A Comprehensive Review of Early Detection of Diabetic Retinopathy from Digital Fundus Images

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***Abstract*—The effects of the eye abnormalities are mostly gradual in nature which shows the necessity for an accurate abnormality identification system. Abnormality in retina is one among them. Most of the ophthalmologists depend on the visual interpretation for the identification of the types of diseases. But, inaccurate diagnosis will change the course of treatment planning which leads to fatal results. Hence, there is a requirement for a bias free automated system which yields highly accurate results. In this paper, we are classifying normal and abnormal retina. . We first present an summary of diabetic retinopathy and its causes. Then, a literature review of the maximum current automatic detection of diabetic retinopathy techniques is offered. Explanation and restrictions of retina databases which are used to test the performance of these detection algorithms are given. Here we project a vital assessment of the current researches associated with the retinopathy detection process. In this paper, we present a wide review of major researches on disease detection process based on various features.**

***Keywords*—Gabor filtering, Adaptive histogram equalization, optic disk measurement, RGB segmentation, OCT, Skeletonization, Vein diameter measurement.**

1. INTRODUCTION

Diabetic retinopathy is damage to the retina caused by complications of diabetes mellitus, which can eventually lead to blindness. It is an ocular manifestation of systemic disease which affects up to 80% of all patients who have had diabetes for 10 years or more. The detection of hemorrhages is one of the important factors in the early diagnosis of diabetic retinopathy (DR). The existence of hemorrhages is generally used to diagnose DR or hypertensive retinopathy by using the classification scheme [9] Diabetic retinopathy (DR) remains the commonest cause of blindness in the working age population of the developed world. Effective treatment is available if the condition is detected early, before visual symptoms occur. The need for a comprehensive DR screening programme has long been recognized and it is now feasible [8]. It is a silent disease and may only be recognized by the patient when the changes in the retina have progressed to a level, that treatment is complicated and nearly impossible [13].This disease can be prevented from developing into blindness if it is treated at an early stage. However, it has been recorded that approximately 3,000 people have lost their vision following the onset of DR. Fundus photographs obtained by the fundus camera are used to diagnose DR [10].

Digital imaging is widely used for diabetic retinopathy screening. The storage and transmission of digital images can be facilitated by image compression. The ease and flexibility of digital photography has led to the widespread use of this technology for ophthalmic imaging, particularly for retinal screening [6]. The retina is a forward extension of the brain and its blood vessels. Images of the retina tell us about retinal, ophthalmic, and even systemic diseases. The ophthalmologist uses images to aid in diagnoses, to make measurements, to look for change in lesions or severity of disease, and as a medical record [7]. Although the accessibility of retinal fundus photographs suitable for screening these diseases, a large number of examinations will result in an increased burden for ophthalmologists. Computerized analysis of retinal fundus images can potentially reduce ophthalmologists' workload and improve diagnostic efficiency [1]. The structure of retinal vessels is a prominent feature that reveals further information on the state of diseases that are reflected in the form of measurable abnormalities in diameter, color, and tortuosity. Thus, reliable methods of vessel detection that preserve various vessel measurements are needed [20].

Pathologies in the ocular fundus are a major cause of blindness. These pathologies include diabetic retinopathy and age-related macular degeneration (ARMD). In both of these conditions, the distribution of blood and/or macular pigments is altered from the normal [5]. Ocular fundus image can provide information on pathological changes caused by some eye diseases and early signs of certain systemic diseases, such as diabetes and hypertension. Pathological changes of the retinal vasculature are a feature of many diseases. For example, diabetic retinopathy is often characterized by the presence of new blood vessels, venous beading, micro aneurysms, and intra- retinal macular abnormalities. Several vascular diseases, such as diabetic retinopathy, have manifestations that require analysis of the vessels network. In other cases, e.g. pathologies like Retinal micro aneurysms and hemorrhages, the performance of automatic detection methods may be improved if regions containing vessels can be excluded from the analysis [11]. A possibility of providing some automated assistance in this screening process lies in accurate computer measurement of vessel width and tortuosity near the posterior pole (back) of the retina [12].

Optic Disc is considered one of the main features of a retinal fundus image where methods are described for its automatic detection. OD Detection is a key preprocessing component in many algorithms designed for the automatic extraction of retinal anatomical structures and lesions [3] The relatively constant distance between the OD and the fovea can be used to help estimate the location of the latter. The OD is considered the exit region of the blood vessels and the optic nerves from the retina, also characterized by a relatively pale view owing to the nerve tissue underlying it. The main features of a fundus retinal image are defined as the optic disc, fovea and blood vessels. The optic disc is the entrance and exit region of blood vessels to the retina and its localization and segmentation is an important task in an automated retinal image analysis system. Indeed, the fovea corresponds to the region of retina with highest sensitivity [11]. OD segmentation is also relevant for automated diagnosis of other ophthalmic pathologies. One of them and may be the most relevant is Glaucoma. It is the second most common cause of blindness worldwide. This disease is identified by means of recognition of the changes in shape, color or depth that it produces in the OD [15].

