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Detection of Diabetic Retinopathy from Fundus Images using Python

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***Abstract*: The study is based on the rising situation in the developing world, suggests diabetic retinopathy may soon be a major problem in the clinical world as it is a major cause of blindness. Hence, detection of diabetic retinopathy is important. This paper focuses on to analyse the retinal images normal or abnormal and find the metrics of DR by using Raspberry Pi kit. To detect the diabetic retinopathy from retinal images using python through Threshold, Colour-k means clustering algorithm, water algorithm, mean shift algorithm, distance algorithm.**

***Keywords*: Euclidean Distance, Feature Extraction, Image Pre-Processing, Leaf Classification, Specie Recognition, Image Segmentation**

1. Introduction

World Health Organization (WHO) predicts that developing countries will bear the brunt of the epidemic in the 21st century. An estimated 285 million people, corresponding to 6.4% of the World's adult population, will live with diabetes at the end of 2011.The number is expected to grow to 438 million by 2030, corresponding to 7.8% of the adult population.70% of the current cases of diabetes occur in low and middle income countries. With an estimated 50.8 million people living with diabetes, India has the world's largest diabetes population, followed by China with 43.2million. 80% of all patients who have diabetes for 10 years or more or prone to diabetic retinopathy. This is the main cause of vision loss and its prevalence is set to continue rising. Diabetic is a disease that affects blood vessels throughout the body, particularly in the kidneys and eyes. When blood vessels in the eye are affected, the condition is referred to as Diabetic retinopathy, is a major public health problem and a leading cause of blindness in the World. Diabetic retinopathy is a micro vascular complication that may occur in patients with diabetics' mellitus. It is the number one cause of blindness in people between the ages of 24-64 in United States. It is, therefore, a worthwhile topic for all medical students. Diabetes mellitus is extremely common, so it is not surprising that DR affects 3.4 percent of the population (4.1 million individuals) of millions of people with DR, nearly one-fourth have vision-threatening disease.

2. Literature review

For the past several decades, tremendous efforts have been made to decrease the complications of diabetes, including diabetic retinopathy. New diagnostic modalities like ultra wide field fundus fluorescein angiography and spectral domain has allowed more accurate diagnosis of early diabetic retinopathy and diabetic macular edema. According to survey Antivascular endothelial growth factors are now extensively used to treat diabetic retinopathy and macular edema with promising results. There remains uncertainty over the long term effects and the socioeconomic costs of these agents.

A.Hoover and M.Goldbaum (2010) demonstrated the locating the optic nerve in a retinal image using the fuzzy convergence of the blood vessels. This novel algorithm analyze 31 images of healthy and 50 images of diseased retina. Time consume is a risk factor.

L .Giancardo, F. Meriaudeau, T. Karnowski ,Y. Li, K. Tobin and E. Chaum.,(2011) described, Microaneurysam detection with radon transform-based classification on retina images. This segmentation technique is based on novel application. Surface reflectance property is the high risk factor involved in this.

M. Garnier, T. Hurtut, Haber Tahar, F. Cheriet., (2014) demonstrated automatic multi-resolution age related mascular degeneration detection from fundus images in a local binary pattern with a risk of pixel by summing binary string.

E. Soto-Pedre ,A. Navea, S. Millan, M. C. Hernaez Ortega, J. Morales, M. C. Desco and P. Perez., (2016) have demonstrated an evaluation of automated image analysis software for the detection of diabetic retinopathy to reduce the ophthalmologist workload with an retinal image processing algorithm.

C. Sinthanayothin J. Boyce H. Cook T. Williamsom, Br.J Ophthalmol, vol.83 (August 1999) has detailed the automated localization of optic disc fovea and retinal blood vessels from digital color fundus images.

S. Jerald Jeba Kumar Madheswaran,(2009) did Extraction of blood vascular network for development of an automated diabetic retinopathy screening system with an International conference on computer technology and development.

3. Materials and methods

- Raspberry PI
- Raspbian OS

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- Computer monitor
- Rs232 cable
- Software required: python, opencv package

A. Research plan

- The existing segmentation algorithms were implemented only using MATLAB.
- No practical use.
- Consume more time to execute
- Need high configuration system

1) Problem definition

- Diabetic retinopathy is the major cause of blindness.
- Over 50 million people have this disease and it is expected to be about 366 million in 2030.
- Exudates
- Micro aneurysms.
- Hemorrhages

B. Research framework

1) Exudates

A fluid, rich in protein and cellular elements that oozes out of blood vessels due to inflammation and is deposited in nearby tissues. The altered permeability of blood vessels permits the passage of large molecules and solid matter through their walls. The vessels seem to weep, to sweat, in keeping with the Latin "exsudare", to sweat out, from which the exudate is derived.

