Detection of Retinal Diseases by Tracing Vessel Trees and Accurately Segmenting Vessels

K.V.V.Kumar, T.Ravi, B.M.S.Rani, Habibullah Khan

ABSTRACT- The extraction of retinal vessels plays an important role in the diagnosis and analysis of retinal diseases, such as Age-related Macular Degeneration (AMD), Diabetic Retinopathy, and Retinopathy of Prematurity (ROP). The blood vessels are the part of the circulatory system that transports blood throughout the body. There are three major types of blood vessels: the arteries, which carry the blood away from the heart; the capillaries, which enable the actual exchange of water and chemicals between the blood and the tissues; and the veins, which carry blood from the capillaries back toward the heart segmentation is the process of partitioning a digital image into multiple segments (sets of pixels also known as super pixels). The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image. The objective of fusion is to convolve foreground and background images to analyze the retinal vessels

Keywords – BRVO (Branch retinal vein oclusions), CNVM (Chroidal neo vascular membrane),VMT (Vitro macular traction),ERM(Epiretinal membranes),DR(Diabetic Retinopathy).

I. INTRODUCTION

The blood vessels are the part of the circulatory system that transports blood throughout the body. There are three major types of blood vessels the arteries, which carry the blood away from the heart; the capillaries, which enable the actual exchange of water and chemicals between the blood and the tissues; and the veins, which carry blood from the capillaries back toward the heart. Blood vessels do not actively engage in the transport of blood (they have no appreciable peristalsis), but arteries and veins to a degree can regulate their inner diameter by contraction of the muscular layer. This changes the blood flow to downstream organs, and is determined by the autonomic nervous system. Vasodilation and vasoconstriction are also used antagonistically as methods of thermoregulation.[1] Oxygen (bound to hemoglobin in red blood cells) is the most critical nutrient carried by the blood. In all arteries apart from the pulmonary artery, hemoglobin is highly saturated (95-100%) with oxygen.

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In all veins apart from the pulmonary vein, the hemoglobin is desiderated at about 75%. (The values are reversed in the pulmonary circulation.) The blood pressure in blood vessels is traditionally expressed in millimeters of mercury (1 mmHg = 133 Pa). In the arterial system, this is usually around 120 mmHg systolic (high pressure wave due to contraction of the heart) and 80 mmHg diastolic (low pressure wave). In contrast, pressures in the venous system are constant and rarely exceed 10 mmHg.

Vasoconstriction is the constriction of blood vessels (narrowing, becoming smaller in cross-sectional area) by contracting the vascular smooth muscle in the vessel walls. It is regulated by vasoconstrictors (agents that cause vasoconstriction). These include peregrine factors (e.g. prostaglandins), a number of hormones (e.g. vasopressin and angiotensin) and neurotransmitters (e.g. epinephrine) from the nervous system.

Vasodilation is a similar process mediated by antagonistically acting mediators.[1] The most prominent vasodilator is nitric oxide (termed endothelium-derived relaxing factor for this reason).

Permeability of the endothelium is pivotal in the release of nutrients to the tissue. It is also increased in inflammation in response to histamine, prostaglandins and interleukins, which leads to most of the symptoms of inflammation (swelling, redness and warmt)

II. RETINAL DISEASES

2.1 BRVO (BRANCH RETINAL VEIN OCCLUSIONS).

Macular edema occurs when fluid and protein deposits collect on or under the macula of the eye (a yellow central area of the retina) and causes it to thicken and swell. The swelling may distort a person's central vision, as the macula is near the center of the retina at the back of the eyeball. This area holds tightly packed cones that provide sharp, clear central vision to enable a person to see detail, form, and color that is directly in the direction of gaze. Macular edema sometimes appear for a few days or weeks after cataract surgery, but most such cases can be successfully treated with NSAID or cortisone eye drops. Until recently there were no good treatments for macular edema caused by central retinal vein occlusion (CRVO). Laser photocoagulation has been used for macular edema caused by branch retinal vein occlusion (BRVO). Cystoid macular edema (CME) involves fluid accumulation in the outer plexiform layer secondary to abnormal perifoveal retinal capilary permeability. The edema is termed "cystoid" as it appears [1] cystic; however, lacking an epithelial coating, it is not truly cystic. The etiology for

CME can be remembered with the mnemonic "DEPRIVEN" (Diabetes, Epinepherine, Pars planitis, Retinitis pigmentosa, Irvine-Gass Syndrome, Venous occlusion, E2-prostaglandin, Nicotinic acid and Niacin).