Diabetic macular edema is the main cause of visual impairment in diabetic patients. Exudates are well contrasted with respect to the background that surrounds them and their shape and size vary considerably [2]. Diabetic macular edema (DME) is a complication of DR and it is a common cause of vision loss and blindness. DME occurs from swelling of the retina in diabetic patients due to leaking of fluid from micro aneurysms within the macula [18]. The OD region is removed before identifying retinal exudates, which are used to assess and grade risk of Macular Edema (ME). It provides a modality that greatly reduces subjective human variation and the cost of the current screening process and therefore facilitates a more objective and economical method of diagnosis. In addition, the technology offered by the computer system will likely be an aid to human experts to produce diagnostic results of higher quality and accuracy [16].

Revascularization is the most serious abnormality type in diabetic retinopathy and consists in the formation of new blood vessels that are weak and can therefore easily break, causing hemorrhages which appear as dark irregular spots on the retina [14]. Maculapathy is the advanced stage of diabetic retinopathy, where the injuries are located at the area near the macula (the part of the retina that provides clear vision). If this disease is not diagnosed at its early stages, its progress will eventually lead to blindness. Its symptoms are hidden until late stages of the disease [17]. many computer image analysis methods based on image processing and machine learning have been proposed to interpret digital photographs of the retina to increase the efficiency of early detection of DR [4] The economic and social consequences of vision loss in people with the eye disease diabetic retinopathy (DR) could be reduced considerably if an inexpensive broad-based screening program existed for this disease [19].

2. DIFFERENT TYPES OF DIABETIC RETINOPATHY

It can be classified in different ways, but there are three main types:

- Non-proliferative retinopathy
- Maculopathy
- Proliferative retinopathy.

2.1 Proliferative Diabetic Retinopathy (PDR)

It refers to a severe stage of diabetic eye disease in which new blood vessels proliferate on the surface of the retina. Most patients with PDR have had Non-proliferative Diabetic Retinopathy for at least a few years prior to developing the proliferative form of the disease. The diagnosis of PDR requires the presence of new proliferating blood vessels (neo-vascularization) arising from the retina or optic disc and growing on the retinal surface or into the vitreous cavity. This diagnosis is made primarily by examination of the retina and sometimes by fluorescein angiography.

Fig. 1: Tuft of neo-vascularization

The photograph shows a tuft of neo-vascularization (arrowhead) extending from the optic nerve head into the vitreous cavity. These new vessels take on a frond-like configuration as they grow, similar in appearance to a sea fan. The photograph on the right is a fluorescein angiogram of a different patient showing a frond of vessels (arrowhead) extending from the disc. Neo-vascularization leaks fluorescein dye (white in this photograph), giving it a fluffy appearance.

2.2 Diabetic Maculopathy

In diabetic maculopathy, fluid rich in fat and cholesterol leaks out of damaged vessels. . If the fluid accumulates near the center of the retina, there will be distortion of central vision. If too much fluid and cholesterol accumulates in the macula, it can cause permanent loss of central vision. CSME (clinically significant macular oedema) is the term given to describe water logging of the macular area. The area of the retina we use most is called the macula. It provides our central vision and is essential for clear, detailed vision.In maculopathy, the haemorrhages, exudates and swellings of the non-proliferative stage occur in the macula

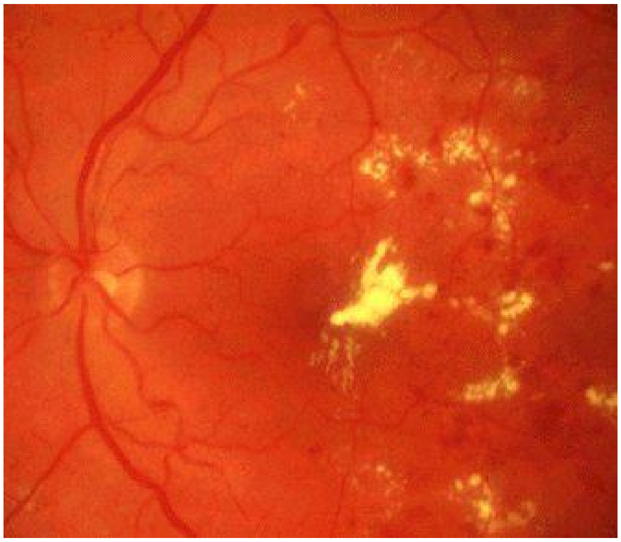

Fig. 2: Diabetic maculopathy

Diabetic maculopathy requires treatment if fluid is leaking into the macula. The treatment begins with identifying the leaking blood vessels on the fluorescein angiogram. Laser treatment can be applied to seal the leaking vessels. The laser is an intense beam of light which can be finely focused on each individual leak. Laser is effective in stabilizing or improving vision in 75% or patients with macular edema. Despite treatment, 25% of patients continue to lose vision due to recurring leaks. Control of the diabetes and blood pressure is important in reducing the chances of leaking vessels returning following treatment. The fluid often takes up to 2 to 3 months to dry up following closure of abnormal vessels. Visual recovery is slow and gradual. If the fluid persists, the fluorescein angiogram is repeated to determine the site of the vessels still leaking and laser treatment may be repeated. The average patients needs 2-3 laser sessions per eye to control diabetic maculopathy over the course of their lifetime.

