase [12]. The major objective of this paper was that the grade of non-proliferative diabetic retinopathy had classified automatically at any retinal image. To achieve this, the blood vessel, microaneurysms and hard exudates were separated in the former image processing phase for the extraction of attributes. The SVM had employed these extracted features for discovering the retinopathy grade of each retinal image. A database that included 400 retinal images employed for the testing of suggested technique. These images labelled in accordance with four grade scale of non-proliferative DR. The results proved that the suggested diagnosis had achieved maximum sensitivity that was evaluated 95%, and predictive capacity was evaluated 94%. The evaluation of robustness had done considering changes in the parameters of the algorithm.

Kashyap, et.al (2017) introduced a new technique to identify and retrieve the query image from the retina database [13]. This novel approach mainly included an image retrieval mechanism. The numbers of bins were set in the histogram for designing the retrieval process, which helped in extracting the colour histogram feature and identifying the feature vector of required magnitude. The proposed approach helped in reducing the tasks performed by professionals while analyzing the fundus image. This approach also results in developing an ideal DR image handling scheme to enhance the efficiency of disorder detection.

Bui, et.al (2017) introduced a novel approach for detecting DR by identifying the cotton wool spots found in retinal images by providing an automatic segmentation mechanism [14]. Initially, the detection of cotton wool was considered important to prevent any losses like blindness or vision loss in future. This research also proposed a neural network approach to conduct learning and perform tests using the k-fold cross-validation. Real-time evaluations of the proposed approach were done by applying the proposed approach on DIARETDB1 public data. It was seen through the achieved results that the performance of the proposed technique was better in terms of different performance parameters.

Kimpan, et.al (2017) proposed a new technique for extracting the properties of images. An image retrieval system was applied by extracting the image properties by applying the theory of gravitation proposed by Newton [15]. Higher numbers of details were provided from retinal DR images to improve the image retrieval so that the doctors could be benefitted for diagnosing DR. Based on the experimental results it was seen that it was possible to detect and retrieve the DR affected images from a database efficiently. Thus, this technique provided highly effective outcomes for diagnosing the retinal disorders.

III. RESEARCH GAPS

Some gaps in this research work have been discussed below:

1. This work aims at diabetes retinopathy detection by means of segmentation and feature extraction. The efficient approach is required for the segmentation which segment blood vessels efficiently. When the blood vessels are not detected accurately the accuracy of diabetes spot detection gets reduced.

2. The diabetes retinopathy detection requires the classification method for the classification of diabetic retinopathy and non-diabetes retinopathy portion. The classification approach should require low execution time for the classification.

3. The efficient approach needs to be designed, which can detect diabetes spots effectively. It means that the portion of the spot which is not included in the affected region should be removed.

IV. RESEARCH METHODOLOGY

Following are the various phases of proposed methodology: -

A. Pre-processing:

This process makes use of am algorithms with three stages for measuring the risk level of diabetic retinopathy disease and also for its automatic grading. This automated approach uses fundus images of the eye retina. This process faces some problems such as blurred images, unclear images, inappropriate image magnitude. First of all, the resizing of the image is carried out. Next, different tasks related to colour space transformation and image restoration are carried out. At last, improvement in the image is performed. The transformation of the colour fundus input image is carried out into HSI. HSI set-up decouples colour model space from the colour pictures. Initially, HE (Histogram Equalization) and contrast improvement are performed one by one. Later, the scaling of the pixel brightness is carried out.

B. Features extraction

Candidate extraction involves the extraction of several morphological operations so that the MAs (Micro-aneurysms) and EXs (exudates)attributes can be detected. Image inversion is carried out by means of the invert image method [4]. Finally, the filling of image holes is performed.

i. Optic disc Removal: The optic disc (OD) is a round region in the back of the eye where retinal nerve fibers gather to frame the optic nerve. OD is sometimes called optic nerve head (ONH) since it is the leader of the optic nerve as it enters the eye from the brain. In order to detect DR disorder, the first step is the removal of OD due to its similarity with other attributes of retina image in terms of colour, intensity, and contrast. Some The edge detection algorithm is applied after pre-processing to detect the optic disc as well as the blood vessels. The Canny edge detection algorithm is applied to perform counter recognition. The blurred edges are improved by this algorithm by ensuring that all the local maxima known as gradients are preserved. Thus, this algorithm optimally detects the edge attributes. The rational B&W (black and white) function is employed for generating the mask image by creating and inverting the image. Further, this process helps in generating a mask image and removing it from the image.