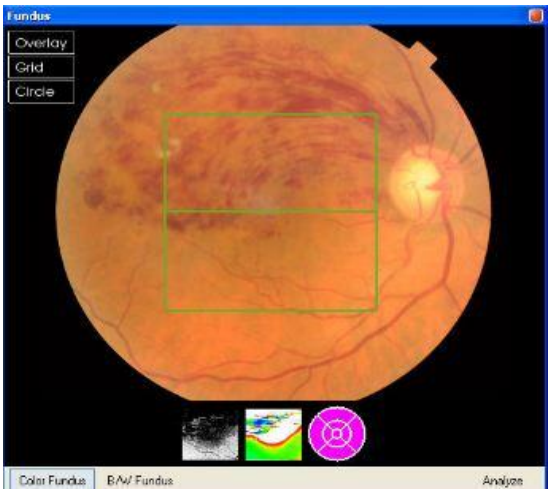


Fig 1:Branch Retinal Vein Oclusion

2.2 CNVM (Chroidal neo vascular membrane)

Most commonly associated with wet macular degeneration, choroidal neovascular membrane (CNVM) involves the development of new, abnormal vessels below the retina, the light-sensitive multi-layered tissue that lines the back of the eyeball. Macular degeneration and other retinal diseases, like myopic degeneration and ocular histoplasmosis can damage the important layers of the retina, compromising its ability to act as a barrier to the vascular layer below the retina, called the choroid.

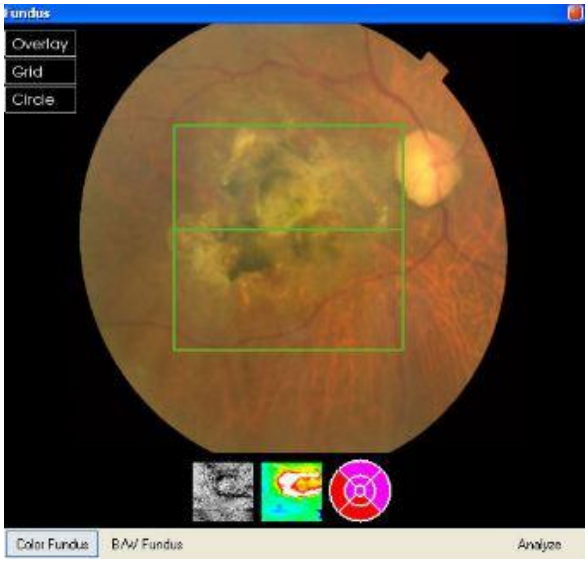


Fig 2: Choroidal Neo Vascular Membrane

Once the retinal layers are damaged by diseases like macular degeneration, the choroid can produce new blood vessels (neovascularization) which grow up through the damaged layers and leak or bleed into the retina. Once this happens, the vision can become blurry, darkened or distorted.

CNVM Symptoms

Since the retina acts as the "film in the camera" of the eye, any retinal irregularities in it can cause distortion, dark or fuzzy spots and loss of vision.[1] If CNVM bleeds into the retina, the patient can experience dark or missing areas in the vision.

Using an Amsler grid daily is usually effective at picking up any early changes in the central macular area -- a common location of CNVM lesions.

CNVM Diagnosis

CNVM is most commonly diagnosed using Optical Coherence Tomography (OCT) or fluorescein angiography.

2.3 VMT (Vitreomacular traction),

Vitreomacular traction syndrome (VMT) is a special subset of macular epiretinal membranes (ERMs) with an incomplete posterior vitreous separation at the macula and optic nerve head. Glial cells are the predominant cell type in the ERM. Vitreomacular traction syndrome may create a shallow retinal detachment in addition to distortion of the macula from the epiretinal membrane. Optical Coherence Tomography (OCT) may be useful in helping to differentiate between Vitreoretinal Traction and Idiopathic Epiretinal Membrane. This syndrome is often progressive and is associated with greater visual loss than that from Epiretinal Membrane alone.[8] Surgery consists of a standard pars plana vitrectomy and peeling of the epiretinal membrane after removal of the posterior vitreous traction

However, there is also a ~10% chance of developing a complete macular hole, with some loss of sight (surgery may be needed). This occurs when the vitreous pulls the retina in the foveal area to the extent that it creates a hole. The hole may cause loss of vision, and may be helped with surgery.

