

# A Survey: Deep Learning Methods on Diabetic Retinopathy

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**Abstract:** *Diabetes Mellitus (DM) is a metabolic condition that arises because of the elevated level of blood sugar in the body which triggers eye deficiency, also known as Diabetic Retinopathy (DR) which causes severe vision loss. An effective and efficient tool for early DR diagnosis and assisting experts is a computer-aided diagnosis (CAD) device focused on retinal fundus images that can detect this problem. A CAD method requires different phases in fundus images, such as identification, segmentation and lesion classification. Recent advancement of deep learning (DL) and its definitive victory over conventional ML approaches inspired researchers for implementation of many deep-learning-based techniques using different phases of fundus images. This paper highlights these deep learning approaches along with their pros and cons.*

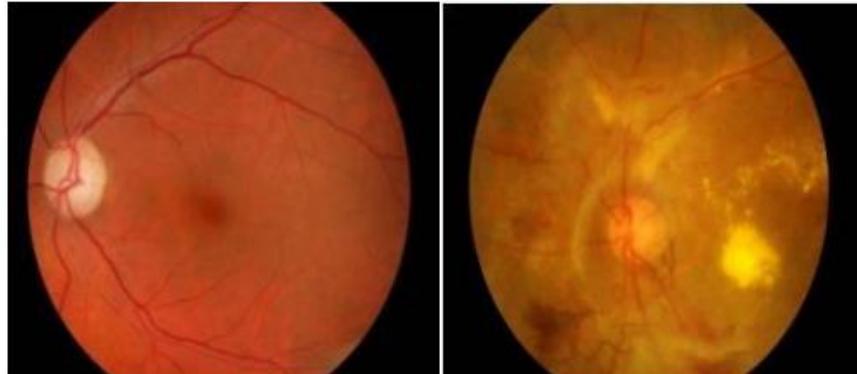
**Keywords:** Deep learning, Convolutional Neural Network (CNN), ResNet50, Diabetic Retinopathy, Fundus Image, Transfer learning.

## I. INTRODUCTION

A The human eye is an important sensory organ which gives us the sensation of sight. The retina is a complex transparent tissue composed of many layers that cover two-thirds of the back of the eyeball, where light stimulation occurs and visual sensation is induced. A disorder that arises due to diabetes is diabetic retinopathy (DR). Diabetes affects the retina of the eye of the patient, so diabetic retinopathy is considered a disorder. A complication of diabetes mellitus, including stroke, heart failure, diabetic nephropathy, and diabetic neuropathy, is Diabetic Retinopathy (DR). In mellitus diabetes, damage to the retinal capillaries occurs. Non-Proliferative Diabetic Retinopathy (NPDR) is the first stage, with mild, moderate and extreme threat levels, while Proliferative Diabetic Retinopathy (PDR) is the second stage, which causes full blindness[1]. Diabetic retinopathy is initially asymptotic, so most patients remain unaware of the disease until their vision is emotionally restricted. In order to prevent further difficulties and to monitor the progression of the disease, prior and consistent screening for diabetic retinopathy is therefore necessary. Exudates, which can be bagged in the eye fundus picture, are a key symptom of DR and are a sign of the patient's development of DR or he may have already developed it.

With conventional machine-learning (ML) methods for DR diagnosis, hand-engineered characteristics are widely used. These conventional approaches have been checked by numerous surveys[2–8]. Mookiah et al.[2] and Mansour[5], for example, identified DR diagnosis according to the methodologies adopted, such as mathematical morphology, retinal lesion. However, expert experience is a requirement for hand-engineered features, and it involves extensive investigation of different choices and repetitive parameter settings to select the right features.

In recent years, the availability of enormous datasets and the enormous Graphics processing units (GPUs) have computing power provided by deep-learning algorithm study with encouragement, which have achieved a definitive victory over conventional hand-engineered tasks. There were also several deep-learning (DL)-based algorithms Developed to examine retinal fundus images for several tasks in order to improve computer -aided automated DR diagnostic systems. The new DL algorithms used in DR detection are analysed in this paper, highlighting the achievements and challenges of recent research papers.



**Figure 1:** Fundus images; (a) Normal image (non-malignant); (b) Diabetic (malignant)

## II. OVERVIEW OF IMAGE PROCESSING IN DIABETIC RETINOPATHY

Image processing is a way of converting a picture into a digital form and conducting a few operations on it, keeping in mind the ultimate objective of having an improved image or extracting any useful data from it. The system for image processing usually consists of treating images as two-dimensional signals, while they essentially apply set signal processing techniques.

