Literature Review on the Diabetic Retinopathy in Retinal Images

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Abstract—Diabetes is one of the most harmful diseases of our age and that’s because of the fast and unhealthy pace of our lives. Numbers are still rising and the number of people getting diabetes is increasing around the world, one of the most recognizable side effects of Diabetes is Diabetic Retinopathy that might lead to total loss of sight in the diabetic patients and that’s if it is not detected and medicated early, for the importance of early detection of this disease there is a great effort in the literature to early detect Diabetic Retinopathy, a literature review is introduced in this report to cover the different aspects of retinopathy and its detection methods. In this review we try to cover a great part of the literature and our review based on two parts: the first part about the detection of the lesions of the Diabetic Retinopathy including hemorrhages, microaneurysm and exudates. The second part is about the measuring of different severity level of diabetic retinopathy and its detection and classification systems.

Keywords—Diabetic retinopathy, Medical Images, Retinal images, Feature extraction, Segmentation.

I. INTRODUCTION

Diabetes which is scientifically known as diabetes mellitus (DM) is a disease usually caused by a deficiency at the pancreas that leads to low level of the insulin production which is the hormone responsible of maintaining the sugar level in the blood. The lack of the insulin production will definitely results in the increase of the glucose concentration in the blood, which leads to the damage in multiple organs of the human body, specifically in the vessels and nerves specially retinal vessels [1].

According to the ADA (American Diabetes Association), more than 25.8 million of the adults and children which utilize 8.3% of the population in the United States diabetes patients [1], And these numbers will keep increasing because of the changing life style and the reduced physical activity. The study in [3] was conducted on 91 countries around the world predicted a jump in the numbers of adults with diabetes reaching a rate of 69% in developing countries and a rate of 20% in developed countries in the next few years.

Diabetes is a silent disease the detection is related to the appearance of the multiple primary and secondary symptoms, and without the full conscious of the patient the disease will cause more damage to the retinal vessels causing deflection to the eyes and leading in some cases to the total loss of sight.

One of the famous side effects of diabetes is the diabetes retinopathy or Diabetic Retinopathy (DR) that can causes severe eyes damage and blindness for diabetic people, commonly DR is resulted from long-term diabetes, Diabetic Retinopathy comes usually as result of the leakage of proteins and other fluids from retina vessels which causes the formation of exudates on the surface of the retina that leads to vision impairment. Researchers have shown that the chance of contracting a diabetic retinopathy rise in a person with more than 10 years of diabetes in 80% [4]. Nowadays this health burden affects the life of more than 100 million people worldwide, a study conducted between 1990 and 2010 estimates that DR-related blindness and vision problems increased by 64% and 27%, respectively [5].

Diabetic Retinopathy (DR) considers as very dangerous eye disease because people with diabetic retinopathy might not feel any symptoms in the beginning of the disease, the patient will not feel any symptoms until a serious damage happened to the retina, these symptoms includes: vision Blurring, nighttime seeing difficulties, blood vessels swelling in the eye, fluid leakage, growing abnormal blood vessels on the retina’s surface. As the problem getting worse, a new blood vessel grows on the retina which blurs the vision. Unfortunately, the damage to the retina happened to be in the two eyes, so the vision is changed gradually in the diabetic patients. In Fig 1 the difference between the vision of a patient with diabetic retinopathy and a vision of normal individual is shown.
As most of the health problems, the early diagnosis of the disease can reduce complications of disease in the 90% of the cases. There are many efforts to detect the early symptoms of this harmful disease. One of these techniques is the detection of the abnormalities in the retina and blood vessels in the retinal images. These techniques include the use of various techniques of image processing and computer vision techniques including: neural networks, classification techniques etc.

In this research paper we will review the different detection techniques of the diabetic retinopathy from retinal images, the paper is arranged as follows: a background about retinopathy features and fundamentals are presented in section two which describes some of important aspects of the diabetic retinopathy disease and its detection methods, it followed by a literature review and the work done in this field of research and finally a conclusion is introduced.

