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Apprehension of Choroidal Neovascularization using Image Processing

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Abstract: "Neovascularization" means "new blood vessels." These new, anomalous blood vessels originate in the choroid, a vessel-containing layer under the retina. When the retinas of people with AMD produce too much vascular endothelial growth factor (VEGF), new blood vessels sprout from the choroid and then grow into the retina. The new vessels, unlike normal ones, are leaky, and they allow fluid from the blood, and sometimes even red blood cells, to enter the retina. This fluid can immediately distort the vision because it forms a "blister" in the retina, which is normally flat. Over the course of days to months, this fluid can harm the retina, killing the light-sensing cells, called photoreceptors.
Objective: Image processing and the related imaging modalities is a very vast progressive upcoming field. Medical imaging is the approach used to acquire images of the body parts for medical uses which would be applicable in identifying or studying diseases. In this paper, we focus on its applications in the field of ophthalmology and retinal imaging where a review of a defect in the eye using image processing and the techniques available in it would help recognize the defective parts.

Keywords: Image Processing, VEGF, Choroid Neovascularization, AMD, CNVM

1. INTRODUCTION

"Choroidal Neovascularization" which means growth of new blood vessels is caused most probably because of Age-related Macular Degeneration. These new anomalous blood vessels develop in the choroid and the vessels embrace with a layer under the retina. For people with AMD sometimes the retinas produce too much vascular endothelial growth factor (VEGF) which leads to the development of new blood vessels from the choroid which then grows into the retina. These new vessels are leaky unlike normal ones, and they allow fluid from the blood, and sometimes even red blood cells, to enter the retina. This fluid can immediately distort the vision. It forms "vesicles" in the retina, which is normally flat. In the fullness of time, this fluid can harm the retina, killing the light-sensing cells, called the photoreceptors. Since the diagnosis is complicated due to the occurrence of the blood vessels. Image processing would be the foremost field to support the diagnoses.
Choroidal neovascular membranes (CNVM) are unusual blood vessels that grow underneath the retina and interrupt vision. A signaling protein called the VEGF (Vascular endothelial growth factor) promotes the growth of new blood vessels. This signaling protein forms as a part of a mechanism that restores blood supply to cells and tissues that are deprived of oxygenated blood supply due to improper blood circulation. The choroid (area between the retina and the sclera) which is the white part of your eye supplies oxygen and nutrients to the eye. When the supply of oxygen is compromised the cells in the choroid region produce VEGF to promote the growth of blood vessels. These blood vessels grow in the choroid. CNV occurs when the recently developed blood vessels start to grow in the choroid and break through the barrier between the choroid and the retina. When CNV leaks in the retina, it leads to vision loss. Since CNV can often originate from posterior pole lesions (a region in an organ or tissue which has suffered damage through injury or disease) and can be hard to spot, an accurate examination is obligatory to a proper diagnosis. Since clinical and fluorescein angiographic findings are often indistinguishable among central serous chorioretinopathy, PCV, and occult choroidal neovascularization, indocyanine green angiography might help to establish a more deficient diagnosis. CNV is associated with many serious eye diseases, most commonly wet age-related macular degeneration. In addition, CNV is found in patients with histoplasmosis, eye trauma, and myopic macular degeneration, an eye disease in extremely nearsighted patients.

1.1 Symptoms of Choroidal Neovascularization

Distortion or waviness of central vision or a gray/black/void spot in the central vision are symptoms of CNV. These symptoms cannot be ignored and if it occurs one must immediately visit an ophthalmologist to prevent further damage

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which could lead to loss of eyesight. After proper diagnosis of the disease, ophthalmologists can treat the patient to protect them from further damage by halting the growth and leakage of the blood vessels. It is effective only if they can deliver the drug within hours or a few days from the time you notice the vision change. Time lost is vision lost!

1.2 Other Conditions That May Cause Choroidal Neovascularization

Age-related macular degeneration is the most common disease-causing CNV, but other diseases that "stress" the retina, causing it to produce excess VEGF, or disrupting the barrier between the retina and choroid, can also cause CNV.

1.2.1 In patients with pathologic myopia (extreme nearsightedness), the eye is longer than normal, and this lengthening stretches and stresses the retina.

1.2.2 Ocular histoplasmosis is a fungal infection that can cause CNV.

1.2.3 Eye trauma and angioid streaks (small breaks in one of the retina's layers) can break the barrier between the retina and choroid, resulting in CNV.

1.2.4 Severe ocular inflammation, a condition called uveitis, can also cause CNV.

2. TREATMENT OF CHOROIDAL NEOVASCULARIZATION

2.1 Anti-VEGF drugs

A common way to treat CNV is with anti-VEGF drugs. These drugs target the signaling protein VEGF produced by the cells and tissues in your eye that causes the growth of abnormal blood vessels. Several anti-VEGF drugs can block the trouble-causing VEGF in the eye. Blocking VEGF reduces the growth of CNV which slows down leakage, helps to slow vision loss, and in some cases improves vision. Your ophthalmologist administers the anti-VEGF drug directly to your eye in an outpatient procedure. The drug is injected into the white area of your eye using a very thin needle. Before the injection, your ophthalmologist will clean and numb your eye to reduce pain. A small device might be used to hold our eyelids in place so that it doesn't affect the procedure. You may receive multiple anti-VEGF injections over the course of many months. Repeat anti-VEGF treatments are often needed for continued benefit.