The cause of the VMT is linked to PVD formation, when the vitreous gel shrinks. Normally the gel separates completely from the retina, but in this condition the back face of the gel remains stuck to the retina, in the foveal area.

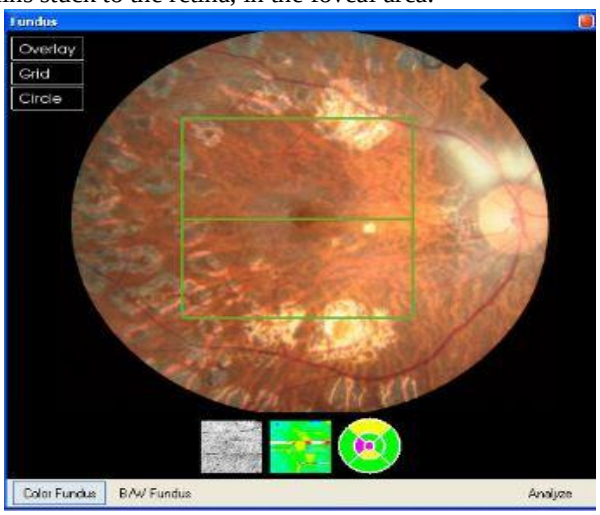


Fig 3:Vitreo Macular Traction Disease

2.4 ERM(Epiretinal membranes)

Macular epiretinal membranes (ERMs) have a variable clinical course but usually reach maximal formation within few months before stabilizing. Most eyes maintain excellent visual acuity with minimal distorsion of central vision,[8] but the small percentage of patients who do develop market distortion of central vision may be candidates for pars plana vitrectomy. Patients primarily complaining of metamorphopsia may derive the most benefit from this surgery.And following surgery, approximately 60%-80% of patients achieve 2 or more lines of visual acuity improvement, often continuing to improve for 6-12 months after surgery. Intraoperative complications of this surgery include retinal tear or retinal detachment in less than 5% of cases. Pregresive nuclear sclerosis occurs postoperatively in the majority of patients, and the rate increases over time. Epiretinal membrane is a disease of the eye in response to changes in the vitreous humor or more rarely, diabetes. It is also called macular pucker. Sometimes, as a result of immune system response to protect the retina, cells converge in the macular area as the vitreous ages and pulls away in posterior vitreous detachment (PVD). PVD can create minor damage to the retina, stimulating exudate, inflammation, and leucocyte response.