II. BACKGROUND

The changing level of blood sugar can be considered as the main signal of diabetic retinopathy that would causes severe damages to the eye vessels, which mainly nourishes the eye-retina. this changing level of blood sugar can lead to a leakage of blood and fluids from the capillaries that might cause a permanent damage to the retina [7]. This leakage help in the formation of different DR related features like hard exudates (HEs), microaneurysms (MA), hemorrhages (HEM), cotton wool spots (CWS), venous loops, etc. [8]. Fig. 2 describes the difference between healthy retina and a retina affected with DR.

According to severity and the presence of the DR features such as microaneurysm an Hemorrhages the diabetic retinopathy is classified to two categories or stages: non-proliferative DR (NPDR), and Proliferative Diabetic Retinopathy (PDR), these two types can be further classified according to their severity into three phases: mild DR, moderated DR and severe DR.

A. Diabetic Retinopathy Features:

A.1 Microaneurysm (MA):

The earliest feature can be detected in DR is Microaneurysm (MA). MA is round in shape small objects that has dark red spots. MA usually has sharp margins that ranges between 20 to 200 μm [10]. Increasing number of microaneurysm will lead to retinal ischemia and retinopathy progression. The formation of MA caused usually by the abnormal permeability of retinal blood vessels [11]. The microaneurysms can cause a blockage of retina blood vessels in addition to wakening the vessels wall [12]. These microaneurysms may rupture, causing hemorrhages [12]. According to an international classification of DR levels of severity [13], the MA are features that can be always found or detected in the early phases of DR while the hemorrhages could be found in more advanced phases.

A.2 Hemorrhages:

Hemorrhages (HEM) are the next symptom of DR which causes a pressure to the vessels that will lead to the bleeding of a jelly texture substance at the center of the eye. HEM are primarily caused of the leakage of a weak vessels. As the MA, HEM are also in the form of a red spot with varying density and non-uniform margin. Dimensionally is 125 μm [10]. HEM are usually classified into two categories: flame and dot-blot HEM (DBH), in the first type it originates from the precapillary arterioles and emerges at the nerve fibers. In the other side the DBHs are round in shape and smaller comparing to MA. DBHs can emerge at different levels of retina and it can occurs at the venous end of capillaries.

A.3 Hard exudates:

Hard exudates (HE) are the third symptom of DR that are yellowish, irregular in shape and shiny. HE can exist inside the retina which, Unlike MA, are causing of a leaking of lipoproteins and proteins out of the retinal vessels [14]. HEs are usually taking the form of a circular ring neighboring the MA and tend to be found in outer layer of the retina.
the retina [10] Fig.3 shows an example of these features in the human retina images.

![Retina Images](image)

The more advanced type of diabetic retinopathy is known as (PDR) Proliferative DR, PDR is basically the formation of new blood vessels in the eye and hemorrhage, that scares the retina and other parts of the eye. This causes many problems with sight and might lead to complete vision loss. Studies in [15] showed that approximately 3% of the patients suffer complete vision loss with such condition.

Fig 4 shows the stages of PDR according to its severity.

![PDR Stages](image)

NPDR is the first stage where enlarged blood vessels and fluids leaking into the retina that might lead to sight problems, Fig 5 shows the three stages of (NPDR). According to its severity, NPDR can be classified into three stages: mild, moderate, and severe NPDR.

1. Mild: It is usually characterized by the presence of at least one MA with or without any HE, HEM, or CWS. Research showed almost 40% of the diabetic patients possess minimally mild NPDR symptoms [16].

2. Moderate: It characterizes the presence of a number of both MAs and HEM. Study in [16] revealed that almost 16% of the patients having moderate NPDR are probable to develop PDR within a year.

