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Svm And Morphological Process Based Diagnosis Of Diabetic Retinopathy

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ABSTRACT : *Diabetic Retinopathy (DR), the most common eye disease of the diabetic patients, occurs when small blood vessels gets damaged in the retina, due to high glucose level. It affects 80% of all patients who have had diabetes for 10 years or more, which can also lead to vision loss. Detection of diabetic retinopathy in advance, protects patients from vision loss. The major symptom of diabetic retinopathy is the exudates. Exudate is a fluid that filters from the circulatory system into lesions or area of inflammation. Detecting retinal fundus diseases in an early stage, helps the ophthalmologists apply proper treatments that might eliminate the disease or decrease the severity of it.This paper focuses on automatic detection of diabetic retinopathy through detecting exudates in colour fundus retinal images and also classifies the rigorousness of the lesions. Decision making of the severity level of the disease was performed by SVM classifier.*

Index Terms— Diabetic Retinopathy, Erosion, Exudates, Support Vector Machine Classifier

INTRODUCTION :

Diabetes mellitus or commonly known as diabetes is a disease that affects the pancreatic glands and interferes with the production of insulin. Insulin is a key hormone that regulates the level of blood glucose (sugar) in a human body. Diabetes can be broadly classified into two types Type 1 or juvenile-onset diabetes and Type 2 or adultonset diabetes. The former results when there is a destruction of the beta cells producing insulin resulting in insulin deficiency. This form is generally seen in children, adolescents and young adults. Type 2 diabetes is the most common form of diabetes and constitutes 90% of the people affected by diabetes. Type 2 diabetes is usually the result of obesity which results in resistance to the insulin produced causing compensatory hyperinsulinemia at onset but due to increased demands on the pancreas eventually result in beta cell death and insufficient insulin production. According to the 2014 National Diabetes Statistics report by the American Diabetes Association (ADA), 29.1 million people or 9.8% of the United States population have been diagnosed with diabetes. As a result of either form of diabetes, when glucose control is inadequate, multiple long term complications results and affects multiple major organs of the body such as heart, eyes, kidneys and the nervous system. This research focuses on the effect that diabetes has on the eye, in particular, the retina. The effect is termed as diabetic retinopathy. Approaching the research from an electrical engineering background, this work aims to identify healthy patients from those diagnosed with retinopathy.

Diabetic Retinopathy:

Diabetic retinopathy is a common consequence of poorly controlled diabetes that causes damage to the vasculature of the eye. It has been estimated that 5% of the world's blindness cases can be attributed to diabetic retinopathy. Almost all patients with Type I diabetes after 15 years and more than 60% of patients with Type II diabetes are affected by retinopathy These statistics provide an alarming trend in the number of people suffering from this disease. In order to understand the disease, it is essential to understand the anatomy of the eye and in particular the retina. The eye has an asymmetrical spherical shape and consists of five important components cornea, iris, pupil, lens and retina. Chronic hyperglycemia (high sugar) damages the retinal vasculature that is translated into diabetic retinopathy. The anatomy of the eye and the various layers in the retina is as shown in Figure 1.

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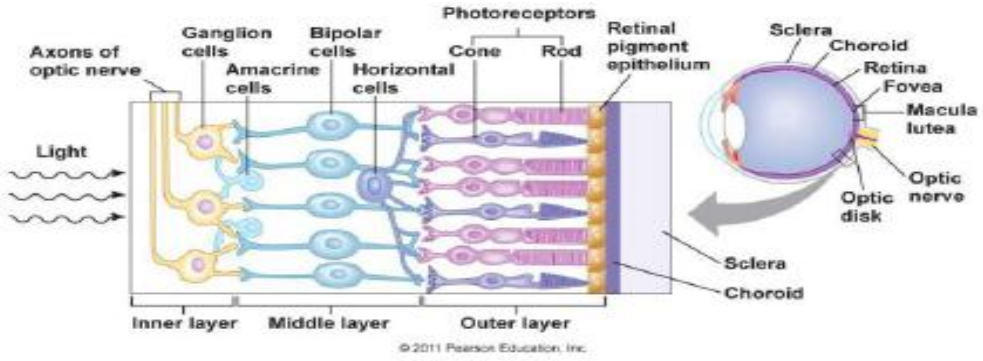

