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***Abstract*—** *In this paper we discussed a framework on the review of Diabetic retinopathy by using various techniques. The retinopathy is mostly observed in diabetic patients. Most of the diabetes faces this complication which leads to vision impairment and blindness among working-age adults. By detecting the stage of DR as early, then they take treatment in time, so, the risk of blindness can be reduced by 95 %.. By using different classifications and segmentations, the stage of retinopathy can be detected as early as possible. In past, there is a method used for evaluating diabetic retinopathy which involves direct and indirect ophthalmoscopy. Segmentation of blood vessels is a main process of color retinal fundus images analysis for diagnosing diabetic retinopathy in ophthalmology. To detect DR in early stage, the system mainly consists of different steps like pre-processing, segmentation, feature extraction and classifications like NPDR and PDR. The DeepDR system is used for detecting the early and late stages of diabetic retinopathy. The segmentation is applied to the images for detection of diabetic retinopathy has some approaches and methodologies. Segmentation, features and classification results of different techniques for various retinopathy images for detecting DR are reviewed..*

Keywords— *Diabetic images, Blood vessel segmentation, DR Classification, Image processing*

I.INTRODUCTION

Retinopathy is mostly observed in diabetes which leads to blindness. By using proper techniques the diabetic retinopathy can detect in early stage. Based on the stage of diabetic retinopathy appropriate treatment will be available [1]. Due to this, the vision loss will be decreased. Generally, a comprehensive dilated eye exam is best diagnosed for diabetic retinopathy. But, DeepDR system is mostly used, which process diagnosis of DR from early stage to late stage based on the accuracy of retinal tissues. There are some tools which are used to detect DR very effectively like optical coherence tomography (OCT) and Fluorescein angiography. In this, we are providing a review on classifications and segmentation of diabetic retinopathy. The classification is very important to categorize, classify and stage the severity of DR in order to provide appropriate treatment [2]. Segmention is the process of automatic detection of blood vessels boundaries. If the features are lost during segmentation which are again region merging and passed them through the image classifier with the accuracy up to 93.33% [3]. DR is progressive conditions that lead to retinal ischemia, retinal permeability, etc.

There are mainly two different types of diabetes those are Type 1 and Type 2. The reasons and reactions are different for each type: In first type i.e., type 1 diabetes, the retinopathy can occur at any age, but most of the cases had observed in children, young persons (age from 13 to 19) and young adults (generally age from 18 to 22 or 18 to 25). This type diabetes their bodies can't provide sufficient glucose to get energy. As the body can't provide energy, then the body tries to get the energy from elsewhere which stats to break down the stores of protein and fat. This causes to weight loss. If the body does not use any glucose, the insulin producing cells will destroyed. Due to this reaction, which will be effected by any virus or infection [5]. The notice of symptoms of type 1 diabetes can take months or years of time. The symptoms can develop in a few weeks or a month also. Once the symptoms will appeared then the person get severe stage. In second type diabetes i.e., type 2 diabetes, only insulin is not sufficient, so the cells are partially unlocked and glucose builds up in the blood. It makes up most diabetes cases. Mostly, this was occurs in old age persons. However, because of high obesity rates, teens and young adults are now being diagnosed with it. In type 2 diabetes, many of them they don't know as they have this disease.[5].

In these techniques and process, some are not accurate and some techniques are not effective in performance. From all these techniques, the best and the important techniques are discussed in segmentation and classification (sec 4 and 5) which will gives better accuracy and effective results in the detection of DR process. Finally, we concluded with the best techniques of segmentation and classification of

DR which give a high accuracy rate.

II. METHODOLOGY

Many researchers describe diabetic retinopathy detection technology with better performance and higher accuracy. When detecting DR, any system can follow steps such as preprocessing, segmentation, feature extraction, and classification. The belowshown figure is the block diagram for implementing the system for detecting DR.

