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Image Segmentation and Analysis in the Case Study of Macular Degeneration Using Labview

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Abstract— Computer assisted analysis of retinal images to diagnose Age Related Macular Degeneration (AMD) requires the quantification of drusen deposits in human retina. Age-related macular degeneration is a disease associated with aging that gradually destroys sharp, central vision. An increase in the size or number of drusen raises a person's risk of developing advanced AMD. These changes can cause serious vision loss. Incorporation of image processing technologies in the field of ophthalmology presents a wide range of possibilities when there is a demand for improving the quality of medical care. An automated and reliable method for finding the drusen exudates has been developed using retinal image analysis. The retinal images are enhanced and morphological operations done so as to segment drusen areas that differ slightly from the background. The software Vision Assistant of Lab VIEW is used for the automatic detection and mapping of drusen deposits in the retinal images. The result is the display window which helps the doctor to make the accurate diagnosis or get information regarding the efficacy of the treatment very faster during the course of the disease.

Index Terms—Macular Degeneration, Drusen, Image segmentation, Histogram equalization, Mathematical morphology.

I. INTRODUCTION

Age related Macular Degeneration is a disease associated by the breakdown of the macula resulting in the progressive loss of vision. It is the leading cause of worldwide blindness in the elderly people. It is a bilateral ocular condition that affects the central area of retina known as the macula [9]. The aim is to analyze and enhance the images of retina acquired using a fundus camera in order to estimate the extent of the damage caused by Macular Degeneration [1]. Different mathematical and morphological tools are used for extracting the image components that are useful in the analysis of the disease. In case of AMD, aim is to analyze the retinal images and find the regions containing drusen. Drusens are bright spots and have non homogenous intensity with round shape in the best cases.

Digital cameras are used to capture the retinal images for analysis of retinal images, so as to detect the presence of drusen and help the examiner meet the right decision [8].

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Drusen are bright spots and have non-homogenous intensity with a round shape in the best cases. This work on image processing is done as an extension of earlier works of the authors [2-4].

II. BASIC PROCESSES

The various processes are gray-scale extraction, histogram equalization, gamma correction, morphological processes, edge detection, area calculation and segmentation [10].To convert any color to a grayscale representation of its luminance, first one must obtain the values of its red, green, and blue (RGB) primaries in linear intensity encoding, by gamma expansion. Then, add together 30% of the red value, 59% of the green value, and 11% of the blue value (these weights, depend on the exact choice of the RGB primaries, but are typical).

In image processing histogram equalization is a method of contrast adjustment using the image's histogram. Also histogram equalization can produce undesirable effects (like visible image gradient) when applied to images with low color depth. For example if applied to 8-bit image displayed with 8-bit gray-scale palette it will further reduce color depth (number of unique shades of gray) of the image. Morphological operations are used to understand the structure or form of an image. This usually means identifying objects or boundaries within an image. Morphological operations are dilation and erosion. Dilation causes objects to dilate or grow in size; erosion causes objects to shrink. The amount and the way that they grow or shrink depend upon the choice of the structuring element. The erosion of a set by a structuring element is the set of pixel position for which, a structuring element placed with its reference point there will be contained completely within the set.

The combination of erosion followed by dilation is called an opening, referring to the ability of this combination to open up gaps between just touching features. Performing the same operations in the opposite order produces a different result. This sequence is called a closing because it can close breaks in features. Openings can be used to separate touching features. It is possible to continue erosion until all features have separated but none have been completely erased. Afterthe separation is complete, dilation grows the features back toward their original size. Edge detection is a terminology in image processing and computer vision, particularly in the areas of feature detection and feature extraction, to refer to algorithms which aim at identifying points in a digital image at which the image brightness changes sharply or more formally has discontinuities.