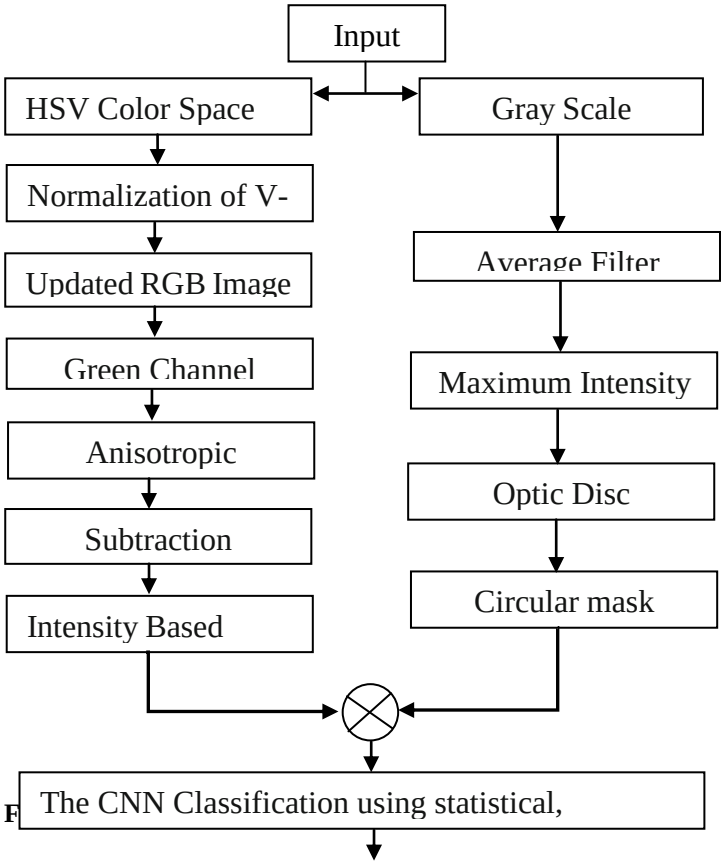
ii. Blood vessels extraction and removal: Micro-aneurysms and exudates from retinal images can be detected by removing blood vessels and OD as both of these attributes have the same concentration levels. In an intensity image, the implementation of dilation is carried out for the removal of blood vessels with a large contrast. The small holes found in the images are filled as well, using the structuring elements by applying the dilation operation. The structure elements are available in various shapes. A framework in the shape of flat disc is applied for removing the OD and BVs (Blood Vessels).

iii. Detection of exudates and micro-aneurysms: Once the OD and BVs are removed, the EXs features can be detected. Exudates appear as bright lesions in a retinal picture. MCO (Morphological Closing Operation) can be applied for the detection of these attributes. This final operation is implemented on the eroded fundus image [5].

C. Classification

Extraction of features from fundus images is possible once the EXs and MAs are detected. After computing all the features, classification models are applied. These features are given as input to these classification models. CNN is a popular classifier for DR detection.

A Convolutional Neural Network (CNN) is a multilayered neural network. This classifier has a unique design for detecting complex features in data once a CNN is constructed, it is possible to use this classifier for classifying the contents of different images. First of all, images are fed into the model. Similar to ANNs, CNNs are inspired by the workings of the human brain. CNNs can perform image classification by detecting features in the way a human brain detects features for identifying objects.



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V. RE

Final Exudates

The implementation of this research work has been carried out in MATLAB. This work compares the presented an earlier approach with regard to accuracy, sensitivity, specificity and execution time as shown below.

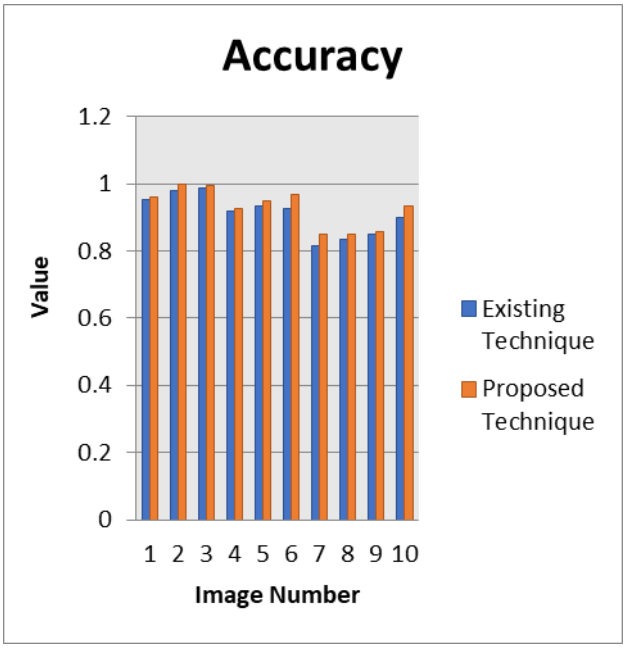

Fig 2: Accuracy Analysis

Figure 2 shows that the accuracy of the new and earlier algorithmic approach is analyzed on a different set of images. As per the analysis, the new algorithmic approach has a higher accuracy than the earlier one.