2.3 Pre-proliferative (or Background) diabetic retinopathy

It is primarily a disease of retinal blood vessels. It is the result of two major processes affecting the retinal blood vessels: vessel closure and abnormal vessel permeability.

2.3.1 Retinal Blood Vessel Closure

The earliest vessel closures in diabetic retinopathy are usually the capillaries. These small vessels are critical to the health of the retina, since they are needed to deliver oxygen and nutrients to the area and to carry away carbon dioxide and other waste products. The source of this capillary closure is not completely understood. Theories as to why these vessels close off include:

- Clumping of blood cells or other blood elements.
- Abnormality or damage to the endothelium (the cells lining the inner wall of the capillary).
- Swelling of an abnormally permeable vessel wall.
- Compression of the capillary by surrounding retinal swelling.

Diabetics tend to have capillary closure causing areas of decreased oxygen supply to the small patches of retina corresponding to these capillaries. There is an associated dilation of the adjacent capillaries, probably in response to the decreased oxygen level in that part of the retina. In addition, small focal dilations of the retinal capillaries called micro aneurysms can develop. These micro aneurysms are small sacs budding off from the vessel, often visible as tiny red dots on ophthalmologic examination. It is thought that micro aneurysms are the result of weakened capillary walls that allow a bulging outward of the endothelial lining of the capillary.

Localized closure of retinal capillaries (non-perfusion) is not usually noticed by the patient, since the non-perfuse area is so small. However, if the non-perfusion is in the central portion of the retina (the fovea), the vision can be significantly reduced. There is no known treatment for this visual loss due to foveal non-perfusion.

The below diagram shows the photograph of retinal vessels which shows the larger artery (A) and vein (V) as well as a tangle of smaller retinal capillaries. Multiple round micro aneurysms (arrowhead) can be seen attached to the retinal capillaries.

Fig. 3: Retinal capillary closure

Retinal capillary closure can produce Proliferative diabetic retinopathy in more severe cases. When multiple areas of the retina have lost their blood supply, they start to send out chemical signals called neurogenic factors. These neurogenic factors stimulate the development of new blood vessels that are fragile and can cause bleeding and scar the retina. This is one way blindness associated with diabetes occurs.

2.3.2 Abnormal Vessel Permeability

Retinal blood vessels are different from vessels elsewhere in the body. Most blood vessels are fenestrated, meaning that they have tiny openings that allow fluid to pass through the vessel wall. The openings are small enough to prevent the egress of larger blood elements such as blood cells and large proteins), but large enough to allow water and small molecules such as ions to pass. Retinal blood vessels, on the other hand, have tight junctions between the cells of the blood vessel wall, so all fluid and molecules exiting the vessel have to pass through the cells. This lack of fenestration helps keep the retina relatively dehydrated, which is necessary for proper function.

In diabetic retinopathy, the vessels become more permeable. Water, blood cells, proteins, fats, and other large molecules may leak out into the surrounding retinal tissue. Accumulation of this fluid in the central region of the retina (the macula) is called macular edema or diabetic maculopathy. Diabetic Maculopathy is the most common cause of decreased vision in patients with background or non-proliferative diabetic retinopathy. It is visible on examination as a thickening and slight graying of the retina, and is often associated with exudates (yellow clumps or spots within the retina). Exudates are the result of fats and proteins leaking out of the permeable vessels along with water. The water can be quickly reabsorbed into the vessels or into the tissue under the retina, but the fatty material is absorbed only very slowly. These fatty exudates are left behind like a "bathtub ring", often in a ring-like shape surrounding the leakage site.

Fig. 4: multiple micro aneurysms (small arrowheads) and hemorrhages

This photograph of a retina shows multiple micro aneurysms (small arrowheads) and hemorrhages scattered through the macular region. There is an area of diabetic maculopathy to the left of center, with some associated yellow exudates (large arrowhead).

Swelling in the retina is fairly common in background diabetic retinopathy, but it is not always significant swelling. In other words, retinal edema does not always affect vision and does not always need to be treated. Edema in the retina is considered "clinically significant" if it is close enough to the center of the retina to pose a risk to vision. This was defined more precisely in the Early Treatment Diabetic Retinopathy Study (ETDRS), a large multi-center study designed to evaluate the usefulness of laser treatment for diabetic maculopathy. The diagnosis of clinically significant macular edema (CSME) requiring treatment is made by your eye care professional. If possible, it is best to find diabetic maculopathy when it is clinically significant, but before it affects the vision, since treatment is most effective at this stage.