2.2 Photodynamic therapy (PDT)

PDT uses a light-activated drug called a photosensitizer and a special low-power, or cool, laser to target the CNVM. Your ophthalmologist performs this procedure on an outpatient basis, usually in an ophthalmologist's office. The photosensitive drug is injected into a vein in your arm. It travels throughout the body and to the abnormal blood vessels. The laser is targeted directly on the abnormal vessels, activating the drug. This causes damage specifically to those unwanted blood vessels. After PDT, the abnormal blood vessels may reopen, so you may need multiple treatments. Treating CNVM can help stabilize your vision and prevent further vision loss. However, in many patients, it is not possible to regain lost sight. In such cases, it is important to learn How to make the most of your remaining vision?

2.3 Thermal Laser Treatment

Another form of treatment for CNVM is thermal laser therapy. Laser treatment is usually done as an outpatient procedure. The laser beam in this procedure is a high-energy, focused beam of light. It produces a small burn when it hits the treatment area of the retina. This destroys the abnormal blood vessels, preventing further leakage, bleeding, and growth.

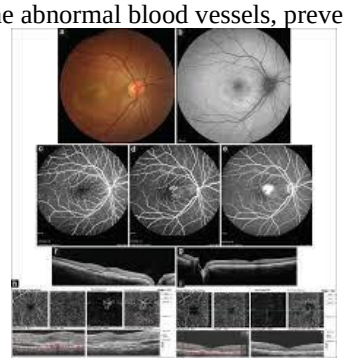

Fig.1. Choroidal Neovascularization Analyzed on OCT Image

3. OCT AND IMAGE PROCESSING

Optical coherence tomography (OCT) is an emerging imaging modality that has been broadly used in the field of biomedical imaging. In the recent past, it has found uses as a diagnostic tool in dermatology, cardiology, and ophthalmology. In 1991 Huang developed OCT with micrometer resolution. Capable of Image cross-sectional view of

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the retina and can construct a 3D image of the retina. For an ophthalmologist, it is interesting to see how healthy the layers of the retina are and they really need to know the boundary layers & how they are separated.

4. OPTICAL COHERENCE TOMOGRAPHIC ANGIOGRAPHY

Optical coherence tomographic angiography (OCTA) is a novel imaging tool, which allows visualization of the retinal and choroidal microvasculature in vivo by detecting intravascular blood flow. In general, OCTA monitors blood flow by detecting changes in reflectivity, which are thought to be related to the dynamic motion of red blood cells, and are facilitated by sequential cross-sectional scans, which are then repeated at the same location over time. This process is repeated throughout many cross-sectional locations in the area of interest to create a volumetric (three-dimensional) vascular map.

Because it is based upon flow motion detection, there is no need for contrast dye injections. Additionally, the OCTA image could be obtained in only 30–60 s, which is quicker when compared to FA and ICGA, both of which require approximately 10–30 min. Furthermore, layer-by-layer and three-dimensional volumetric analyses of the chorioretinal vascular architecture are possible using OCTA imaging, which could not be performed through the use of conventional imaging modalities such as FA and ICGA. Precise localization of CNV is important for the purpose of both evaluating therapeutic effects and predicting prognoses.

OCTA is a safe, fast, and noninvasive method for the diagnosis and analysis of microvascular abnormalities associated with retinal vascular disease and AMD. However, CNV lesions are found in a variety of shapes, sizes, and locations, with the flow visualization within these structures possibly being significantly different. Moreover, OCTA images are degraded by projection and corrupted by speckle noise, resulting in a low contrast between CNV and its background. Therefore, interpretation of the images acquired through the use of this technology remains challenging

In fact, you can measure various kinds of biomarkers. Due to the underlying physics, OCT images suffer from a granular pattern, called speckle noise, which restricts the process of interpretation. This requires specialized noise reduction techniques to eliminate the noise while preserving image details. Another major step in OCT image analysis involves the use of segmentation techniques for distinguishing between different structures, especially in retinal OCT volumes. The outcome of this step is usually thickness maps of different retinal layers which are very useful in the study of normal/diseased subjects. Lastly, movements of the tissue under imaging as well as the growth of the disease in the tissue affect the quality and the proper exegesis of the obtained images which require the use of different image registration techniques.

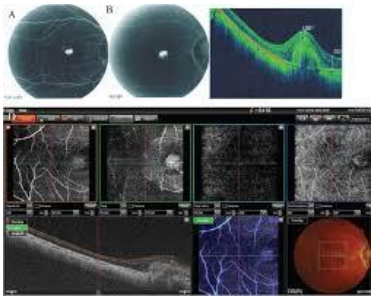

Fig.2. Optical coherence tomography angiography in the diagnosis of choroidal neovascular membrane

CONCLUSION

Age-associated macular degeneration is one of the important reasons behind blindness. But, the intrinsic structures of retinas are complicated and hard to be identified owing to the neovascularization occurrence. Conventional surface detection techniques may face failure in layer segmentation. To resolve this issue, the recent research presents a supervised technique, which is suggested for simultaneous segmentation of the layers and neovascularization. To have better clarity of the structure of the OCT images, digital images can also be implemented through techniques to identify patterns and segmentation of images. Developing a Mobile application with image processing techniques with enhanced algorithms would be very useful in identifying the diseased eye.

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