2) Types

They are classified into two types of exudates. Hard and soft exudates are separated based on chosen threshold value. Soft exudates are often called "cotton wool spots" and are more often seen in advanced retinopathy. Hard exudates are also called as yellow flecks.

Fig. 1. Hard exudates

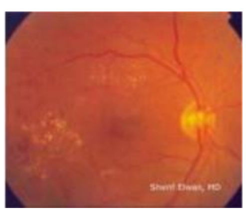


Fig. 2. Soft exudates

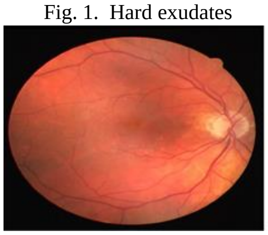


Fig. 3. Normal Input Image

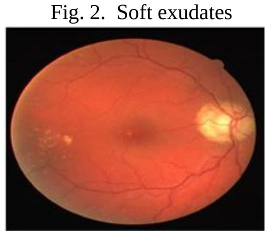


Fig. 4. Abnormal Input Image

3) Input of retina Image

4) Causes

Exudates are one of the earlier signs of diabetic retinopathy. Exudates occur when the lipid or fat leaks from the abnormal blood vessels. The screening diabetic patients for the detection of exudates can potentially reduce the risk of blindness in these patients. Diabetes has been recognized as the main cause of blindness. If not diagnosed early and treated in time, it can lead to severe damage to retinal structure leading to partial or even complete blindness. Normally, the screening process involves excessive dilation of pupil (mydriasis) to get a closure view of the retina and ophthalmoscope magnifies the retina in greater detail. The various drugs used for mydriasis are tropicamide, atropine, cocaine, mescaline, LSD, amphetamine, etc. In addition to diabetic retinopathy, the drugs used for screening process also affect the patients' eye sight.

5) Diagnosis

We have analyzed the performance of three template matching algorithms to detect blood vessels in the retinal images for both gray level and colored images. The complete and continuous map of the blood vessels is detected using the proposed 2D Gaussian matched filtering and remove from the eye funds images and then retinal vessels bifurcations and crossover points to locate their facilities and remove vascular network, using operators and the retinal blood vessels were automatically segmented digital images using Gabor Wavelet transform. The detection of blood vessels is improved by using better filter parameters. A method has been proposed to identify mild NPDR and severe NPDR using a procedure involving global image feature extraction. Using the scale and orientation selective Gabor filter banks, the abnormalities are detected.

6) Open CV

Definition: Open CV (Open Source Computer Vision) is a library of programming functions mainly aimed at real-time computer vision, developed by Intel Russia research center in Nizhny Novgorod, and now supported by Willow Garage and Itseez. It is free for use under the open-source BSD license. The library is cross-platform. It focuses mainly on real-time image processing. If the library finds Intel's Integrated Performance Primitives on the system, it will use these proprietary optimized routines to accelerate itself.

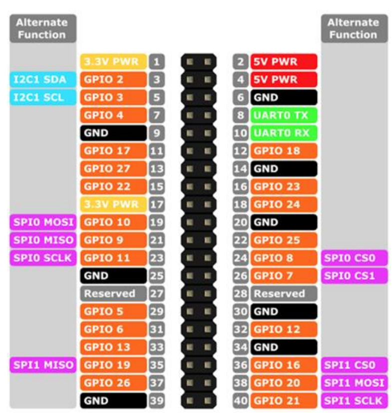


Fig. 5. Pin Diagram of Raspberry

7) Non-mydriatic retinal cameras

A fundus camera or retinal camera is a specialized low power microscope with an attached camera designed to photograph the interior surface of the eye, including the retina, optic disc, macula, and posterior pole (i.e. the fundus). Fundus cameras are used by optometrists, ophthalmologists, and trained medical professionals for monitoring progression of a disease, diagnosis of a disease, or in screening programs, where the photos can be analyzed later. System, it requires non-mydriatic fundus photographs as input. Some of the non-mydriatic retinal cameras are KOWA-7, Iidek NM-200D, CR-DGi and Topcon NW-200.