Image segmentation is a subjective and context-dependent cognitive process. It implicitly includes not only the detection and localization but also the delineation of the activated region. Contextual segmentation refers to the process of partitioning a data into multiple regions. The goal of segmentation is to simplify and / or change the representation of data into something that is more meaningful and easier to analyze. Data segmentation is typically used to locate data in a vector. Segmentation is done using contextual clustering and classification of the exudates is done using radial basis function (RBF) network. The performance classification of exudates by using RBF and CC is better than that of using only CC.

3. LITERATURE SURVEY

The problem inherent in DR is that the patient is not aware of the disease until the changes in the retina have progressed to a level that treatment will tend to be less effective. Automated screening techniques for exudates detection have great significance in saving cost, time and labour. Image processing techniques for exudates detection can help in extracting the location, size and severity grade of exudates in the retinal images. The screening of diabetic patients for the development of diabetic retinopathy can reduce the risk of blindness by 50%. With a large number of patients, the number of ophthalmologists is not sufficient to cope with all patients, especially in rural areas or if the workload of local ophthalmologists is substantial. Therefore, automated early detection could limit the severity of the disease and assist ophthalmologists in investigating and treating the disease more efficiently.

Automated image processing techniques have the ability to assist in the early detection of diabetic retinopathy disease which can be regarded as a manifestation of diabetes on the retina. Blood vessel segmentation is the basic foundation while developing retinal screening systems, since vessels serve as one of the main retinal landmark features However, in screening examinations, the fundus images obtained are usually macula-centered for screening for various diseases in the larger retinal area. Therefore, it may be more reliable to use temporal vessels for the AVR measurement in such images. The main goal of this screening process is to reliably identify subjects who have progressed to threshold disease, so they can be promptly treated. At present this screening process is carried out by ophthalmologists skilled in the examination of infants' eyes.

There may exist different kinds of abnormal lesions caused by diabetic retinopathy, the most frequent being microaneurysm, hard exudate, softexudate, hemorrhage, and neovascularization. All these pathologies have specific characteristics and are important in the clinical assessment of this disorder. Some of the main issues regarding medical image processing are image enhancement, feature extraction, classification etc. employing analog and/or digital techniques. content-based image retrieval (CBIR) which uses visual content of images to search amongst large databases. The main idea here is the extraction of visual features from an image, and stores them as an index of that. Retrieving is carried out later based on those visual features and a similarity measurement scheme. It is desirable to detect hemorrhages and micro aneurysms on retinal fundus images without using the contrast medium; however, detection of hemorrhages and micro aneurysms is difficult because of their low contrast in non contrast images. Therefore, a computer-aided diagnosis (CAD) system for the detection of these lesions can help ophthalmologists and physicians who review the mass screening exams in diagnosing DR.

A handful of researches have been presented in the literature for Diabetic Retinopathy using various methods. Recently, the use of automation method using fundus images for DR have received a great deal of attention among researchers. A brief review of some recent researches is presented here

Giri Babu Kande *et al* [21] presented an algorithm for the extraction of Blood Vessels from Fundus images using Matched filter and thresholding based on Spatially Weighted Fuzzy c-Means (SWFCM) clustering algorithm. Such a tool proved them self useful to eye care specialists for purposes of patient screening, treatment, and clinical study. They make use of a set of linear filters sensitive to vessels of different orientation and thickness. Such filters were obtained as linear combinations of properly shifted Gaussian kernels. The Spatially Weighted Fuzzy c-Means clustering algorithm was formulated by incorporating the spatial neighborhood information into the standard FCM clustering algorithm. An experimental evaluation demonstrates superior performance over global thresholding and a vessel detection methods recently reported in the literature. Due to its simplicity and general nature, their algorithm were expected to be applicable to a variety of other applications.

Yuji Hatanaka *et al* [9] indicated that the importance of developing several automated methods for detecting abnormalities in fundus images. The purpose of that study was to improve their automated hemorrhage detection method to help diagnose diabetic retinopathy. They found a new method for preprocessing and false positive elimination in the present study. The brightness of the fundus image was changed by the nonlinear curve with brightness values of the hue saturation value (HSV) space. In order to emphasize brown regions, gamma correction was performed on each red, green, and blue-bit image. Subsequently, the histograms of each red, blue, and blue-bit image were extended. After that, the hemorrhage candidates were detected. The brown regions indicated hemorrhages and blood vessels and their candidates were detected using density analysis. They removed the large candidates such as blood vessels. Finally, false positives were removed by using a 45-feature analysis. To evaluate the new method for the detection of hemorrhages, they examined 125 fundus images, including 35 images with hemorrhages and 90 normal images. The sensitivity and specificity for the detection of abnormal cases was were 80% and 88%, respectively. Those results indicate that the new method may effectively improve the performance of their computer-aided diagnosis system for hemorrhages.