3. Severe: this types of NPDR are characterized by a list of one or more of these characteristics:

   a) multiple HEM and MA in all four retinal quadrants;
   b) bleeding (venous) in two or more quadrants; and
   c) Intra-retinal microvascular abnormalities in minimum one quadrant.

The study in [15] revealed that there is a 50% probability that severe NPDR can become PDR within one year.

![NPDR Stages](image)

C. Diabetic Macular Edema (DME):

An additional category in the field of DR is diabetic macular edema (DME), which is an important representation of this disease that can be detected at any severity level of DR both NPDR and PDR and it manifest the most common cause of vision loss in patients with DR, it is usually induced from diabetes-induced breakdown of the blood-retinal barrier (BRB), with continues fluid and circulating proteins leakage into the [17,18]. The abnormal
thickening in the retina comes as result of excessive leakage of fluid into the neural retina and often cystoid edema of the macula.

III. DIABETIC RETINOPATHY FEATURES DETECTION

A massive research effort is done in the field of the diabetic retinopathy. Many researchers tried to find the perfect detection tools that can approve the early detection of diabetic retinopathy and assess the medication process to stop the progress of the disease early. The diabetic retinopathy detection is similar in most of the proposed systems in the literature and that can be generalized into four steps these steps are: preprocessing of the image to modify or enhance the image, retinal elements elimination such as optic disk, macula, and blood vessel, then a segmentation is done using different segmentation techniques and finally classification to have final decision of the system.

This part reviews the recent development of analyzing retinal images for DR detection. We tried to review the studies in this field and we based our literature on two parts the first one assess the detection of DR based on the detection of three features explained in the next parts and the second part that assess the detection of DR and classification its severity level. The overall segmentation methods can be mathematical morphology-based, or region growing based, or transformation based: wavelet, Gray Level Cooccurrence Matrix (GLCM) or hybrid approach based methods.

A. Microaneurysm (MA) Detection:

Microaneurysm is the earliest feature that can be detected in DR, so there are a reasonable amount of the literature that are constraining on the detection of this feature. In the major of researches, segmentation is done for the MA after the elimination of the retinal elements such as: optic disk, macula, and blood vessel.

One of the most famous mathematical morphology based for microaneurysm detection methods proposed by Navarro et al. [19]. Their approach based on segmentation using a multiphase model, at the first phase they performed image preprocessing by using a polynomial contrast enhancement approach on fundus image. Next, they localize MA by applying Tophet transform technique on fundus image. Further, MA segmentation was performed using Global thresholding model. Finally, classification was done by applying Gaussian, kernel density based classifiers and K Nearest Neighbor Classifier (k-NN). The performance of their method shows high sensitivity 97% and accuracy 84%.

In the second category, Region Growing Based MA Detection, Kumar et al. [20] proposed an approach concentrating on both number and area of MA. First, they applied a pre-processing step such as green channel extraction, histogram equalization and morphological operation. For the detection of MA, they used Principal Component Analysis (PCA), Contrast Limited Adaptive Histogram Equalization (CLAHE), morphological process. Finally, they perform the Classification by using a linear Support vector machine (SVM). They achieve a sensitivity and specificity rate of the detection system approaching 96% and 92% respectively.

Fleming et al. [21] applied another segmentation approach for MA using both of contrast normalization, watershed and region growing approaches. First, they processed the image with median filtering then they applied a 2-D Gaussian. Second, contrast normalization of the fundus image using its standard deviation was applied and finally they used Region growing model watershed gradient image to enable candidate region perceptible and detectable. To perform MA detection they used k-NN classifier and they achieved sensitivity rate of 95% and specificity rate of 84.6% to detect Images containing MA and exudes.

Another approach proposed by Hashim et al. in [22] they identify the abnormal region by operating on region by region in the entire image. After applying different techniques of image preprocessing and enhancement to the selected region, they perform the feature extraction using a Gray Level Co-occurrence Matrix (GLCM) applied to the region. They detect several features including MA hard and soft exudes. In The final step all extracted features obtained were fed to SVM classifier and they achieved 82.39% and 62.42% for sensitivity and specificity respectively.