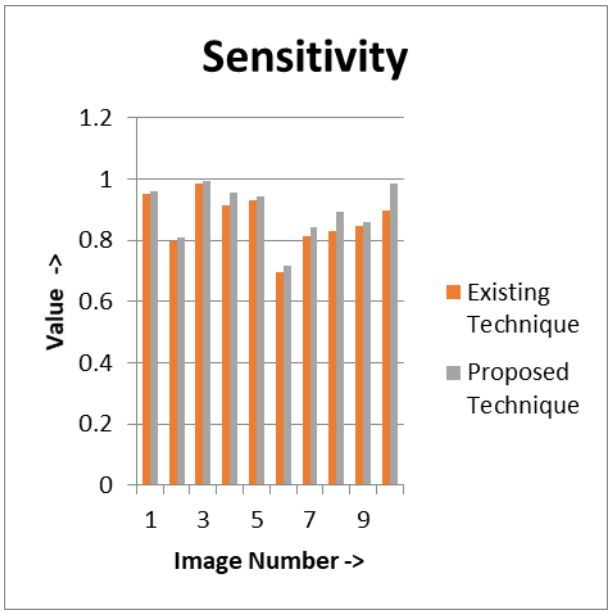

Fig 3: Sensitivity Analysis

Figure 3 shows that the sensitivity of the new and earlier algorithmic approach is analyzed on images acquired from several databases. As per the analysis, the new algorithmic approach has a higher sensitivity than the earlier one.

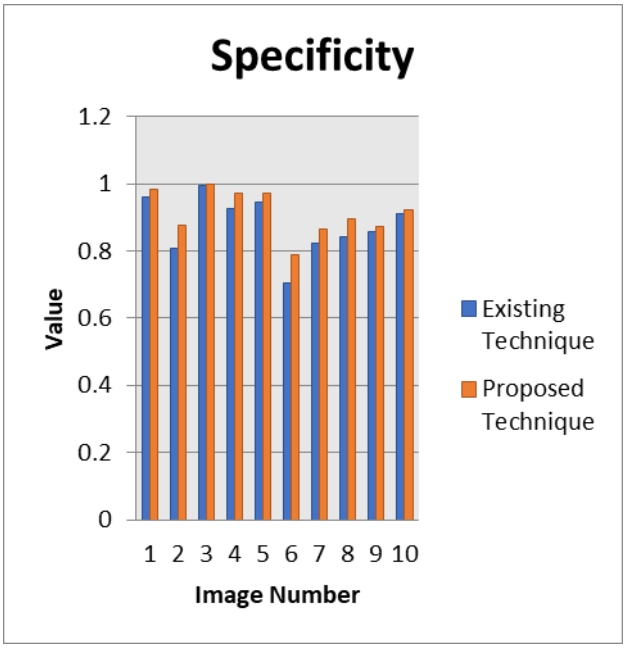

Fig 4: Specificity Analysis

Figure 4 shows that the specificity of the new and earlier algorithmic approach is analyzed on different sets of images. As per the analysis, the new algorithmic approach has a higher sensitivity than the earlier one.

Analysis Type	Existing		Proposed	
	Best	***Worst***	***Best***	***Worst***
Accuracy	0.99	0.81	1.00	0.85
Sensitivity	0.98	0.68	0.99	0.71
Specificity	1.00	0.71	1.00	0.79

Table 1: Comparison metrics

Table 1 shows the comparison of the performances between the existing and proposed techniques, both the worst case and the best case of the same image, on the analysis types of Accuracy, Sensitivity, and Specificity.

VI. CONCLUSION

The detection of diabetic retinopathy is a very challenging task in image processing and machine learning. In this research work, the technique of CNN is applied for classifying diabetic and non-diabetic parts. The proposed algorithm is implemented in MATLAB, and results are compared with the approaches used in the past. The analytic outcomes revealed that the proposed method achieves results for up to 90 per cent for diabetic retinopathy detection.

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