Apichat Suansilpong and Petch Rawdaree [26] demonstrated that Single-field non mydriatic digital fundus image was a convenient screening tool for a diagnosis of diabetic retinopathy. The test could be achieved by a trained endocrinologist who could practically serve his patients in one visit at diabetic clinics. A referral to an ophthalmologist was still recommended in any cases with abnormal findings, or those with questionable findings, and those with poor quality photographs when diabetic retinopathy could not be definitely excluded.

Atsushi Mizutani *et al* [24] stated that the presence of micro aneurysms in the eye was one of the early signs of diabetic retinopathy, which was one of the leading causes of vision loss. They have been investigating a computerized method for the detection of micro aneurysms on retinal fundus images, which were obtained from the Retinopathy Online Challenge (ROC) database. The ROC provides 50 training cases, in which "gold standard" locations of micro aneurysms were provided, and 50 test cases without the gold standard locations. In that study, the computerized scheme was developed by using the training cases. Although the results for the test cases were also included, that paper mainly discusses the results for the training cases because the "gold standard" for the test cases was not known. After image preprocessing, candidate regions for micro aneurysms were detected using a double-ring filter. Any potential false positives located in the regions corresponding to blood vessels were removed by automatic extraction of blood vessels from the images.

Twelve image features were determined, and the candidate lesions were classified into micro aneurysms or false positives using the rule-based method and an artificial neural network. The true positive fraction of the current method was 0.45 at 27 false positives per image. Forty-two percent of micro aneurysms in the 50 training cases were considered invisible by the consensus of two co-investigators. When the method was evaluated for visible micro aneurysms, the sensitivity for detecting micro aneurysms was 65% at 27 false positives per image. Their computerized detection scheme could be improved for helping ophthalmologists in the early diagnosis of diabetic retinopathy.

Aliaa Abdel-Haleim Abdel-Razik Youssif *et al* [3] stated that the Optic disc (OD) detection was a main step while developing automated screening systems for diabetic retinopathy. They present a method to automatically detect the position of the OD in digital retinal fundus images. The method starts by normalizing luminosity and contrast throughout the image using illumination equalization and adaptive histogram equalization methods respectively. The OD detection algorithmis based on matching the expected directional pattern of the retinal blood vessels. Hence, a simple matched filter was used to roughly match the direction of the vessels at the OD vicinity. The retinal vessels were segmented using a simple and standard 2-D Gaussian matched filter. Consequently, a vessels direction map of the segmented retinal vessels was obtained using the same segmentation algorithm. The segmented vessels were then thinned, and filtered using local intensity, to represent finally the OD-center candidates. The difference between the matched filter resized into four different sizes, and the vessels' directions at the surrounding area of each of the OD-center candidates was measured. The minimum difference provides an estimate of the OD-center coordinates. It was evaluated using a subset of the STARE project's dataset, containing 81 fundus images of both normal and diseased retinas, and initially used by literature OD detection methods. The OD-center was detected correctly in 80 out of the 81 images (98.77%). In addition, the OD-center was detected correctly in all of the 40 images (100%) using the publicly available DRIVE dataset.

Michael D. Abràmoff *et al* [4] found that Diabetic retinopathy detection algorithms seem to be maturing, and further improvements in detection performance cannot be differentiated from best clinical practices, because the performance of competitive algorithm development now has reached the human intra reader variability limit. Additional validation studies on larger, well-defined, but more diverse populations of patients with diabetes were needed urgently, anticipating cost-effective early detection of DR in millions of people with diabetes to triage those patients who need further care at a time when they have early rather than advanced DR.

Nathan Silberman *et al* [28] described that Diabetic retinopathy, an eye disorder caused by diabetes, was the primary cause of blindness in America and over 99%of cases in India. India and China currently account for over 90 million diabetic patients and are on the verge of an explosion of diabetic populations. That may result in an unprecedented number of persons becoming blind unless diabetic retinopathy can be detected early. That paper describes their early experiences working with Aravind Eye Hospitals to develop an automated system to detect diabetic retinopathy from retinal images. The automated diabetic retinopathy problem was hard computer vision problem whose goal was to detect features of retinopathy, such as hemorrhages and exudates, in retinal color fundus images. They described their initial efforts towards building such a system using a range of computer vision techniques and discuss the potential impact on early detection of diabetic retinopathy.

V.Vijaya Kumari and N.SuriyaNarayanan [33] indicated that Diabetic retinopathy was the cause for blindness in the human society. Early detection of it prevents blindness. Image processing techniques can reduce the work of ophthalmologists and the tools used automatically locate the exudates. Early detection helps the patients to aware of the seriousness of the disease. In that paper they present a method which was automatic and involves two steps: optic disk detection and exudates detection. The extraction of optic disk was done using propagation through radii method. Exudates detection was done using feature extraction, template matching and enhanced MDD classifiers and the methods were compared.