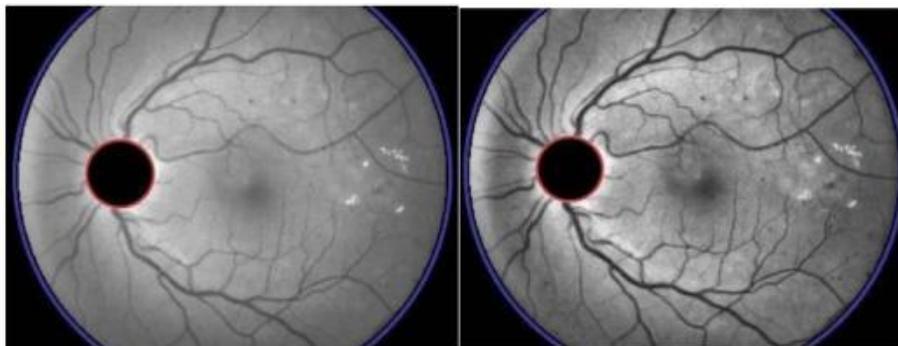
Diabetic retinopathy screening is currently a popular field of research in which several scientists focus on finding and proposing multiple strategies or methods to identify certain characteristics of diabetic retinopathy [14]. However, some scientists propose the development of automated systems for the identification and classification of ordinary or abnormal diabetes retinopathy. The three key components of digital image processing systems are: image preprocessing, feature extraction, and classification.

### 2.1 Image Preprocessing

The preprocessing phase is used to reduce retinal image variations/noise and to improve image contrast and image quality of the fundus image. In addition to noise removal and contrast improvement, the preprocessing stage may be used for image normalization and non-uniform correction of illumination to eliminate artefacts and increase the precision of the steps being taken.

### 2.2 Image Normalization

To compensate for lighting variations, photometric normalisation is used. single-scale retinex scale Contrast Limited Adaptive Histogram Equalization has been implemented with linear, logarithmic transformation. Image normalization is used in Fundus images to reduce intra-image variability. Atul Kumar et al[9] indicated that for brightness correction, color adjustment and contrast enhancement, color normalization can be used.



**Figure 2:** (A) original image and (B) is image after applying Normalization

### 2.3 Feature Extraction

Many feature extraction methods are use with image processing like histogram of oriented gradient (HOG) and Gabor filter based features extraction. The extraction of functions represents a kind of reduction in the dimensionality of a large number of pixels in the image so as to efficiently capture interesting sections of the image.

### III. OVERVIEW DEEP LEARNING WITH DIABETIC RETINOPATHY

In computer vision, artificial intelligence, games and other deep learning technologies are used. For the continued improvisation of DR-detection, researchers start working with deep learning algorithms like neural network, convolution neural network (CNN), recurrent neural network (RNN), Deep neural network .We study the state-of-the-art DL-based algorithms in the following sub-section.

#### 3.1 Neural Network

Neural networks are widely used in application areas such as device detection and control, pattern recognition, medical diagnosis, economic application, data mining, visualisation and many more. In order to present biomedical engineering apps, they have used one of the Artificial Neural Network (ANN) paradigms. One of its common application is breast cancer classification. The techniques and findings of the analysis corresponding to the extraction of laws from a mammography dataset were presented using the Dynamic Fuzzy Neural Network (D-FNN).

Gardner et al.[10] initially developed a screening technique to diagnose diabetic retinopathy automatically using anartificial neural network and to compare the network with the screening of a series of fundus images by an ophthalmologist. As a result, the network achieved exceptional accuracy such that the device could be used to aid diabetic retinopathy screening for diabetes patients.

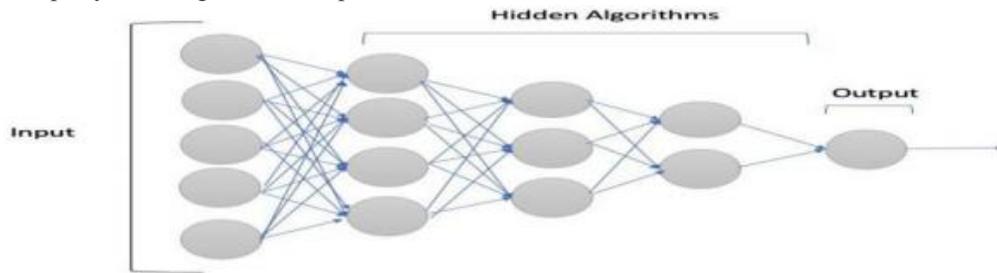


Figure 3: Neural network architecture

#### 3.2 Recurrent Neural Network

RNN is a neural network class, but it is a fully linked neural network with a refactoring of its layer into a loop. It learns and combines the output of the previous iterations with the current input to yield an output, an RNN is thus capable of influencing itself by recurrences.