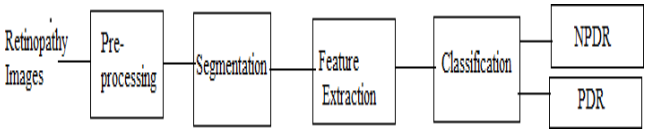

Figure1: Image analysis and detection DR

III.PRE-PROCESSING

In image analysis and detection of DR the first step is the preprocessing which is used to removing noise with the help of Gaussian filter and the next one is DR detection which includes some methods like segmentation and classification. In segmentation, which is used to remove optic papilla with the help of blood vessel segmentation and the features will be extracted mainly based on their shape,textual, and region. Digital images have various types of noises. In the image acquisition process, noise is a result oferror, which affects the value of pixels. Due to this, the original intensities of the actual scene will be change. The noise can be introduced into an image in several ways that depending on the creativity of an image. There are some real time examples of occurring noise in an image. When an image is scanned from a photograph which is made on a film, here the source of noise is film grain. Due to this noise the film will be damaged or it can affect the scanner also. Another example is, when the image is acquired directly in the form of data, then the noise can introduced by gathering the data. To avoid these type of problems, imnoise function is provided by the toolbox. In this process, various types of noises are used to add to an image.

In pre-processing, another method will be useful to remove the noise, that is, image enhancement. There are some useful examples and methods of image enhancement: Filtering with morphological operators, Linear contrast adjustment, Median filtering, Contrast-limited adaptive histogram equalization (CLAHE). The below fig. shows the difference between an image after enhancement and after enhancement.

Figure 2: An image before pre-processing and after pre-processing

IV.SEGMENTATION

Image segmentation is a fundamental step for pattern recognition application in many computer visions. From the past three decades, in numerous scientific fields which including medical imaging computerized segmentation techniques have been observed. Landsite image analysis, machine vision, etc. In the process of image analysis, segmentation plays very important role and performed as a first step in producing a description of the image. In this step an image can analyzed, which determines whether the algorithm is successes or failure. Due to this, the successful image can analyzed, which require the need of robust image segmentation algorithms. Image segmentation is the procedure of finding the problem related to segments in an image. Filtering of noisy images and find the problems of feature extraction and recognition are some of the applications of image segmentation range[8].

Segmentation is a key issue in modern biomedical image analysis, which enabled numerous clinical applications. Computerized lesion detection and classification have become important in clinical diagnosis with the introduction of digital imaging devices in medical systems. One of the applications of segmentation is where one may be interested in locating and segmenting Diabetic retinopathy Lesions in fundus image. Image segmentation is also necessary in volumetric analysis of particular lesion and structures. Another important image segmentation application is automated biological image understanding, which is related to Diabetic Retinopathy. It plays an important role in finding the sie and shape of lesion. Thus, image segmentation takes part in a vital role in biological/biomedical images understanding and analysis [10].

In the process of detecting severity of retinopathy by segmentation method, there are several steps including removing the optic papilla from the fundus image. While performing the removal of papilla, which will be useful to segment the blood vessels accurately. In most of the DR detection methods, segmentation has mainly two types, there are optic disk segmentation and blood vessel segmentation.

In a retinal fundus image, one of the most important part is Optic disc. The detection of OD is often considered as a preprocessing step in the automatic image segmentation of retinal structures [11]. The optic disk has a shape that is most commonly described as an elliptical. The central zone, or cup, of the oval features more densely packed cells than the peripheral zone which surrounds it. Image segmentation refers to dividing an image into its component parts by drawing lines between corresponding points on the graphical representation of said image. The different segmentations of an image as shown in below figure3.

Figure 3: Segmentation of an image

Several methods for the segmentation of retinal image have been reported by many authors. Blood vessel segmentation of Retinal image can be divided into two groups based on machine learning methods; those are supervised methods and unsupervised methods [13]. Supervised methods are based on the prior labeling information which gives the information about which pixels belong to which vessel or non-vessel classes. Whereas, unsupervised methods do not use prior labeling information and have ability to learn and organize information. It can find the patterns or clusters that resemble the blood vessels on its own. Filtering or kernel-based methods use a Gaussian form curve to model the cross-section of a vessel and, it can rotate the matched filters to detect blood vessels with different orientations. Different shaped Gaussian filters such as simple Gaussian model and derivative of Gaussian function have been used for blood vessel detection.