For wavelet transform methods, Quellec et al. [23] proposed segmentation of MA using wavelet transform technique, in this approach to detect MA they matched the sub bands of wavelet transformed images with the lesion template. Unlike other approaches they achieve detection without candidate region extraction and classification. They achieved 93.74% for sensitivity.

Another approach using wavelet was proposed in [24], first the pre-processed image is segmented by applying Legendre transformation. The wavelet transforms can be
applied to transform data, and then encode the transformed data, ensuing in effective compression. First order statistical, discrete wavelet transform (DWT) and GLCM features are taken and trained by Artificial Neural network classifier. Radial Basis function is applied to classify the severity level of Diabetic Retinopathy. Finally, the test image is loaded and preprocessed. The features are extracted and the evaluation of diabetic retinopathy is performed based on clinical symptoms. They test their approach on several databases and achieve almost 100% accuracy levels.

A hybrid model for MA detection in [25, 26], it is a hybrid red lesion segmentation model where they at first apply pixel classification technique to identify the red lesion ROIs. Next, they applied segmentation to segment retina blood vessels and red lesions, and to perform the extraction they ignored the connected vasculature and retrieve the segmented ROI, the classification was done using k-NN classifier. For sensitivity and specificity they achieved are approaching 87.69% and 92.44% respectively.

Table 1 summarize the reviewed research in the field of Microaneurysm (MA) Detection.

<table>
<thead>
<tr>
<th>NUM</th>
<th>Segmentation/Features extraction methods</th>
<th>Database</th>
<th>Classification Method</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>[19]</td>
<td>Tophet transform technique, Segmentation by global thresholding</td>
<td>MESSIDOR</td>
<td>K-NN</td>
<td>SEN=97% ACC=84%</td>
</tr>
<tr>
<td>[20]</td>
<td>(PCA)(CLA-H)</td>
<td>DIABETD21</td>
<td>SVM</td>
<td>SEN=96% ACC=92%</td>
</tr>
<tr>
<td>[21]</td>
<td>segmentation by watershed and region growing</td>
<td>13 219 test images</td>
<td>K-NN</td>
<td>SEN =95% ACC= 84.6%</td>
</tr>
<tr>
<td>[22]</td>
<td>GLCM feature extraction</td>
<td>DIARETDB1</td>
<td>SVM</td>
<td>SEN = 82.39% ACC=62.42%</td>
</tr>
<tr>
<td>[23]</td>
<td>wavelet transform approach</td>
<td>1900 test images acquired from 52 DR patients</td>
<td>None</td>
<td>SEN = 93.74% ACC=-</td>
</tr>
<tr>
<td>[24]</td>
<td>segmentation by Legendre</td>
<td>DRIVE, MESSIDOR, E-OPHTHA</td>
<td>NN</td>
<td>SEN = -</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DIARETDB</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>K-NN</td>
<td>SEN = 87.69% ACC=92.44%</td>
</tr>
</tbody>
</table>

Table 1: Microaneurysm (MA) Detection.

B. Hemorrhages (HEM) Detection:

The first clinically detected lesions indicating diabetic retinopathy are Hemorrhages and Microaneurysm, therefore their detection is very important for this kind of systems. First stage is the extraction of red lesion candidate which requires excessive application of different image preprocessing techniques in order enhance the image, reduce noise and improve contrast. The classification comes in the second stage that is applied to decide that the detected features is a hemorrhage (abnormal) or not hemorrhage (normal).

In the Morphological methodology approaches researchers tend to use different techniques used for extracting image components. Shivaram et al. [27] as preprocessing step they applied mathematical morphology methods for detection of hemorrhages and discriminate the detected results from the blood vessels. The result was compared with ophthalmologists’ hand-drawn ground-truth images pixel by pixel. As result they reported rates of 89.49, 99.89 and 98.34 for sensitivity, specificity and predictive values respectively.