Figure 1. Anatomy of the eye and retina

The retina is a complex, multi layered structure nourished by blood vessels. The photoreceptor cells, rods and cones form a layer at the very end of the retina. The middle layer consists of three types of neurons, namely, bipolar calls, horizontal cells and amacrine cells. The third layer consists of the neuron cell bodies. The cell bodies form a bundle at a region on the retina known as the optic disk. The optic nerve originates from the optic disk and is connected to the central nervous system. The center of the retina, directly behind the lens, is a rod free region consisting only of cones. This region is termed as fovea. The fovea is covered by a pigment known as macula which protects the retina from absorbing ultraviolet (UV) radiation. This disease is characterized by the following symptoms

- Blurring of vision
- Visibility of floating spots
- Difficulty in night time vision

Diabetic retinopathy can be categorized into two types based on severity: Non- Proliferative Diabetic Retinopathy (NPDR) and Proliferative Diabetic Retinopathy (PDR). NPDR is a mild form of the disease and occurs due to damage of the blood vessels that supply the retina. The damage is expressed as micro aneurysms (MA), cotton wool spots (CWS), hemorrhages (HEM) and exudates. Early detection during this stage can be rectified through surgery in fig 2. The human body has a tendency to replace damaged cells by growth of new cells. The eye is one of the most highly vascularized and metabolically active organ in the body. The damage which occurs in NPDR results in decreased blood flow to the retina. This triggers the release of multiple growth factors 12 which the formation of new blood vessels known as neovascularization. Unfortunately, these new blood vessels are abnormal in terms of their structure and very prone to leakage of serum contents into the retina as well as rupture and both of these problems cause irreparable damage to the retina leading to a severe form of diabetic retinopathy called as PDR. A distinction between the two types of retinopathy is shown in Figure

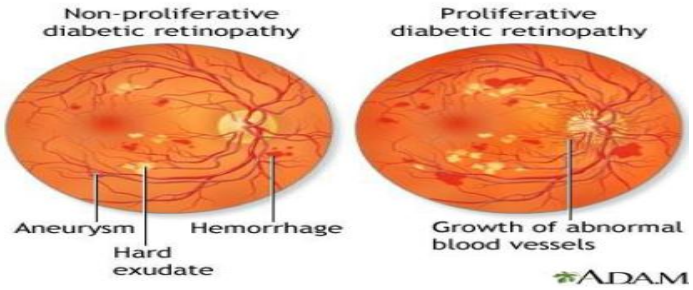

Figure 2. Difference between NPDR and PDR

Medical evaluation of retinopathy involves a detailed analysis of the eye by an ophthalmologist. The protocol followed is exhaustive and requires the support of the following tests, namely, visual acuity, measurement of intra ocular pressure (IOP),gonioscopy and slit-lamp biomicroscopy, retinal photography and fluorescein angiography. Fundus images captured by a fundus camera

provide the input for an assessment of the disease diabetic retinopathy.

PREVIES METHOD

Diabetic retinopathy identification has been a subject of interest for the last couple of decades. Recent advancements in image processing, machine learning and computer vision algorithms has garnered a greater interest in this field. describes the various algorithms existing in the literature briefly analyses the limitations of the prevailing methods and outlines the scope for this research. Literature survey reveals that identification of diabetic retinopathy has been achieved using various approaches summarized in A number of methods achieve detection of diabetic retinopathy by segmenting important regions as well as various abnormalities in the retina from the fundus images a type of anomaly known as exudates has been described as an important indication of the disease. Describe an approach using mathematical morphology to isolate exudates after eliminating the optic disk region. The algorithm achieves a sensitivity and specificity of 80% and 99.5% respectively proposed detection of exudates using Fuzzy-C means clustering, Gabor filtering and neural net They achieve an accuracy of 93.5%. However, both these methods fail to make a distinction between exudates and small blood vessels and do not take into account other anomalies such as CWS, MA and HEM that are expressed in the disease. Most of the effects of retinopathy are observed in the area around blood vessels and hence blood vessel segmentation has been deemed of higher importance.Soares et al. follow a 2D Morlet wavelet approach and Bayesian classification in order to detect blood vessels in a retinal fundus image. As mentioned in their discussion and conclusion section, this technique disregards any information about the shape and structure of elements present in the image. Budai et al. describe a Gaussian hierarchy method to isolate retinal blood vessels from fundus images. The classification accuracy achieved is about 94%. However, due to downscaling and then subsequent image fusion a lot of finer details are lost that is required to uniquely identify images of NPDR and PDR. A highly efficient method called matched filtering to detect blood vessels has been described. However, this technique can be applied only to stationary processes (process wherein the joint probability distribution function does not vary when shifted in time).