Fig. 6. Kowa -7 Non Mydriatic Retinal Camera

4. Preprocessing

A. Definition

Image pre-processing is an important and challenging factor in the computer-aided diagnostic systems. In medical image processing and especially in exudate segmentation task it is very important to pre-process the image so that segmentation and feature extraction algorithms work correctly. Proper detection and segmentation of the tumor leads to exact extraction of features and classification of those tumors. The accurate image segmentation is possible if image is pre-processed as per image size and quality.

B. Need for preprocessing

The pre-processing is required for retinal images as:

- Marks or labels present (Film artifacts) can interfere in the post-processing of these images.
- Images are to be made more suitable for further processing in CAD systems.
- The image quality needs to be enhanced
- Noise in the image needs to be removed.

Here an attempt has been made to identify the suitable algorithms for preprocessing the retinal images have exudate. The objective of this work is to:

- To detect exudates which are the yellow pigments in the retina
- To classify the severity of the lesions using the PLS classifier.

C. Gray scale conversion

A grayscale (or gray level) image is simply one in which the only colors are shades of gray. The reason for differentiating such images from any other sort of color image is that less information needs to be provided for each pixel. In fact, a `gray' color is one in which the red, green and blue components all have equal intensity in RGB space, and so it is only necessary to specify a single intensity value for each pixel, as opposed to the three intensities needed to specify each pixel in a full color image. This function will convert the input BGR image to grayscale. Often, the grayscale intensity is stored as an 8-bit integer giving 256 possible different shades of gray from black to white. If the levels are evenly spaced then the difference between successive gray levels is significantly better than the gray level resolving power of the human eye. Grayscale images are very common, in part because much of today's display and image capture hardware can only support 8-bit images. In addition, grayscale images are entirely sufficient for many tasks and so there is no need to use more complicated and harder-to-process color images.

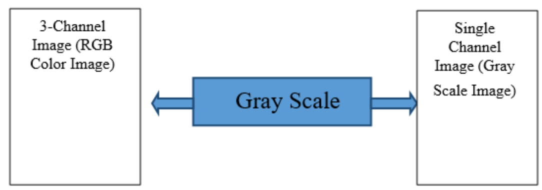


Fig. 7. Gray scale conversion

D. Filters

1) Image Blurring (Image Smoothening)

Image blurring is achieved by convolving the image with a low-pass filter kernel. It is useful for removing noise. It actually removes high frequency content (e.g.: noise, edges) from the image resulting in edges being blurred when this is filter is applied. (Well, there are blurring techniques which do not blur edges). Open CV provides mainly two types of blurring techniques.

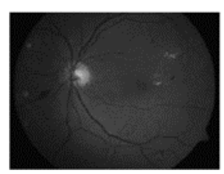


Fig. 7. Smoothed image

2) Gaussian Filtering

Gaussian filtering is used to blur images and remove noise.

- The Gaussian function is used in numerous research areas:
- It defines a probability distribution for noise or data. It is a smoothing operator.
- It is used in mathematics.
- In electronics and signal processing, a Gaussian filter is a filter whose impulse response is a Gaussian function (or an approximation to it). Gaussian filters have the properties of having no overshoot to a step function input while minimizing the rise and fall time. This behavior is closely connected to the fact that the Gaussian filter has the minimum possible group delay.

It is considered the ideal time domain filter, just as the since it is the ideal frequency domain filter. These properties are important in areas such as oscilloscopes and digital telecommunication systems.

- Mathematically, a Gaussian filter modifies the input signal by convolution with a Gaussian function; this transformation is also known as the Weierstrass transform.
- In this approach, instead of a box filter consisting of equal filter coefficients, a Gaussian kernel is used. It is done with the function, cv2.GaussianBlur(). We should specify the width and height of the kernel which should be positive and odd. We also should specify the standard deviation in the X and Y directions, sigmaX and sigmaY respectively. If only sigmaX is specified, sigmaY is taken as equal to sigmaX. If both are given as zeros, they are calculated from the kernel size. Gaussian filtering is highly effective in removing Gaussian noise from the image. If you want, you can create a Gaussian kernel with the function, cv2.getGaussianKernel().

3) Median Filtering

In signal processing, it is often desirable to be able to perform some kind of noise reduction on an image or signal. The median filter is a nonlinear digital filtering technique, often used to remove noise. Such noise reduction is a typical pre-processing step to improve the results of later processing (for example, edge detection on an image). Median filtering is very widely used in digital image processing because, under certain conditions, it preserves edges while removing noise (but see discussion below).