A method for segmentation that based on the morphological reconstruction retina lesion was proposed by Kande et al.[28], they proposed a pixel classification and mathematical morphology for the detection of Microaneurysms and hemorrhage. They used the matched filter and top-hat transformation morphological method to detect red lesion candidates. To classify the detected results to red lesion and non-red lesion areas they used Support Vector Machine (SVM). The method was tested with 89 retinal images selected randomly from 3 databases STARE, DIARETDB, and DIARETDB1 and they achieved a sensitivity rate of 100% and specificity rate of 91%.

In the neural network field there are a vast amount of research, one of the first approaches was proposed by
Garcia et al. [29], their approach based on using a Neural Network to detect features based on color and shape, extraction was carried out by morphological and region growing method and selection was done by logistic regression. They applied Three NN classifiers : multilayer perceptron (MLP), radial basis function (RBF) and support vector machine (SVM). Preprocessing applied to the images and a classification applied using the previously mentioned classifiers. finally, they achieved the best performance with SVM as sensitivity of 100 % and specificity of 56 %.

In the classification Tang et al. [30] used segmentation of splats by using watershed algorithm, a similar collection of pixels in color and spatial location. They used automated vessels segmentation method to remove connected vasculatures. feature selection was done using the K-NN classifier. Another approach that perform splat segmentation is the approach in [31] they first perform splats segments that share the same intensity, color and spatial location. We can extract different features from each splat. Then, feature selection is carried out from the extracted features based on different filters, area, color, texture and splat related features etc. For classification of different features SVM is used for classifying to DR features and non DR features. The method achieved an 89% sensitivity and an 88% specificity.

Sharath kumar P N et al.[32] the proposed system consists of four stages process, first a preprocessing in order to Standardize the retinal images using cubic interpolation, local contrast enhancement and background subtraction. Then they localize the optic disk and blood vessel regions the optic disk and blood vessel regions. to detect the DR different symptoms they used each of HSV space, Gamma correction, histogram, binary thresholding, shade correction, top-hat transform, contrast limited adaptive histogram equalization. finally to classify the retina as DR or Non-DR they used water-fall model. The proposed method achieved sensitivity rate of 80% and specificity rate of 50%.

Bae et al. [33] proposed hybrid method of hemorrhage detection that based on using region growing method. First, to extract Hemorrhage candidates they used a circular shaped template matching with normalized cross-correlation (NCC). Then, a segmentation of hemorrhages was done by two methods of region growing: region growing segmentation using the local threshold and adaptive seed region growing segmentation. They achieved a sensitivity of 85%.

Table 2 summarize the reviewed research in the field of Hemorrhages (HEM) Detection.

<table>
<thead>
<tr>
<th>NUM</th>
<th>Features extraction method</th>
<th>Database</th>
<th>Classification Method</th>
<th>Results sensitivity and specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>[27]</td>
<td>mathematical morphology</td>
<td>Fundus images captured by fundus camera</td>
<td>None</td>
<td>SEN = 89.49%, ACC=99.89%</td>
</tr>
<tr>
<td>[28]</td>
<td>pixel classification, mathematical morphology</td>
<td>STARE DIARETD B1</td>
<td>SVM</td>
<td>SEN = 100%, ACC=91%</td>
</tr>
<tr>
<td>[29]</td>
<td>morphological region growing</td>
<td>115 images</td>
<td>NN</td>
<td>SEN = 100%, ACC=56%</td>
</tr>
<tr>
<td>[30]</td>
<td>Splat segmentation</td>
<td>MESSIDO R DRIVE</td>
<td>K-NN</td>
<td>SEN = 80%, ACC = -</td>
</tr>
<tr>
<td>[31]</td>
<td>Splat segmentation, Feature extraction</td>
<td>MESSIDO R</td>
<td>SVM</td>
<td>SEN = 89%, ACC=88%</td>
</tr>
<tr>
<td>[32]</td>
<td>HSV space, Gamma correction, histogram, binary thresholding, shade correction, top-hat transform</td>
<td>1344 retinal images of 368 diabetic patients at the Regional Institute of Ophthalmology (RIO)</td>
<td>Water fall</td>
<td>SEN = 80%, ACC=50%</td>
</tr>
<tr>
<td>[33]</td>
<td>a morphological filter region growing method</td>
<td>DRIVE STARE</td>
<td>None</td>
<td>SEN = 85%, ACC= -</td>
</tr>
</tbody>
</table>