RETINAL BLOOD VESSEL SEGMENTATION

Several studies were carried out on the segmentation of blood vessels in general, however only a small number of them were associated to retinal blood vessels. In order to review the methods proposed to segment vessels in retinal images, seven classes of methods have been considered: matched filters, vessel tracking, morphological processing, region growing, multiscale, supervised and adaptive thresholding approaches.

LOCALIZATION AND CONTOUR DETECTION OF OPTIC DISK

Reliable and efficient optic disk localization and contour detection are significant tasks in an automated diabetic retinopathy screening system. Optic disk localization is required as a prerequisite for the succeeding stages in many algorithms applied for identification and segmentation of the anatomical and pathological structures in retinal images. Accurate localization of the optic disk and its contour are very useful in detecting proliferative diabetic retinopathy. Because of the circulation problems occurred during the early stages of diabetic retinopathy, new blood vessels which are very delicate and weak will be developed largely in the optic disk region of the retina. If the location of optic disk is known, then the position of other regions of medical significance like macula and fovea can be determined. The location of optic disk can be employed as a marker for retinal image registration. As the optic disk or optic nerve head is the source of major retinal vessels, its centre may be employed as a beginning point for vessel tracking approaches. Many schemes have been proposed to localize optic disk. Majority of these schemes were finding only the location of the optic disk and not addressing the problem of contour detection of optic disk. Accurate localization of optic disk is surprisingly complicated, because of its highly variable appearance in fundus images.individually isolate hemorrhages, MA and CWS from 430 images. The area of these abnormalities act as input to a neural net for classification. A classification accuracy of 82.6% for normal and NPDR and 88.3% for PDR is demonstrated these use of first order statistic features makes the system less robust as they provide no spatial information and are hence unreliable for the problem at hand. demonstrate that the use of a second order statistic such as contrast in conjunction with first order features provide a higher classification accuracy (93%) which leads us to establish that second order features are more robust in handling rotation, translation and scaling of the input images With advances in computer vision techniques, content based image retrieval (CBIR) has been used extensively for diabetic retinopathy screening applications .The proposed a multiple instance learning (MIL) based algorithm that detects the diabetic

retinopathy lesions without manual segmentation by clinicians. In a similar approach define the Point of Interest (PoI) in an image and extract features from around this using an algorithm termed as Speeded-Up Robust Features (SURF). A modified color auto-correlogram based feature extraction approach is used in conjunction with the MIL has been utilized. Although these techniques work well when obtaining the ground truth on extremely large datasets (greater than 100,000 samples) is difficult, they are computationally complex and have a large dependency on reference datasets or "dictionary". have incorporated the use of Probabilistic Neural Network (PNN) for a three class classification achieving an accuracy of 96.15%. However, it has been established that PNNs are extremely slow and require large memory space. This implies that a real-time effective diagnostic tool would be difficult to implement. Also, the training set need to be an accurate representation of the data for the classifier to work as expected.

Automatic detection of diabetic retinopathy

The interest towards automatic detection of diabetic retinopathy has been increasing along with the rapid development of digital imaging and computing power. However, the single most important event that attracted the wider attention of medical research community has been the decision to recognise digital imaging as an accepted modality to document eye fundus. Since then, a considerable amount of effort has been spent on automated detection and diagnosis of diabetic retinopathy from digital eye fundus images. The relevant research is well documented in three recent surveys which encapsulate the main algorithms used in the field during the past 10-15 years. In this section, the methodology behind these existing approaches is shortly reviewed. The review is divided into three parts of which the first two parts discuss the automatic detection of diabetic retinopathy from the lesion point of view (i.e. detecting lesions indicative of diabetic retinopathy) while the discussion in the third part concentrates on algorithms that attempt to detect the presence or even the severity of diabetic retinopathy. The review provides a short description for each method and the reported performances are gathered into summary tables. It should note, however, that the interpretation of the used performance measures varied between publications and different data sets were employed in the evaluation.