V.CLASSIFICATIONS

DR progresses from mild to moderate stages when there is no proper intervention. To get timely treatment, It is essential to identify the disease at an earlier stage. There are mainly two types of Diabetic Retinopathy, those are Non-Proliferative Diabetic Retinopathy (NPDR) and Proliferative Diabetic Retinopathy (PDR) [14]. Non-proliferative retinopathy is defined by Microaneurysms, cotton wool spots, and hemorrhages, and proliferative retinopathy is defined by iris or retinal neovascularization. Non-Proliferative DR (NPDR) is a milder structure. It is generally symptomless, while Proliferative (PDR) is a high-level phase of DR, and it prompts the arrangement of abnormal veins in the retina. It causes extreme misfortune during this stage. These features are examined by ophthalmoscopy or fundus images, and they can be graded in clinical terms as normal, mild, moderate, and severe Diabetic Retinopathy for research purposes.

There are five stages of Diabetic retinopathy; they are Mild NPDR, Moderate NPDR, Severe NPDR, Very severe NPDR and Prolific DR [15].

Mild Non Proliferative Diabetic Retinopathy

This is the beginning stage of non-proliferative dementia, which is defined by the presence of at least one microaneurysm. Microaneurysms are small tears in the brain tissue that are visible under an eye scope. This condition typically develops over time and leads to more serious forms of dementia.This is the starting stage of non-proliferative DR that is, mild NPDR and is characterized by the presence of at least one microaneurysm. Microaneurysms are the early sign of DR that are ophthalmoscopically visible. These appear as red dots and are difficult to distinguish from small dot hemorrhages. The rupture of these microaneurysms results in haemorrhages. The haemorrhages in the deeper layers of retinal appear as blot haemorrhages. Superficial haemorrhages may appear as flame shaped haemorrhages as those seen in hypertensive retinopathy.

Moderate Non Proliferative Diabetic Retinopathy

This is characterized by intra retinal microaneurysms and blot haemorrhages of greater severity [16]. Cotton wool spots, venous calibre changes including venous beading and intra retinal micro vascular abnormalities are present but which are in less amount.

Severe Non Proliferative Diabetic Retinopathy

In severe non proliferative DR can present at least any one of these one, Haemorrhages and microaneurysms in all four quadrants of the fundus. Venous beading can present in at least two quadrants. Intra retinal micro vascular abnormalities can present in at least one quadrant. In addition to clogging the many blood vessels that supply multiple areas of the retina, the body is signaled to grow new vascular tissue to supply blood [18].

Very Severe Non Proliferative Diabetic Retinopathy

Patients are diagnosed with very severe nonproliferative DR when the eye examination shows two or more of the above findings.

Proliferative Diabetic Retinopathy

Proliferative DR is characterized by new vessels arising from retinal vasculature. Severity of Proliferative DR is determined by the area covered with new vessels in comparison with the area of the disc. When they are located at or within one disc diameter of the optical disc they are called Neo Vascularisation of the Disc (NVD). When they are further than one disc diameter from the optic disc they are called Neo Vascularisation Elsewhere (NVE). The characteristics are any new blood vessels on the Optic Disk or new vessels elsewhere in the fundus. The below figure shows the different classifications of Diabetic Retinopathy.