Table 2 : Hemorrhages (HEM) Detection.
C. Exudates Detection:

The last studies symptoms of retinopathy is exudates, most of the research in the literature based on applying segmentation techniques on the retinal images to segment the area that includes the feature. As before the most basic steps is starts with preprocessing and moving to apply different segmentation techniques and finally the use of different classification techniques. In this part of the literature we found a great deal of systems that based on the exudates detection that using The Morphological Methodology Approaches which used in most of the systems in addition to the use of different classification techniques to classify the detected features from images.

Fleming et al. [34] the applied system proposed a system aimed to exudates detection in retinal fundus images by developing a multiscale morphology model. First, they preprocess green channel images to correct the variations in image natures by applying median and Gaussian filtering models. For the detection, they used multiple linear structuring elements with a single disk shaped structuring component. Next, to isolate the results from the retinal blood vessels they applied watershed retinal region growing model. As final step, support vector machine (SVM) was applied for classification to exudates and non-exudates. Their proposed model has registered rates of 99.6%, 98.7% for sensitivity, specificity respectively on online database.

Welfer et al. [35] applied exudates segmentation using mathematical morphology like local minima detection, morphological reconstruction and H-maxima transform. They proposed method was evaluated and tested on the known database DIARETDB1 and they achieve an average sensitivity rate of 70.48% and an average specificity rate of 98.84%.

In [36] they proposed an exudates detection technique. The proposed two steps approach, the first step is preprocessing and image enhancement to remove noise, the second step is localization of the connected components in the image and call them blobs. Then the resulted blobs are divided to three categories on the basis of number of pixels they contain and again put the large blobs to processing stage to remove strong boundary effect. Finally, a custom designed morphological cascading tree is used to remove non-exudates. The morphological tree contains morphological filters which filter out the non-exudates blobs. The results of experiments showed 78% and 56% for sensitivity, specificity respectively.

Anitha et al.[37] proposed a feature detection system based on a threshold based segmentation. Next, HOG (histogram of gradient) Classification was done using the convolutional Neural Network (CNN) classifier. Their approach was tested on a data set of color fundus images taken from STARE database and the values of sensitivity, specificity and accuracy were found as 96%, 98% and 99.68% respectively for the neural network based classification.

Osareh et al. [38] applied a feature selection approach that based on the genetic algorithm GA. At first, FCM technique was used for ROI segmentation. Next, The identified ROIs were processed for feature extraction and then selection using GA. Further, NN classifier was applied to classify the region into exudates or non-exudates. The proposed approach was implemented and tested using a large image dataset of 300 images and the results showed an accuracy including 93.5% sensitivity and 92.1% predictivity for identification of retinal exudates at the pixel level.

Ganesan et al. [39] applied a system that based on used trace transformation on fundus images. At first, they developed a trace transform model based human visual system where they used SVM algorithm for the features extraction. Further, they applied feature selection and DR classification using GA and probabilistic NN (PNN) algorithms respectively. They test their method and achieved an accuracy rate of 99.41% and rate of 99.12% for sensitivity and predictivity respectively.

Table 3 summarizes the reviewed research in the field of exudates detection.