PROPOSED METHODOLOGY

Diabetic retinopathy:

Diabetic retinopathy is retinopathy (damage to the retina) caused by complications of diabetes, which can eventually lead to blindness. It is an ocular manifestation of diabetes, a systemic disease, which affects up to 80 present of all patients who have had diabetes for 10 years or more. Despite these intimidating statistics, research indicates that at least 90% of these new cases could be reduced if there were proper and vigilant treatment and monitoring of the eyes. The longer a person has diabetes, the higher his or her chances of developing diabetic retinopathy. Each year in the United States, diabetic retinopathy accounts for 12% of all new cases of blindness. It is also the leading cause of blindness for people aged 20 to 64 years.

Diabetic retinopathy often has no early warning signs. Even macular edema, which may cause vision loss more rapidly, may not have any warning signs for some time. In general, however, a person with macular edema is likely to have blurred vision, making it hard to do things like read or drive. In some cases, the vision will get better or worse during the day.In the first stage which is called non-proliferative diabetic retinopathy (NPDR) there are no symptoms, it is not visible to the naked eye and patients will have 20/20 vision. The only way to detect NPDR is by fundus photography, in which micro aneurysms (microscopic blood-filled bulges in the artery walls) can be seen. If there is reduced vision, fluorescein angiography can be done to see the back of the eye. Narrowing or blocked retinal blood vessels can be seen clearly and this is called retinal ischemia (lack of blood flow).

Macular edema may occur in which blood vessels leak contents into the macular region can happen at all stages of NPDR. The macular edema symptoms are blurring, darkening or distorted images with not the same between two eyes. 10 percent of diabetic patients will get vision loss related with macular edema. Optical Coherence Tomography can show areas of retinal thickening (fluid accumulation) of macular edema. On the second stage, as abnormal new blood vessels (neovascularisation) form at the back of the eye as a part of proliferative diabetic retinopathy (PDR), they can burst and bleed (vitreous hemorrhage) and blur vision, because the new blood vessels are weak. The first time this happens, it may not be very severe. In most cases, it will leave just a few specks of blood, or spots, floating in a person's visual field, though the spots often go away after a few hours.

These spots are often followed within a few days or weeks by a much greater leakage of blood, which blurs vision. In extreme cases, a person will only be able to tell light from

dark in that eye. It may take the blood anywhere from a few days to months or even years to clear from the inside of the eye, and in some cases the blood will not clear. These types of large hemorrhages tend to happen more than once, often during sleep. On funduscopic exam, a doctor will see cotton wool spots, flame hemorrhages (similar lesions are also caused by the alpha-toxin ofClostridium novyi), and dot-blot hemorrhages. The pericyte death is caused when "hyperglycemia persistently activates protein kinase C-δ (PKC-δ, encoded by Prkcd) and p38 mitogen-activated protein kinase (MAPK) to increase the expression of a previously unknown target of PKC-δ signaling, Src homology-2 domain–containing phosphatase-1 (SHP-1), a protein tyrosine phosphatase. This signaling cascade leads to PDGF receptor-dephosphorylation During the initial stage, called non proliferative diabetic retinopathy (NPDR), most people do not notice any change in their vision. Early changes that are reversible and do not threaten central vision are sometimes termed simplex retinopathy or background retinopathy. Some people develop a condition called macular edema.

Proliferative diabetic retinopathy

As the disease progresses, severe non proliferative diabetic retinopathy enters an advanced, or proliferative (PDR), stage when blood vessels proliferate (i.e. grow). The lack of oxygen in the retina causes fragile, new, blood vessels to grow along the retina and in the clear, gel-like vitreous humour that fills the inside of the eye. Without timely treatment, these new blood vessels can bleed, cloud vision, and destroy the retina. Fibrovascular proliferation can also cause tractional retinal detachment. The new blood vessels can also grow into the angle of the anterior chamber of the eye and cause neovascular glaucoma.

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Nonproliferative diabetic retinopathy shows up as cotton wool spots, or microvascular abnormalities or as superficial retinal hemorrhages. Even so, the advanced proliferative diabetic retinopathy (PDR) can remain asymptomatic for a very long time, and so should be monitored closely with regular checkups.

Risk factors

All people with diabetes mellitus are at risk – those with Type I diabetes and those with Type II diabetes. The longer a person has diabetes, the higher the risk of developing some ocular problem. Between 40 to 45 percent of Americans diagnosed with diabetes have some stage of diabetic retinopathy. After 20 years of diabetes, nearly all patients with Type I diabetes and >60% of patients with Type II diabetes have some degree of retinopathy; however, these statistics were published in 2002 using data from four years earlier, limiting the usefulness of the research. The subjects would have been diagnosed with diabetes in the late 1970s, before modern fast acting insulin and home glucose testing.Prior studies had also assumed a clear glycemic threshold between people at high and low risk of diabetic retinopathy.