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III. PROGRAM METHODOLOGY

Here program is developed using Vision Assistant which is supported by LabVIEW. LabVIEW stands for Laboratory Virtual Instrumentation Engineering Workbench. It is commonly used for data acquisition, instrumentation control and industrial automation on a variety of platforms. LabVIEW provides a platform and development environment for a visual programming language from National Instruments. It consists of a comprehensive set of tools for acquiring, analyzing, displaying and storing data. Vision Assistant which is supported by LabVIEW is used to prototype and test image processing algorithms or applications. With the help of Vision Assistant images can be directly loaded into the program and various operations can be performed on it [11]. The prototype is created using LabVIEW. Vision Assistant is a tool for prototyping and testing image processing applications. Here custom algorithms are built with the Vision Assistant scripting feature. The scripting feature records every step of the processing algorithm.

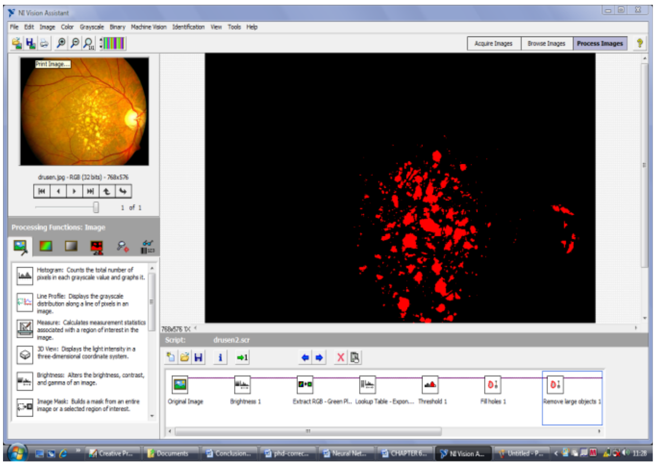

Figure 1 Display window showing vision assistant script

After completing the algorithm, it can be tested on other images to make sure it works. The algorithm is recorded in a script file, which contains the processing functions and relevant parameters for an algorithm to be built. The Figure 1 shows the display window where the script is build and the retinal image affected with Macular Degeneration.

IV. DETECTION OF AMD

The main steps of the algorithm are non uniform illumination composition, extraction (green plane) filtering, threshold and morphological operations. The shape irregularity of retina causes shadow on the field of view when illuminated by bright source as in the fundus camera[6,7]. This results in the non uniform brightness distribution. Hence first step is to provide uniform brightness to the image. The Vision Assistant software provides a specific tool to adjust the brightness of an image within a particular range. It is used for improving the appearance of the image and enhancing the lesions present in the eye image. Here the brightness is expressed in gray levels centered at 128. Higher values (up to 255) results in a brighter image and the lower values result in a darker image.

V. IMAGE ENHANCEMENT

The next processing step aims at enhancing the contrast of retinal image. Each image requires a different contrast depending on the type of illumination. The gamma value is used in gamma correction. Higher the value of gamma, stronger is the intensity correction. Gamma correction is important for displaying an image accurately on a computer screen. If images are not corrected properly the image looks bleached out or too dark. Gamma correction changes the brightness and also ratios of red to green to blue. The changes made in the brightness, contrast and gamma correction is observed in a lookup table (LUT). Each pixel of color image has three values; one each for color of red, green and blue component. Hence the color image is composed of three color frames; red plane, green plane and blue plane. In the RGB color space, brightness can be thought of as the arithmetic mean μ of the red, green, and blue color coordinates (although some of the three components make the light seem brighter than others, which, again, may be compensated by some display systems automatically).

Here green plane components are extracted to get the clear perception of all the image properties. The result of this function is a grayscale image of 8 bits with intensity values that correspond to plane extracted. This image has to be further enhanced to such that only the drusens are visible and the rest of the image details are discarded. This is done by applying a lookup table (LUT) to an image. The lookup table transformations are basic image processing functions that highlights details in areas containing significant information, at the expense of other areas. LUT transformations are used to improve the contrast and brightness of an image by modifying the dynamic intensity of regions with poor contrast. For each grayscale value of an image, the corresponding grayscale value is obtained from LUT and assigned to every pixel in the gray scale plane.

Here an exponential transform is used which decreases the brightness and contrast in dark regions. It increases contrastin bright regions. Here only the drusens are illuminated and rest of secondary details such as veins is darkened. Only the disadvantage is that the retinal disc is also illuminated.