<table>
<thead>
<tr>
<th>NUM</th>
<th>Features extraction method</th>
<th>Database</th>
<th>Classification Method</th>
<th>Results sensitivity specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>[34]</td>
<td>morphology model watershed retinal region growing model</td>
<td>DRIVE</td>
<td>SVM</td>
<td>SEN = 99.6%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ACC=98.7%</td>
</tr>
<tr>
<td>[35]</td>
<td>morphology model</td>
<td>DIARETDB1</td>
<td>None</td>
<td>SEN =70.48%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ACC=98.84%</td>
</tr>
</tbody>
</table>

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The degree and level of the diabetic retinopathy based on the detected features.

A decision system for diabetic retinopathy early stages detection proposed in [40], their Methodology starts by image enhancement and image pre-processing. For marking the region of interest, they applied different techniques including: Oriented and rotated binary robust independent basic feature algorithm (BRIEF) and Speeded up Robust Features (SURF) were used. To extract the feature from the region of interest they used: Gabor Attributes (GA) and Discrete Fourier Transform Attributes (DFTA). To get the significant features feature selection is done using Spectral Regression Discriminant Analysis (SRDA). Finally, classification of stages of DR were done using Logistic regression (LR) and Random Forest (RF) classifiers. The proposed system achieved 85.33% sensitivity, 94.66% specificity and 90% accuracy.

There are two stages of Diabetic retinopathy: Non Proliferative Diabetic Retinopathy (NPDR) and Proliferative Diabetic Retinopathy (PDR). The early stage is NPDR which progresses in three stages namely mild, moderate and severe. There are a vast amount of literature that concentrate on this kind of classification bounding their classification between (NPDR) and (PDR), such as the system in [41]. The paper proposed a method of filter based retinal vessel extraction, Fuzzy C means for exudates detection, Convex Hull used for detection and removal of optical disk. They used Support Vector Machines (SVM) for the classification of the fundus images into Normal and Non-proliferative Diabetic Retinopathy (NPDR) or Proliferative Diabetic Retinopathy (PDR). The system achieved an efficiency rate of 96.23%.

Another system classifying between (NPDR) and (PDR) is the system in [42], they proposed an algorithm for the patch wise extraction of texture and vesselness features. Gabor wavelet transform was used to obtain the vessel map for the feature extraction. The feature set extracted from the images are classified using a random forest classification. The images are classified into Normal, PDR or NPDR (Non Proliferative Diabetic Retinopathy). The method was tested on STARE and MESSIDOR database and achieved sensitivity of 90% and specificity of 87.5%.

Moreover, the other systems in the literature extend their classification of diabetic retinopathy into its different stages mild, moderate and severe. In this area, Dhiraj Chelvi E et al., [43] proposed another a method for assessing the degree of the DR using SIFT (Scale-invariant feature transform). First a preprocessing was done using

<table>
<thead>
<tr>
<th>[36]</th>
<th>morphological cascading tree</th>
<th>A data set of 10 images manually collected</th>
<th>None</th>
<th>SEN =78%</th>
<th>ACC=56 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>[37]</td>
<td>threshold based segmentation</td>
<td>STARE</td>
<td>CNN</td>
<td>SEN =96%</td>
<td>ACC=98%</td>
</tr>
<tr>
<td>[38]</td>
<td>GENATIC ALGORITHM S</td>
<td>300 manually collected</td>
<td>NN</td>
<td>SEN =93.5%</td>
<td>ACC=92.1%</td>
</tr>
<tr>
<td>[39]</td>
<td>SVM ALGORITHM S</td>
<td>STARE</td>
<td>GN PNN</td>
<td>SEN =99.41%</td>
<td>ACC=99.12%</td>
</tr>
</tbody>
</table>

Table 2: exudates Detection.