However, it has been shown that the widely accepted WHO and American Diabetes Association diagnostic cutoff for diabetes of a fasting plasma glucose ≥ 7.0 mmol/l (126 mg/dl) does not accurately identify diabetic retinopathy among patients.[14] The cohort study included a multi-ethnic, cross-sectional adult population sample in the US, as well as two cross-sectional adult populations in Australia. For the US-based component of the study, the sensitivity was 34.7% and specificity was 86.6%. For patients at similar risk to those in this study (15.8% had diabetic retinopathy), this leads to a positive predictive value of 32.7% and negative predictive value of 87.6%.Published rates vary between trials, the proposed explanation being differences in study methods and reporting of prevalence rather than incidence values. During pregnancy, diabetic retinopathy may also be a problem for women with diabetes. It is recommended that all pregnant women with diabetes have dilated eye examinations each trimester to protect their vision.People with Down's syndrome, who have three copies of chromosome 21, almost never acquire diabetic retinopathy. This protection appears to be due to the elevated levels ofendostatin,[16] an anti-angiogenic protein, derived from collagen. The collagen gene is located on chromosome .

Laser photocoagulation:

Laser photocoagulation can be used in two scenarios for the treatment of diabetic retinopathy. It can be used to treat macular edema by creating a Modified Grid at the posterior pole and it can be used for panretinal coagulation

for controlling neovascularization. It is widely used for early stages of proliferative retinopathy.

Modified Grid Laser photocoagulation :

A 'C' shaped area around the macula is treated with low intensity small burns. This helps in clearing the macular edema.

Panretinal photocoagulation :

Panretinal photocoagulation, or PRP (also called scatter laser treatment), is used to treat proliferative diabetic retinopathy (PDR). The goal is to create 1,600 - 2,000 burns in the retina with the hope of reducing the retina's oxygen demand, and hence the possibility of ischemia. It is done in multiple sittings.In treating advanced diabetic retinopathy, the burns are used to destroy the abnormal blood vessels that form in the retina. This has been shown to reduce the risk of severe vision loss for eyes at risk by 50%.< Before using the laser, the ophthalmologist dilates the pupil and applies anesthetic drops to numb the eye. In some cases, the doctor also may numb the area behind the eye to reduce discomfort. The patient sits facing the laser machine while the doctor holds a special lens on the eye. The physician can use a single spot laser or a pattern scan laser for two dimensional patterns such as squares, rings and arcs. During the procedure, the patient will see flashes of light. These flashes often create an uncomfortable stinging sensation for the patient. After the laser treatment, patients should be advised not to drive for a few hours while the pupils are still dilated. Vision will most likely remain blurry for the rest of the day. Though there should not be much pain in the eye itself, an ice-cream headache like pain may last for hours afterwards. Patients will lose some of their peripheral vision after this surgery although it may be barely noticeable by the patient.

Intravitreal triamcinolone acetonide :

Triamcinolone is a long acting steroid preparation. When injected in the vitreous cavity, it decreases the macular edema (thickening of the retina at the macula) caused due to diabetic maculopathy, and results in an increase in visual acuity. The effect of triamcinolone is transient, lasting up to three months, which necessitates repeated injections for maintaining the beneficial effect. Best results of intravitreal Triamcinolone have been found in eyes that have already undergone cataract surgery. Complications of intravitreal injection of triamcinolone include cataract, steroid-induced glaucoma and endophthalmitis.

Mathematical morphology :

Mathematical morphology (MM) is a theory and technique for the analysis and processing of geometrical structures, based on set theory, lattice theory, topology, and random functions. MM is most commonly applied to digital images, but it can be employed as well ongraphs, surface meshes, solids, and many other spatial structures.Topological and geometrical continuous-space concepts such as size, shape, convexity, connectivity, and geodesic distance, were introduced by MM on both continuous and discrete spaces. MM is also the foundation of morphological image processing, which consists of a set of operators that transform images according to the above characterizations. The basic morphological operators are erosion, dilation, opening and closing. MM was originally developed for binary images, and was later extended to grayscale functions and images. The subsequent generalization to complete lattices is widely accepted today as MM's theoretical foundation

ISSUES :

Potential drawbacks of the SVM are the following three aspects.