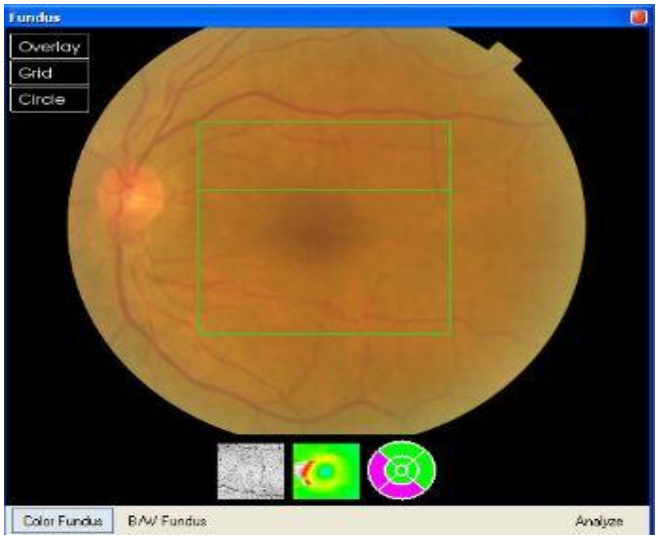


Fig 4 :EpiRetinal Membrane disease

These cells can form a transparent layer gradually and, like all scar tissue, tighten to create tension on the retina which may bulge and pucker (e.g. macular pucker), or even cause swelling or macular edema. Often this results in distortions of vision that are clearly visible as bowing and blurring when looking at lines on chart paper (or an Amsler grid) within the macular area, or central 1.0 degree of visual arc. Usually it occurs in one eye first, and may cause binocular diplopia or double vision if the image from eye is too different from the image of the other eye. The distortions can make objects look different in size (usually larger = macropsia), especially in the central portion of the visual field, creating a localized or field dependent aniseikonia that cannot be fully corrected optically with glasses. Partial correction often improves the binocular vision considerably though. In the young (under 50 years of age), these cells occasionally pull free and disintegrate on their own; but in the majority of sufferers (over 60 years of age), rod cells and cone cells, are usually not damaged unless the membrane becomes quite thick and hard; so usually there is no macular degeneration

Ocular fundus image can provide information on pathological changes caused by local ocular diseases and early signs of certain systemic diseases, such as diabetes and hypertension. For example, central retinal artery occlusion usually causes generalized constriction of retinal arteries, while central retinal vein occlusion typically produces dilated tortuous veins, arteriosclerosis can cause arteries to acquire a copper or silver color. Hypertension may result in focal constriction of retinal arteries, and diabetes can generate new bloodvessels.

(neovascularization).Analyzing and interpreting retinal images have become a necessary and important diagnostic procedure in ophthalmology and considerable research effort has been devoted to automate this process. Among the features in ocular fundus image, the structure of retinal vessels plays an important role in revealing the state of diseases. In addition, blood vessels can also serve as landmarks for image-guided laser treatment of choroidal neovascularization. Thus, reliable methods of vessel detection that preserve various vessel measurements are needed.

2.5 DR (Diabetic Retinopathy)

Diabetic retinopathy is a complication of diabetes mellitus. It is the most common cause of blindness worldwide. Although diabetes itself cannot be prevented, complications such as blindness can be moderated if the disease is diagnosed early.[8] The most effective method currently is regular screening of the fundus to detect early signs of diabetic retinopathy. Microaneurysms – tiny dilations of the blood vessels - are the first unequivocal sign of diabetic retinopathy so that their detection in fundus images through photography might be enough to detect the disease in an early stage. However, with a large number of patients undergoing regular screenings, tremendous amount of time is needed for the medical professionals to analyze and diagnose the fundus photographs. By automating the initial task of analysing the huge amount of retinal photographs for symptoms of diabetic retinopathy, the efficiency of the screening process can be greatly improved. At the same time, patients that require the attention of the ophthalmologist would be timely referred.

On the other hand, diabetic retinopathy resulting from long-term diabetes mellitus is one of the common diseases that lead to choroidal neovascularization (CNV). CNV is an important condition that leads to blindness. It decreases the amount of blood supplying the retina especially within the central area of acute vision. One treatment strategy is the use of lasers to photocoagulate the affected areas of the retina. To obtain satisfactory results, the physician must

identify the full extent of CNV and cauterize it completely. Care must be taken to avoid radiating the macula (the area of acute vision), optic disc, and major blood vessels.

In the analysis of fundus images, two different types of the fundus images are used in term of the image capture procedure: retinal angiographies and normal fundus images. Images of retinal angiographies are obtained after an injection of fluorescein into the patients' arm. Retinal vessels are highlighted using an ultraviolet light. Photographs taken during the 5-min injection represents brighter blood vessels relative to a darker background (i.e., reversed contrast). The normal images are acquired using a fundus camera applied directly to the retina. In these images, the vessels are less contrasted than in angiographic images and they contain less information: small vessels are not obvious in the image. However, they are still very precise in accordance with the information contained in the image and widely used in retinal image analysis.

For both types of images, a charge coupled device (CCD) video camera is attached to the eyepiece of the fundus camera to make the images collected using the fundus camera available in standard image format. The output from the CCD camera is connected to a PC through image digitizer card. The retinal images were captured to the memory of the computer system. The images were saved on a hard disk for further processing. As for color retinal fundus image, the blue band appears to be very weak and does not contain much information. The vessels appear in red, however the red band usually contains too much noise or is simply saturated since most of the features emit a signal in the red band. On the other hand, the green component of color fundus image gives the blood vessels on a highly contrasted background (darker blood vessels on a bright background). Hence, the green channel of the image is employed in the automated analysis of ocular fundusimages.