IV. DIABETIC RETINOPATHY SEVERITY LEVEL DETECTION:

Diabetic Retinopathy (DR) is diagnosis is based on analysis of different features in retinal images. To assess the severeness of disease it is necessary to look for the signs of diabetic retinopathy. The existence of microaneurysms mostly characterize the Early stages of the disease. As the disease progresses, hemorrhages and exudates become apparent. In later stages of diabetic retinopathy the full set of symptoms becomes apparent in the patient. In the other part of the literature there are a wide part of systems that concentrating on the detection of the different symptoms in addition to assess the severity level of the diabetic retinopathy. In this part we will have a look on these kind of systems along with their performance and results.

As in the features detection system these systems start with the same process by preprocessing the image, illumination the non-image features, segmentation and finally classification of the detected features. In addition to these steps the severity level will be assessed according to
each of gray scale conversion, salt and pepper noise, median filter at the pixel level to achieve enhancement and denoising of the Image. The SIFT feature points and histogram value are calculated for input image and template images by matching both the images. Morphological operations were used to calculate the numbers of connected components. The decision whether it is affected by NPDR or PDR is depending on the comparison of these output score and also determines the stages as mild, moderate, severe. In the proposed approach the test results and performance accuracy achieved is 93%.

The methods in [44] combines between the detection of three DR famous features including exudates, hemorrhages and affected blood vessels. The proposed approach consists of several stages which are: pre-processing of the image, detection of vessel and hemorrhages, removal of optic disc and detection of exudate. However, the detection for blood vessel and hemorrhages was performed simultaneously due to similar intensity characteristics. The algorithm was tested on images from the known database DIARETDB1. All of the images were categorized into four DR stages, namely mild Non-Proliferative Diabetic Retinopathy (NPDR), moderate NPDR, severe NPDR and Proliferative Diabetic Retinopathy (PDR). The method achieves sensitivity of 98% and specificity of 100%.

Moreover, Sarwinda et al. [45] proposed a classification of the stage of Diabetic Retinopathy (DR) into three classes, namely normal, mild Non-Proliferative Diabetic Retinopathy (NPDR), and moderate/severe NPDR class. To achieve that they first extract the feature using the Histogram of Oriented Gradients (HOG). As a feature selection method they applied factor analysis. Finally, they implemented Support Vector Machines learning and Random Forest learning for classification to moderate/sever NPDR vs. mild NPDR, mild NPDR vs. Normal, and moderate/severe NPDR vs. Normal. The method was tested and achieved around 85% accuracy.

Table 4 summarize the reviewed research in this field of that constrains in the severity level detection of the diabetic retinopathy in addition to the detection of the disease itself.

| [41] | filter based retinal vessel extraction, Fuzzy C means | DIARET DRIVE MESSIDOR | SVM | SEN = - ACC = 96.23%
| [42] | Gabor wavelet transform. | MESSIDOR STARE | random forest | SEN = 90% ACC = 87.5%
| [43] | SIFT morphological operations | 100 test images | None | SEN = - ACC = 93%
| [44] | blood vessel and hemorrhages | DIARETDB1 | None | SEN = - ACC = 98%
| [45] | (HOG) factor analysis | 150 images set | SVM | SEN = 93% ACC = 80%

Table 4: Diabetic Retinopathy Severity Level Detection.

V. CONCLUSION

Diabetic retinopathy considered as one of the most evolved disease nowadays. Statistics shows that within the next few years the diabetic retinopathy will reach dangerous level. Early detection can increase the chance of therapeutic interventions that would reduce its risk and protect the patient vision. The approaches and efforts in the literature are vast and vibrant. In this report I tried to cover a part of the literature that proposed to detect different symptoms of the disease such as Microaneurysm, hemorrhages and exudates detection. In addition to the system that assess the severity level after the detection of different symptoms. I noticed that there is a vast effort to implement systems to help to automate the detection of the disease which might contribute to detect in early stages and cure the disease. So, as future work, we will try to proposed a detection and classification automated system to participate in this area that is very crucial to save lives.

REFERENCES

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