- Un calibrated class membership probabilities
- The SVM is only directly applicable for two-class tasks. Therefore, algorithms that reduce the multi-class task to several binary problems have to be applied; see the multi-class SVM section.
- Parameters of a solved model are difficult to interpret.

The proposed automatic screening methodology is shown in Fig.3. It starts from image acquisition, preprocessing and then mathematical morphological operations are applied on the preprocessed images to identify the exudates. Then the segmented image is assessed for the degree of abnormality of an image as moderate or severe risk using SVM classifier. In this paper, the evaluation of the automated diagnosis system of diabetic retinopathy has been performed by using a set of 5 images which were captured by retinal fundus cameras. The images are stored in a JPEG image format (.jpg) files with the size of 2196 X 1958 pixels at 24 bits pixel length

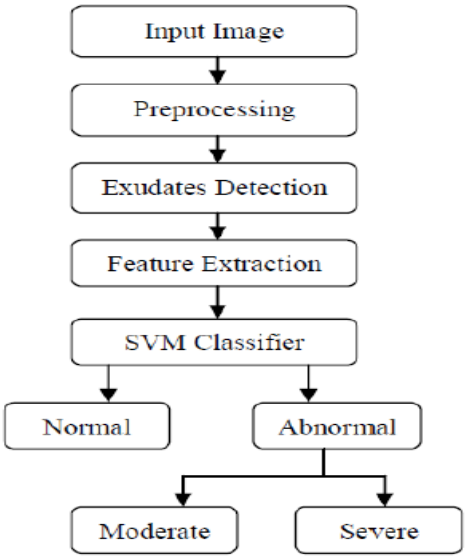


Fig 3:Block diagram of proposed work

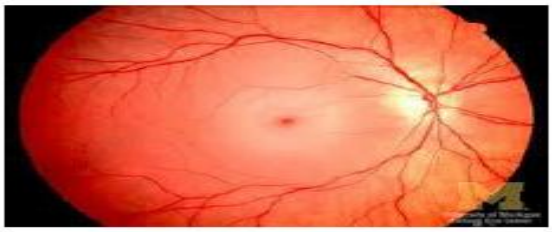
Preprocessing

The input retinal images are preprocessed before it is applied to the segmentation process. In the preprocessing stage, problems arise due to the blurred image or non-clarity images are rectified. This stage involves the color space conversion, image restoration and enhancement. In color space conversion, the color image is converted into gray scale model for the reason that processing with gray scale image is more comfortable than the color images and also intensity adjustment should be done on the images for further process.

The converted images are filtered to remove the noise developed during image acquisition using the adaptive median\ filter. The main purpose of the adaptive median filter is to remove the salt and pepper noises, smoothing the image, and reducing the distortions appeared due to the thinness and thickness of image boundaries. The contrast enhancement is performed on the filtered image by the Histogram equalization. Image before pre-processed.

Optic Disc Elimination:

The Optic Disc (OD) is the brightest feature of the normal fundus, and it has approximately a slightly oval (elliptical) shape. In color fundus images, the OD appears as a bright yellowish or white region. Exudates have high and similar intensity values of Optic disc. So it is necessary to eliminate the optic disc from the retinal image. This brighter optic disc should be masked and removed. Edge detection algorithm is applied on the preprocessed image to make it suitable for detecting the optic disc, blood vessels and exudates. Canny edge detector is employed for the contour detection. This algorithm finds the edges where the gray scale intensity of the image changes and this variation can be found by determining gradients of the image.



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Original Image

Blood Vessels Removal

Since our suggested method is to identify the exudates only, blood vessels have to be removed from the retinal image. Because blood vessels have similar concentration level of exudates, it may be mistaken as exudates by the ophthalmologists. Dilation operator on the intensity image will help to eliminate the high contrast vessels. Dilation can expand the blood vessels by potentially filling in small holes (structuring element) and connecting disjoint pixels. It can be performed by laying structuring element (SE) on that image and sliding over the image. Structuring element, which describes flat disc shaped structure, is used with the aim of removing the vessels that remain in the optic disc region. If the SE starts from brighter pixel, there will be no change. It will move to next pixel. If the SE starts from dark pixel, make all the pixels black from the image covered by the SE. The disc shaped is applied on the image.