III. MATLAB RESULTS AND GRAPHS

In this section, simulation results for different images (256X256) are shown. Their Segment measure graphs are also included. Considered the images retinal image.jpeg and

Blood Vessel.jpeg included MATLAB Library and compare OCT(Optical Coherence Tomography) software.

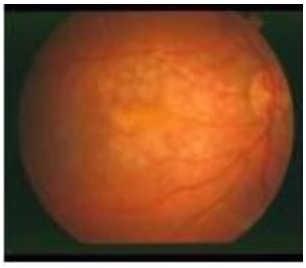


Fig5:input normal fundus image

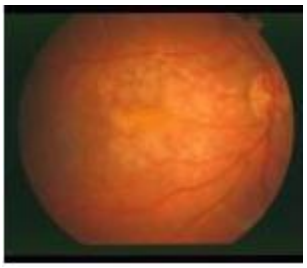


Fig6:Output Original Fundus image

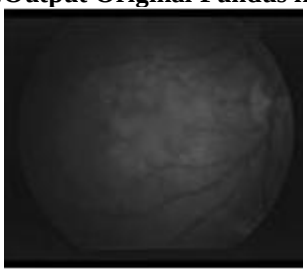


Fig 7:Output RGB2Gray Image

Fig 8:Output of Edge Canny Image

Fig 9:Output of Edge prewitt Image

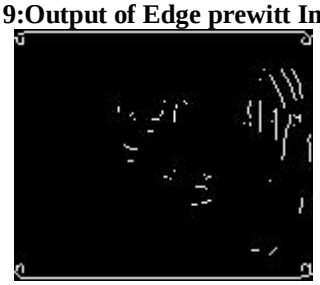


Fig 10:Output Of Edge sobel Image

Fig 11:Output Of Edge Gaussian Image

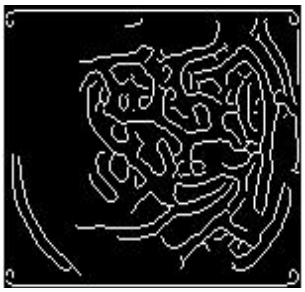


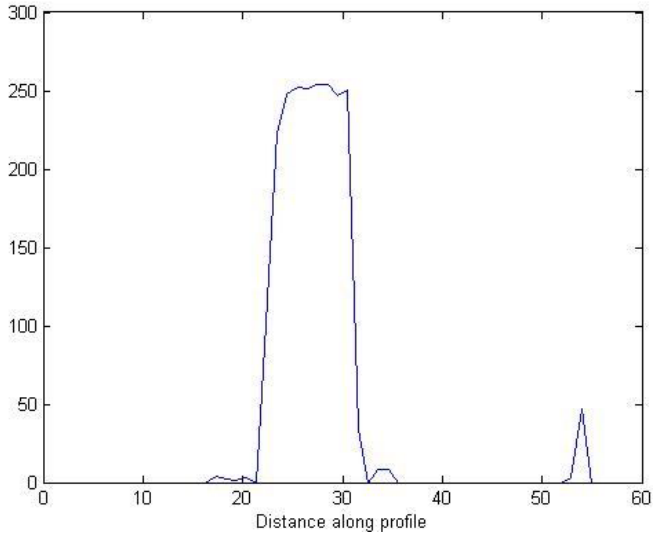
Fig 12: Output of Edge Otsu Image

Fig 13: Output of Edge Motion Image

Fig 14: Output of Thresholding Image

Fig 15: Output of Thresholding Image

Fig16:Output Of Blood Vessel Image



Thickness (micro metres)Vs Length

Fig17: Output Of Segment Response Curve

Fig 18:Output Of Convolve Image

IV. CONCLUSION

The objective of fusion is to convolve foreground and background images to analyze the retinal vessels And compare OCT (Optical Coherence and Tomography) Software and Mat lab Results with Segment Curve in that we are using edge detecting algorithms and detecting the even smaller thin bloodvessels.

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