María García *et al* [34] subscribed that Diabetic retinopathy (DR) was an important cause of visual impairment in industrialized countries. Automatic detection of DR early markers can contribute to the diagnosis and screening of the disease. The aim of that study was to automatically detect one of such early signs: red lesions (RLs), like haemorrhages and micro aneurysms. To achieve that goal, they extracted a set of colour and shape features from image regions and performed feature selection using logistic regression. Four neural network (NN) based classifiers were subsequently used to obtain the final segmentation of RLs: multilayer perceptron (MLP), radial basis function (RBF), support vector machine (SVM) and a combination of those three NNs using a majority voting (MV) schema. Their database was composed of 115 images. It was divided into a training set of 50 images (with RLs) and a test set of 65 images (40 with RLs and 25 without RLs). Attending to performance and complexity criteria, the best results were obtained for RBF. Using a lesion-based criterion, a mean sensitivity of 86.01% and a mean positive predictive value of 51.99% were obtained. With an image-based criterion, a mean sensitivity of 100%, mean specificity of 56.00% and mean accuracy of 83.08% were achieved.

Meindert Niemeijer *et al* [22] implemented that the detection of micro aneurysms in digital color fundus photographs was a critical first step in automated screening for diabetic retinopathy (DR), a common complication of diabetes. To accomplish that detection numerous methods have been published in the past but none of these was compared with each other on the same data. In that work they present the results of the first international microaneurysm detection competition, organized in the context of the Retinopathy Online Challenge (ROC), a multi-year online competition for various aspects of DR detection. The set of data used for the competition consisted of 50 training images with available reference standard and 50 test images where the reference standard was withheld by the organizers. The results obtained on the test data was submitted through a website after which standardized evaluation software was used to determine the performance of each of the methods. A human expert detected micro aneurysms in the test set to allow comparison with the performance of the automatic methods. The overall results show that microaneurysm detection was a challenging task for both the automatic methods as well as the human expert. There was room for improvement as the best performing system does not reach the performance of the human expert. The data associated with the ROC microaneurysm detection competition will remain publicly available and the website will continue accepting submissions.

Balint Antal and Andras Hajdu [23] presented an approach to improve microaneurysm detection in color fundus images. This task was usually realized by candidate extraction, which was followed by a classification step. Their method aims to increase the number of true positives in the first phase of the microaneurysm detection process. Thus, they establish a framework for selecting an optimal combination of preprocessing methods and candidate extractors. Their investigation shows that the state-of-the-art candidate extractors provide significantly improved results, when they were optimally combined with preprocessing approaches. they show that the performance can be further increased with an ensemble formed by a globally optimal combination of the preprocessing methods and candidate extractors.

Hussain F. Jaafar *et al* [40] proved that Retinal image analysis was commonly used for the diagnosis and monitoring of diseases. In fundus photographs, bright lesions representing hard and soft exudates were the earliest signs of diabetic retinopathy. In that paper, an automated method for the detection of those exudates in retinal images was presented. Candidates were detected using a combination of coarse and fine segmentation. The coarse segmentation was based on a local variation operation to outline the boundaries of all candidates which have clear borders. The fine segmentation was based on an adaptive thresholding and a new split-and-merge technique to segment all bright candidates locally. Using a clinician's reference for ground truth exudates were detected from a database with 89.7% sensitivity, 99.3% specificity and 99.4% accuracy. Due to its distinctive performance measures, it have been successfully applied to images of variable quality.

Neera Singh and Ramesh Chandra Tripathi [39] indicated that the automated Diabetic Retinopathy diagnosis system was thus used to detect various lesions of the retina i.e. exudates, micro aneurysms and hemorrhages and there count size and location to assess the severity of the disease so that the patient can be diagnosed early and referred to the specialist well in advance for further intervention. There were certain features present in the normal physiology of the retina which have to be differentiated from the abnormal pathology e.g. optic disc have the same pixel brightness as the exudates and thus have to be localized before establishing the presence of the exudates. Similarly the blood vessel and fovea region have to be subtracted from the retinal image before diagnosing micro aneurysms and hemorrhages. Finally the Retinal Grading Algorithm, which follows the International council of Ophthalmology's criteria for the assessment of the severity of the disease, helps in establishing the severity of the disease so that the patient can accordingly be referred to the specialist and hence treated accordingly.

Chisako Muramatsu *et al* [1] introduced an automated method for measurement of arteriolar-to-venular diameter ratio(AVR) was presented. The method includes optic disc segmentation for the determination of the AVR measurement zone, retinal vessel segmentation, vessel classification into arteries and veins, selection of major vessel pairs, and measurement of AVRs. The sensitivity for the major vessels in the measurement zone was 87%, while 93% of them were classified correctly into arteries or veins. In 36 out of 40 vessel pairs, at least parts of the paired vessels were correctly identified. Although the average error in the AVRs with respect to those based on the manual vessel segmentation results was 0.11, the average error in vessel diameter was less than 1 pixel. The method may be useful for objective evaluation of AVRs and has a potential for detecting focal arteriolar narrowing on macula-centered screening fundus images.