Blood vessels removal image

Identifying the Exudates:

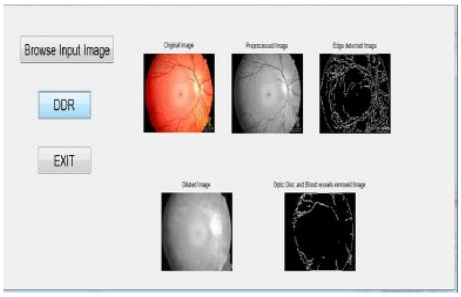
After removing the optic disc and blood vessels from an image, exudates can be detected by closing operator. Image closing operator will be performed on the eroded image since dilation is followed by erosion. It can distinguish the exudates portion from the non-exudates pixels. The closing of an image A by structuring element B is defined as the resultant image, Exposed in yellowish color which clearly indicates the exudates pixels in the segmented retinal image.

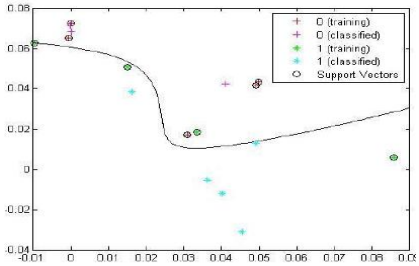
Edge detected Image

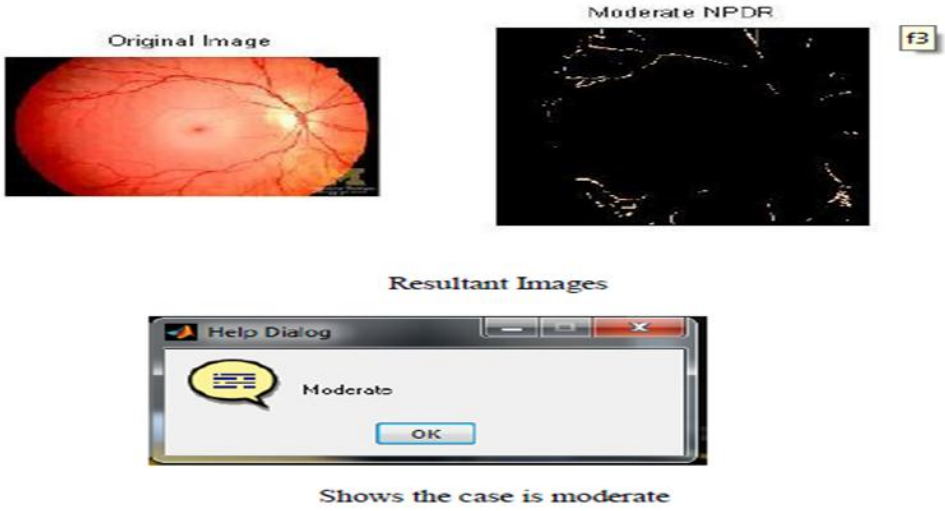
EXPERIMENTAL RESULTS

Currently it is recommended that diabetic patients with no DR should be screened once every 1 to 2 years since the risk of progression to vision threatening retinopathy is low, while patients with mild NPDR (RO–R1) should be screened annually.1 However, there is good evidence to suggest that patients with no DR at their first screen could probably be screened every two years.3 Once moderate NPDR (R2) is reached, patients are at a higher risk of developing PDR (12–26% within 1 year and 30–48% within 3 years) and should be screened on a six-monthly basis. Patients with PDR should be referred urgently to the eye clinic and appropriate treatment administered.

IDENTIFICATION OF NORMAL/ABNORMAL BEHAVIOR







Conclusion and Future scope

In this proposed method, the exudates were clearly distinguished from optic disc and blood vessels. As the optic disc and blood vessels have similar intensity level of exudates, they are completely removed prior to the detection of exudates. Thus the morphological operation such as dilation and erosion are used to detect the presence and location of exudates. This segmented image shows the location of exudates confirming the disease diabetic retinopathy. This paper not only confirms the disease but also tends to measure the severity level of the disease. The SVM classifier is used to assess the severity of this disease whether the patient is moderately affected or severely affected.

This information from the classifier algorithm improves the clarity in the diagnosis of Diabetic Retinopathy. The earlier diagnosis of this Diabetic Retinopathy helps the patients to take proper treatment to eliminate the disease or decrease this severity of the disease.

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