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Automatic Detection of Diabetic Retinopathy using Image Processing

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Abstract. We present a reliable, automatic digital procedure for diagnosing and following-up Diabetic Retinopathy. Specifically, we implement a procedure that records retinal areas of interest, which are suitably magnified and binarized employing fractal image techniques. Then, from two well-known retinal data banks (ROC and DIARETDB), we create an automatic Bayesian classifier for the decision making stage. We show that the reported procedure is capable of detecting 96.7 % of the Diabetic Retinopathy lesions.

Keywords. Retinopathy diabetic, image processing, aneurysm format.

1 Introduction

The World Health Organization considers Diabetes Mellitus (DM) as a public health problem, due to its high prevalence, its associated morbidity and its mortality. It is known that within 15 years of the first diagnosis, some patients develop diabetic retinopathy; which affect anatomically and functionally the performance of the human retina. Hence, there is a need for an early detection of DM, as well as for following up any retinal [1].

For early detection, a trained expert performs the diagnosis; and after the diagnosis is made, at fixed periods, a physician needs to examine the retina for identifying the evolution of the lesions. Within 15 years of the first diagnosis, approximately 98 % of people with diabetes type 1, and 78 % with type 2, develop some form of retinopathy [1].

The World Health Organization reports that by 2030 the prevalence will be 300 million people with DM type 2. In Mexico the number of people with DM fluctuates between 6.5 and 10 million [2]. Furthermore, the World Health Organization estimates that Retinopathy Diabetic (RD) produces 4.8% of the 37 million blind people in the world [3]. Hence, DM is a serious health problem.

Here, we discuss an automatic procedure for identifying and for extracting abnormalities, as a hemorrhages and aneurysms. We believe that the procedure will provide a tool, to the specialists, for early diagnosis timely following-ups. To this end, we employ fractal analysis and image segmentation. In the section 2, we revise the fundamentals of image processing, including a brief discussion on fractal analysis. In section 3, we describe the proposed procedure. In section 4, we show the main results of this work. And in section 5, we summarize our contribution.

2 Basics on Image Processing

Digital image processing is a set of methods and tools used often in several branches of science and engineering. As part of these set of tools, image segmentation is used for detecting edges between different regions in a picture. And then after edge detection, by using other set of tools, one can isolate different regions.

For medical applications, Bhattacharya and Das have employed discrete wavelet transformations, due to its multiresolution properties [4]. Sung et al. have used mathematical morphology operations, together with wavelet transforms, for locating Regions of Interest (ROI) in a picture [5].

Rather recently, a procedure was tested for diagnosing cancer, from screening mammographs. This procedure employs morphological operators, machine learning techniques and a clustering algorithm for intensity-based segmentation [6]. By using this procedure, it is possible to distinguish masses and micro calcifications from background tissue.

It is convenient to recognize that image segmentation has been found applications for detecting textures, for identifying tumors and lesions in photo-acoustic images [7], and in thermographic images [8].

2.1 Fractal Geometry and Analysis

The term fractal is commonly used to describe the family of non-differentiable functions that are infinite in length. Fractal objects contain structures that are nested within one another. There are 2-D fractal pictures, as well as 3-D fractal images. In all cases, the main feature of a fractal image is that it characterizes the way in which a quantitative dataset grows in mass, with linear size [9].

Fractal geometry offers an alternative model for seeking regularities in picture, by looking at its parts at different scales. To this end, the object is expressed as the geometric limit of an iterative process. However, there is a risk of generating fractures, which lead to the absence of differentiability at the boundaries of the regions in a picture [10].

Various natural phenomena display self-similarity, which is characterized by a parameter called fractal dimension, D. This real number is used as an exponent for describing how the object structure is repeated N times, at different scales here denoted by the real number r. These quantities are interrelated by Equation 1a:

$$N=1/r^{D}. \tag{1a}$$

Equivalently, we have that:

$$D=log\,(N)/Log(1/r). \tag{1b}$$

In this contribution, the fractal dimension D characterizes a pathological tissue. The rationale being that within the human body healthy tissues have a high degree of similarity. Fractal descriptors can be found in [11, 12].

3 Proposed Procedure

In figure 1, we depict the flowchart of the proposed methodology. As a first step of the proposed methodology, the input is a RGB image. We select the green channel, since the green channel offers a high contrast; when identifying lesions in the retinal images.

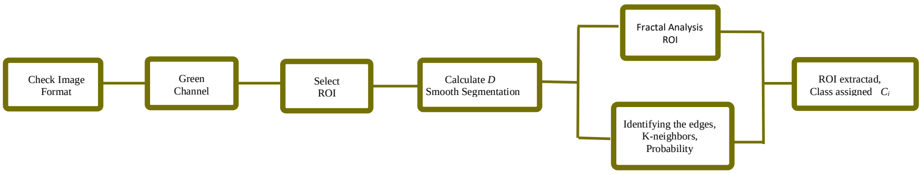

Fig. 1. Flowchart of the proposed methodology.

Then, we select the region for performing the fractal analysis of the image. Next, we evaluated the parameter *D* for performing the segmentation of the image. Once that the image is segmented, we complete the fractal analysis over the selected region. After that, we extract the ROI; and simultaneously we classify the image.

4 Main Results

In figure 2, we exemplify the use of the proposed methodology. In Figure 2 A), we display the original image; we use a frame for locating area of interest. In Figure 2 B), we show a magnified version of the selected area. In Figure 2 C), we present the image after fractal analysis, which describes the ROI extraction process.

In Figure 3 A), we report again the process of selecting an area of interest. In Figure 3 B), we show a magnified picture of the selected area. And in Figure 3 C) we display an image after fractal analysis. This latter picture indicates the absence of retinopathy.

For our present work, we employ 75 retinal images. Of these images 40 were pictures for training our procedure. And the remaining 35 pictures were used for testing the trustworthiness of our procedure. In the test pictures, we select at least one area of interest. For obtaining the ROI, we employ a Bayesian classifier for assigning the class with retinopathy or without retinopathy. The classifier was applied to each of the 35 testing pictures. In 96.7% of the cases, our procedure could assign the right class.

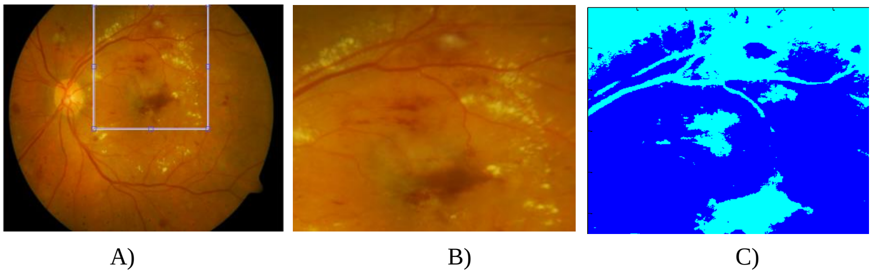

Fig. 2. Example of use of the proposed methodology.

Fig. 3. Result of processing in an image without retinopathy.

5 Conclusions

We have focused our attention on a pathological disorder of the eye, known as Diabetic Retinopathy; which is considered the third cause of irreversible blindness in the world. We have shown that image processing techniques can provide tools for both early diagnoses, as well as for following-ups. Furthermore, we have indicated that image processing techniques are also useful for storing and for sharing relevant medical data. We have shown that by using a Bayesian classifier, one can have an automatic decision making procedure; which can detect 96.7 % of the Diabetic Retinopathy lesions.

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