VI. THRESHOLDING AND SEGMENTATION

The next step is thresholding. The thresholding value is obtained from histogram analysis of a segment. It is done with the help of line profile which gives the gray scale distribution along a line of pixels in the image. A value for the maximum value is selected as the thresholding level. Thresholding can be considered as the special case of clipping [5].

The resultant image becomes binary. In case of 8 bit images the gray level below and including the threshold are mapped onto zero, while gray levels greater than threshold value are mapped onto 255. Because of simplicity of implementation thresholding holds an important central position in image segmentation. Segmenting drusen in an enhanced image is an important prerequisite for measuring and understanding region affected with drusen. The goal here is to separate drusen from rest of unwanted details.

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After the mentioned process good amount of background details are removed. The remaining isolated pixels and the retinal disc can be removed with the help of morphological operations.

The drusens are detected without affecting intensity variations caused by vessels. Since the images that are dealt with have a variable contrast and a background, even choosing the best threshold cannot give good results.

VII. MORPHOLOGICAL OPERATIONS

Here the concept of mathematical morphology is used as a tool for the extraction of image components. Mathematical morphology is an approach to image analysis based on set theory. Morphological processing refers to certain operations where an object is hit with a structuring element and thereby reduced to a more relevant shape. Here two fundamental morphological operations dilation and erosion are used in terms of intersection of an image with a translated shape for extracting features from an image. Dilation allows objects to explore thus potentially filling in small holes and connecting disjoint objects. Erosion shrinks objects by etching away boundary. These operations can be applied by proper selection of the structuring element which determines exactly how the objects will be dilated or eroded.

To remove unwanted segments of the image the morphological process of erosion is used. The software provides various functions based on erosion of which the options to remove small objects and large objects are used. The smallobjects are used to remove noise components and large objects to remove retinal disc. A 2-D 3×3 square matrix is used as the structuring element. In the erosion process the structuring element is moved across the image and if origin of structuring element coincides with zero in the image there is no change, move to the next pixel. The origin of structuring element coincides with '1' in the image and any one of the '1'pixels in the structuring element extend beyond the object (1 pixel) in the image then change the '1' pixel in the image to '0'.

Then the option of gradient is used where the interior contours of the drusens is removed preserving only the boundary of the drusens. The process is a combination of opening and closing which is the derivation of the dilation and erosion operation. The well defined drusen structures have been obtained.

VIII. PARTICLE ANALYSIS

The drusens obtained are analyzed with the help of particle analysis function provided by the software. Particle analysis is used to detect connected regions or groupings of pixels in an image and then make selected measurements of those regions. These regions are commonly referred to as particles. Particle analysis consists of a series of processing operations and analysis functions that produce some information about the particles in an image. A particle is a contiguous region of nonzero pixels. A typical particle analysis process scans through an entire image, detects all the particles in the image and builds a detailed report on each particle. The multiple parameters such as perimeter, angle, area and centre of mass can be used to identify and classify these particles. The different measurements such as area, center of mass, and perimeter can be viewed. It is possible using Vision Assistant to assign numerical variables to all particles in the particle analysis. When a user clicks on the label particles the Vision Assistant highlights the particles in the image and corresponding results can be seen in the table. The user can also click on the result to get corresponding particle on the image.

To find area occupied by each object, particle analysis can be done on the image. Particles can be characterized by measurements related to their attributes, such as particle location, area, and shape. Particle measurements are done to make shape measurements on particles in a binary image.

In addition to making conventional pixel measurements, particle analysis functions can use calibration information attached to an image to make measurements in calibrated real-world units. In pixel measurements, a pixel is considered to have an area of one square unit, located entirely at the center of the pixel. In calibrated measurements, a pixel is a polygon with with corners defined as plus or minus one half a unit from the center of the pixel. Particles can be extracted from a gray-scale image by thresholding the image into background and foreground states. Zero valued pixels are in the background state and all nonzero valued pixels are in the foreground. In a binary image, the background pixels are zero and every non-zero pixel is part of a binary object.

The pixels that are selected for processing appear red. Unselected pixels appear black. The image is now a binary image, which is an image, composed of pixels with values of 0 and 1. This image is displayed using a binary palette, which displays the pixel intensities of an image with unique colors. All pixels with a value of 0 appear black and pixels set to 1 appear red. The red pixels are now referred to as particles. Based on this the area of drusens can be obtained for Macular Degeneration.