R. Vijayamadheswaran *et al* [2] mainly focused of that work was on segmenting the diabetic retinopathy image and classify the exudates. Segmentation was done using contextual clustering and classification of the exudates was done using radial basis function (RBF) network. The performance classification of exudates by using RBF and CC was better than that of using only CC. The proposed RBF classifies the segmented information of the image into hard exudates or not. All the fundus images in that work have transformed to a standard template image condition. That corrects in the illumination effect on the images. Only when the fundus image was taken with good quality, detection of exudates was more accurate.

Tu Ying *et al* [32] sated that Diabetic retinopathy (DR) have emerged as a leading cause of visual impairment and blindness in the working aged population worldwide. That study aimed to assess frequency and associated factors of progression of DR in subjects with known diabetes in a population-based setting. The Beijing Eye Study was a population based study performed in Greater Beijing in 2001 and 2006. The present investigation included all subjects with known diabetes mellitus in 2001, who participated in the follow-up examination in 2006. Fundus photographs were assessed. The study included 170 subjects; 51 (30%) subjects showed signs of DR in 2001 and were re-examined in 2006, 36 (21.2%) subjects (18 subjects with DR present at baseline, 18 subjects with newly diagnosed DR in 2006) showed a progression of DR during follow-up. Progression of DR was associated with rural region (odds ratio (OR): 5.43, P=0.001) and self-reported arterial hypertension (OR: 3.85, P=0.023). In the non-progressive subgroup, presence of DR was associated with different levels of education (<middle school, middle school, college or higher, OR: 0.30, P=0.023), treatment modes of diabetes mellitus (OR: 10.24, P=0.003) and cataract surgery (OR: 9.14, P=0.007).

Priya.R and Aruna.P, et al [36] stated that the automated analysis of human eye fundas image was an important task. Diabetes was a disease which occurs when the pancreas does not secrete enough insulin or the body was unable to process it property. That disease affects slowly the circulatory system including that of the retina. As diabetes progresses, the vision of a patient may start to deteriorate and lead to diabetic retinopathy. The main stages of diabetic retinopathy were non-proliferative retinopathy (NPDR) and Pro-liferative retinopathy(PDR).In that paper, they have approached a computer based approach for the detection of DR stages using color fundus images. The features were extracted from the raw image, using the image processing techniques and fed to the Support Vector Machine (SVM) for classification. The results showed a sensitivity of 99.45 % for the classifier and Specificity of 100 %.

Gopal Datt Joshi and Jayanthi Sivaswamy [30] authenticated that the Diabetic retinopathy was the leading cause of blindness in urban populations. Early diagnosis through regular screening and timely treatment have been shown to prevent visual loss and blindness. It was very difficult to cater to this vast set of diabetes patients, primarily because of high costs in reaching out to patients and a scarcity of skilled personnel. Telescreening offers a cost-effective solution to reach out to patients but was still inadequate due to an insufficient number of experts who serve the diabetes population. Developments toward fundus image analysis have shown promise in addressing the scarcity of skilled personnel for large-scale screening. That article aims at addressing the underlying issues in traditional telescreening to develop a solution that leverages the developments carried out in fundus image analysis.

Clara I. Sánchez et al [35] showed the performance of a comprehensive DR screening system on an independent, publicly available database. The performance of the system on that dataset was comparable to that of human experts and in accordance with the results obtained in previous studies. The system offers retinopathy screening programs a fast solution to reduce the burden of screening diabetes population while maintaining a high sensitivity

Akara Sopharak et al [25] indicated that the Microaneurysms was the first clinical sign of diabetic retinopathy. The number of micro aneurysms was used to indicate the severity of the disease. Early microaneurysm detection can help reduce the incidence of blindness. That paper investigates a set of optimally adjusted morphological operators used for microaneurysm detection on non-dilated pupil and low-contrast retinal images. The detected micro aneurysms were validated by comparing with ophthalmologists' hand-drawn ground-truth. As a result, the sensitivity, specificity, precision and accuracy were 81.61, 99.99, 63.76 and 99.98%, respectively.

Akara Sopharak et al [27] indicated that it was to develop an automated diabetic retinopathy screening system, a detection of lesions in digital fundus photographs was needed. Microaneurysms were the first clinical sign of diabetic retinopathy. The number of micro aneurysms was used to indicate the severity of the disease. Early micro aneurysm detection can help reduce the incidence of blindness. That paper investigates a set of optimally adjusted morphological operators used for microaneurysm detection on non-dilated pupil and low-contrast retinal images. The detected micro aneurysms were validated by comparing with ophthalmologists' hand-drawn ground-truth. As a result, the sensitivity, specificity, precision and accuracy were 81.61, 99.99, 63.76 and 99.98%, respectively.