The blood vessel segmentation issue was formulated by Fu et al.[11] as A task for boundary detection and suggested the method of DeepVessel by Integrating and testing CNN and CRF as an RNN on Move, STARE, and datasets from CHASE.

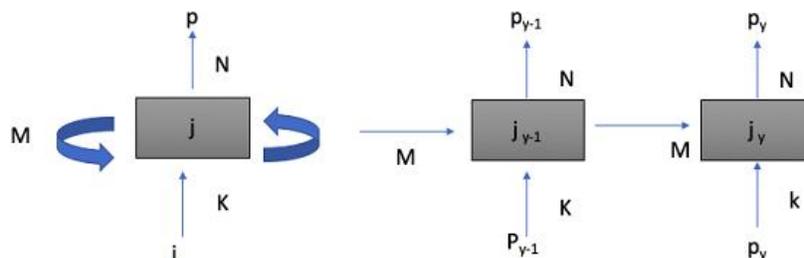


Figure 4: RNN Architecture

### 3.3 Convolution Neural Network

One of the earliest plans to use a 9-layer CNN platform for the OD and OC sectors was Lim et al. [12]. It involves four principal phases: localising the region around the OD, improving this region by over-exaggerating the related visual properties, classifying the improved area at pixels using a CNN model to create a map of probabilities. colour fundus pictures by Carson Lam et al [13] was utilised in the detection of diabetic retinopathy in neural convolution networks (CNNs). A validation sensitivity of 95% has been achieved.

The human visual system is simulated by CNNs and has been commonly used for different computer vision tasks. They consist primarily of three layer types: convolutional, pooling and completely related. To encode local spatial information, convolutional layers use a convolution operation and then FC layers to encode global information.

### IV. LITERATURE REVIEW

Detailed review of above mentioned techniques for DR detection are tabulated and given by Table I.

S. No.	Reference	DR diagnosis Methods	Review
1	[1]	Non-Proliferative Diabetic Retinopathy (NPDR) and Proliferative Diabetic Retinopathy (PDR)	Author presents review on NPDR and PDR where NDPR is the first stage, with mild, moderate and extreme threat levels, while PDR is the second stage, which causes full blindness
2	[2]-[8]	conventional machine-learning (ML) methods for DR diagnosis	Authors [2] and [5], identified DR diagnosis according to the methodologies adopted, such as mathematical morphology, retinal lesion.
3	[14]	Diabetic retinopathy screening	Author [14] explain Diabetic retinopathy screening in which several scientists focus on finding and proposing multiple strategies or methods to identify certain characteristics of diabetic retinopathy.
	[9]	Image normalization in Fundus images to reduce intra-image variability.	Atul Kumar et al[9] indicated that for brightness correction, color adjustment and contrast enhancement, color normalization can be used.
	[10]	Artificial Neural Network (ANN) screening technique to diagnose diabetic retinopathy	Gardner et al.[10] initially developed a screening technique to diagnose diabetic retinopathy automatically using an ANN which increase accuracy such that the device could be used to aid diabetic retinopathy screening for diabetes patients.
	[11]	Recurrent Neural Networks (RNN)	A task for boundary detection for blood vessel segmentation issue was formulated by Fu et al.[11] and suggested the method of DeepVessel by Integrating and testing CNN and CRF as an RNN.
	[12]	Convolutional Neural Networks (CNN)	Lim et al. [12] use a 9-layer CNN platform for the OD and OC sectors. It involves four principal phases: localising the region around the OD, improving this region by overexaggerating the related visual properties, classifying the improved area at pixels using a CNN model to create a map of probabilities.
	[13]	Convolutional Neural Networks (CNN)	Color fundus pictures by Carson Lam et al[13] was utilised in the detection of diabetic retinopathy in neural convolution networks (CNNs). A validation sensitivity of 95% has been achieved.

### V. CONCLUSION

Diabetic Retinopathy (DR) which causes severe vision loss in diabetic patient is diagnosed by several methods. An effective and efficient tool for early DR diagnosis and assisting experts is a computer-aided diagnosis (CAD) device based on retinal fundus images can detect this problem. Various Image processing steps like image preprocessing, image normalization and feature extraction is used for different phases in fundus images, such as identification, segmentation and lesion classification. This paper presents detailed review about various deep learning (DL) methods like ANN, RNN and CNN along with conventional machine learning methods for detection of Diabetic Retinopathy which can be useful in developing new methods of DR detection.

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