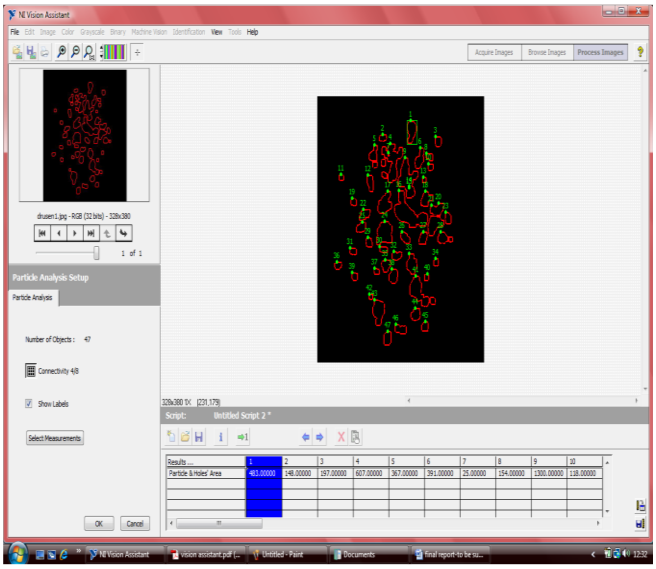

Figure 2 Display window showing the particle analysis

Figure 2 shows the particle analysis done on the image. The particle measurement is done on the image. Numerical variables are assigned to drusens in the image. The area of drusens in pixels is displayed as a table in Figure 2. The first row of the results table lists the numerical label associated with each particle. When a particle is clicked in the display window, the measurement results for that particle are highlighted in blue.

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When the results for a particle are clicked, the particle is highlighted in green in the processing view. Figure 3 shows the image with numerical variables assigned to drusens. Tests were conducted on many retinal images, affected with Macular Degeneration.

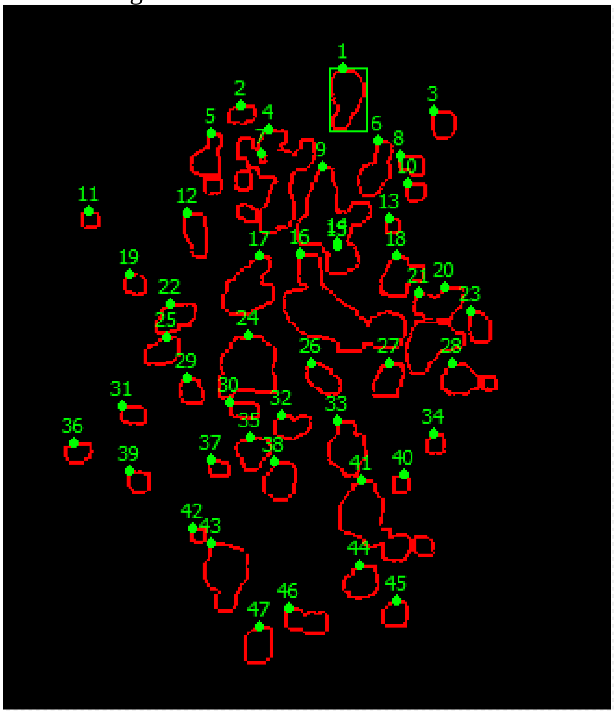

Figure 3 Drusen with numerical variables assigned

IX. CONCLUSION

For AMD detection, the algorithm developed is successful in detecting and extracting the drusens from the fundus images. Here, an automated and reliable method using Lab VIEW is developed for analyzing the progress and extent of AMD (Age related Macular Degeneration) from the retinal image. The final image provides information about drusens, which enables the doctor to identify if the patient is suffering from AMD or not. It also can be used to study the natural course of the treatment. The advantage of the system is simplicity of operation and also borders of drusen areas are much more clearly defined. In LabVIEW no knowledge of programming language is needed. LabVIEW development systems offer the possibility of developing stand alone systems.

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