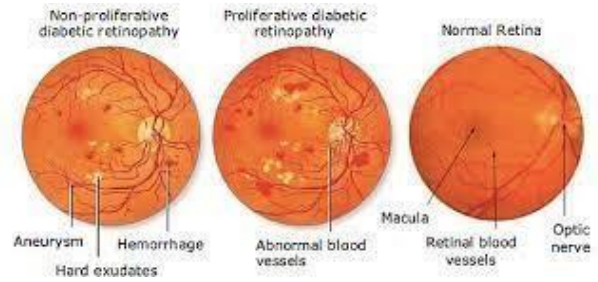

Figure 4: Different classifications of DR

Prolonged and untreated type-2 diabetes is the cause of diabetic retinopathy among diabetic patients. It is a

progressive degenerative retinal disease and is the principal source of low vision in patients between 25 and 74 years of age. The enormous categories of patients who increase DR have no indications by which time it may be too late for effective treatment [19]. Because the rate of progression may be rapid, it is important to screen patients with diabetes regularly for the development of retinal disease. Retinal vessels provide nourishment to the retina and its nerve fibers. In diabetic retinopathy, these blood vessels leak, causing fluid and blood to leak into the retina, especially the macula. When this becomes swollen and thickened, the macula (center of vision) cannot properly function. This causes the central vision to become blurred. Sometimes the blood vessels in Diabetes is blocked and the parts of the retina that depend on these blood vessels for nutrition cease to function. New blood vessels attempt to supply nutrients to areas that are no longer able to receive adequate nutrition from the blocked blood vessels. This results in neovascularization that leads to bleeding and scarring, often leading to severe vision loss or complete blindness. To sum up, diabetic retinopathy is characterized by various pathologies like microaneurysms, hard exudates, soft exudates, haemorrhages, etc.

Untreated Diabetic retinopathy can progress to the Proliferative stage of Diabetic Retinopathy (PDR), which is more severe than NPDR. It occurs when the eye begins to make new abnormal blood vessels. This process is known as neovascularization [21]. Damaged blood vessels shut off in this type, allowing the retina to develop new abnormal blood vessels, which may leak into the translucent, jelly-like fluid covering the middle of the eye. It has a higher risk of having adverse visual consequences [24]. The retinal blood artery is destroyed during the proliferative stage of DR. The major characteristic for detecting the proliferative phase is the retinal blood vessels. PDR develops abnormal blood vessels that form at the vitreoretinal interface in the retina [25]. Neovascularization is a distinctive characteristic of the proliferative stage that separates it from the non-proliferative stage. Because DR is such a severe retinal condition, if it is not discovered early enough, it can result in blindness.

RESULTS

The comparative results of accuracy of number of diabetic retinopathy images using different segmentation methods observed by different authors are given in below table.

Table 3: Segmentation result 1 (DRIVE database)

Method	Accuracy
Jiang et al. [22]	0.8911
Staal et al. [23]	0.9441
Soares et al. [26]	0.9466
Fraz MM et al. [28]	0.9469
Chandani Nayak et al.[29]	0.9724

The comparative results of accuracy, sensitivity and specificity of number of diabetic retinopathy images using different DR classifications observed by different authors are given in below table

Table 2: Performance evaluation of DR classification using IDRiD datasets

	Accuracy	Sensitivity	Specificity
Sakaguchi et al. (2019) [30]	78.3%	-	-
Saha, O et al. (2019) [31]	96.1%	96.4%	78.91%
Kind A. and Azzopardi G (2019) [32]	-	94%	83%
Song Guo et al. (2019) [33]	-	-	84.17%
Gabriel Tozatto et al. (2020) [34.]	-	75.3%	84.1%
Serener, A., & Serte, S (2020) [35]	58.54%	72%	56.54%

CONCLUSION

Diabetic Retinopathy is the common effect of blindness worldwide, although it is generally subclinical until severe. Vision loss can be prevented, when DR is treated at an early stage. If DR is untreated, it can results to a severe stage. So, a regular screening of the patient is required for early detection and treatment. Automated detection of Diabetic Retinopathy from digital fundus images are investigated by different DR classifiers. In the DR detection system Optic Disk can be concentrated and blood vessels extraction is possible. For eye disease, these blood vessels near optic disc region play an important role in diagnosis. This region can checked by an Ophthalmologist to detect normal and abnormal vessels. Sensitivity, specificity, and accuracy are calculated for different classifiers for different image datasets by many researchers.. The performance of these classifiers is effective and also they provide good accuracy.

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