Desai Vidya et al [37] suggested that the Diabetic retinopathy (DR) was one of the micro-vascular complications of diabetes which leads to blindness among the working age individuals. Chronic hyperglycaemia and dyslipi daemia cause oxidative stress and increase the free radicals. Oxidative stress was one of the important causes in the genesis of microangiopathy. Twenty five patients of Type II Diabetes mellitus (DM) without retinopathy, 50 patients of Type II Diabetes mellitus with non-proliferative diabetic retinopathy and proliferative diabetic retinopathy and 25 normal subjects were included in the study. Fasting plasma glucose (FPG), post prandial plasma glucose (PPPG), glycosylated haemoglobin, lipid profile, plasma malondialdehyde (MDA) and Vitamin C were estimated. The plasma MDA levels were significantly elevated ($p< 0.001$) and the Vitamin C levels were significantly decreased ($p<0.01$) as compared to the controls. The study revealed a significant positive association between plasma MDA and both FPG and PPPG ($r=0.438$, $p<0.01$, $r=0.455$, $p<0.01$), a positive correlation between plasma MDA and HbA1c and also, a positive correlation between plasma MDA and serum triglycerides ($r=0.028$, $p<0.01$, $r=0.454$, $p<0.01$) and a negative correlation between MDA and Vitamin C ($r=0.241$, $p<0.01$). The results suggest that increased lipid peroxidation and a decline in the antioxidant defense mechanisms plays a very important role in the initiation and progression of micro-vascular complications like diabetic retinopathy.

C.Jayakumari and R.Maruthi [31] stated Diabetic retinopathy was a severe and widespread eye disease that affects many diabetic patients and it remains one of the leading causes of blindness Usually diabetic retinopathy was asymptomatic in the premature phase and intensifies as it grows. Hence, routine screening was essential to reduce the further complication to a significant level. In that paper, a state-of-art image processing techniques to automatically detect the occurrence of hard exudates in the fundus images were discussed. After the adaptive contrast enhancement as preprocessing stage, fuzzy C-means algorithm have been applied to extort the same. The standard deviation, intensity, edge strength and compactness of the extracted features of the fundus images have been fed as an inputs into a recurrent Echo state neural network to classify the extracted features as true candidate or not. A total of 50 images have been used to find the exudates and out of which 35 images consisting of both normal and abnormal are utilized to train the neural network and obtain 93% sensitivity and 100 % specificity.

X. Merlin Sheeba and S. Vasanthi [29] stated that the previous methods for blood vessel detection in retinal images can be classified into rule-based and supervised methods. That study suggest a method within the latter category. That method presents a new supervised technique for blood vessel detection in digital retinal images. That novel approach used an Extreme Learning Machine (ELM) approach for pixel classification and calculates a 7-D vector comprises of gray-level and moment invariants-based features for pixel representation. The performance of the approach was evaluated on the DRIVE and STARE databases. It was observed that the suggested approach provides significant output in terms of accuracy.

Arturo Aquino et al [38] suggested that in that paper, a new automated methodology to detect the optic disc (OD) automatically in retinal images from patients with risk of being affected by Diabetic Retinopathy (DR) and MacularEdema (ME) was presented. The detection procedure comprises two independent methodologies. On one hand, a location methodology obtains a pixel that belongs to the OD using image contrast analysis and structure filtering techniques and, on the other hand, a boundary segmentation methodology estimates a circular approximation of the OD boundary by applying mathematical morphology, edge detection techniques and the Circular Hough Transform. The methodologies were tested on a set of 1200 images composed of 229 retino graphies from patients affected by DR with risk of ME, 431 with DR and no risk of ME and 540 images of healthy retinas. The location methodology obtained 98.83% success rate, whereas the OD boundary segmentation methodology obtained good circular OD boundary approximation in 94.58% of cases. The average computational time measured over the total set was 1.67 seconds for OD location and 5.78 seconds for OD boundary segmentation.

4. CONCLUSION

The effects of the eye abnormalities are mostly gradual in nature which shows the necessity for an accurate abnormality identification system. Abnormality in retina is one among them. Most of the ophthalmologists depend on the visual interpretation for the identification of the types of diseases. But, inaccurate diagnosis will change the course of treatment planning which leads to fatal results. Hence, there is a requirement for a bias free automated system which yields highly accurate results. In this paper, we are classifying normal and abnormal retina. We first present an summary of diabetic retinopathy and its causes. Then, a literature review of the maximum current automatic detection of diabetic retinopathy techniques is offered. Explanation and restrictions of retina databases which are used to test the performance of these detection algorithms are given. Here we project a vital assessment of the current researches associated with the retinopathy detection process. In this paper, we present a wide review of major researches on disease detection process based on various features.

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