The main idea of the median filter is to run through the signal entry by entry, replacing each entry with the median of neighboring entries. The pattern of neighbors is called the "window", which slides, entry by entry, over the entire signal. For 1D signal, the most obvious window is just the first few preceding and following entries, whereas for 2D (or higher-dimensional) signals such as images, more complex window patterns are possible (such as "box" or "cross" patterns).

Fig. 9. Median filters

4) Media Non-mydriatic retinal cameras

Clustering

5) Introduction

Data clustering is the process of dividing data into classes or clusters so that items in the same are as similar as possible, and items in different classes are as dissimilar as possible. Depending on the nature of the data and the purpose for which purpose for which clustering is being used, different measures of similarity may be used to place items into classes, where the similarity measure controls how the clusters are formed. Some examples of measures that can be used as in clustering include distance, connectivity and intensity. Clustering is a method of unsupervised learning, and a common technique for statistical data analysis used in many fields, including machine learning, data mining, pattern recognition, image analysis and bioinformatics. Besides the term clustering, there are number of terms with similar meanings, including automatic classification, numerical taxonomy and topological analysis. It is used in finding representatives for homogeneous groups (data reduction), in finding “natural clusters” and describe their unknown properties (natural data types), in finding useful and suitable groupings (useful data classes) or in finding unusual data objects (outlier detection). In hard clustering data is divided into distinct clusters, where each data element belongs to exactly one cluster. In fuzzy clustering, data elements can belong to more than one cluster, and associated with each element is a set of membership levels.

6) Types of clustering

A cluster is a collection of objects which are “similar” between them and are “dissimilar” to the objects belonging to other clusters. Clustering algorithm may be classified as listed below:

7) Exclusive Clustering

In this type, the data are grouped in an exclusive way, so that if a certain datum belongs to a definite cluster than it could not be included in another cluster. Example: K-Means clustering algorithm.

8) Overlapping Clustering

The overlapping Clustering uses fuzzy sets to cluster data, so that each point may belongs to two or more clusters with different degrees of membership.

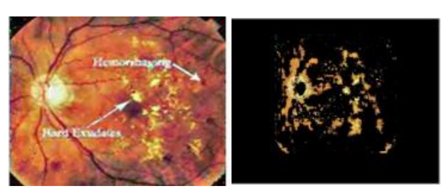
Example: Fuzzy C Means clustering algorithm.

9) Hierarchical Clustering

Hierarchical Clustering find successive clusters using previously established clusters. These algorithms can be agglomerative (“bottom-up”) or divisive (“top-down”). Agglomerative algorithms begin with each element as a separate cluster and merge them into successively larger clusters. Divisive algorithm begins with the whole set and proceed to divide it into successively small clusters.

10) Probabilistic Clustering

It uses a completely probabilistic approach. Example: Mixture of Gaussian.



(a) Normal image (b) Clustered image

Fig. 10. Normal and abnormal images

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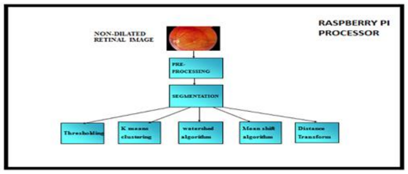

Fig. 11. Block diagram of exudate detection and classification

E. Image acquisition

1) Introduction

Image acquisition in image processing can be broadly defined as the action of retrieving an image from some source, usually a hardware-based source, so it can be passed through whatever processes need to occur afterward. Performing image acquisition in image processing is always the first step in the work flow sequence because, without an image, no processing is possible. The image that is acquired is completely unprocessed and is the result of whatever hardware was used to generate it, which can be very important in some fields to have a consistent baseline from which to work. One of the ultimate goals of this process is to have a source of input that operates within such controlled and measured guidelines that the same image can, if necessary, be nearly perfectly reproduced under the same conditions so anomalous factors are easier to locate and eliminate. One of the forms of image acquisition in image processing is known as real-time image acquisition. This usually involves retrieving images from a source that is automatically capturing images.

2) Retinal image

The retina is a multilayered sensory tissue that lines the back of the eye. It contains millions of photoreceptors such as rods and codes that capture light rays and convert them into electrical impulses. These impulses travel along the optic nerve to the brain where they are turned into images. Optic disc is brighter than any other part of the retina and is normally circular in shape. It is also the entry and exit point for nerves entering and leaving the retina to and from the brain. Nearer to the center of the retina is an oval shape object called macula. The fovea is near the center of the macula and it contains packed cone cells. Due to high amount of light sensitive cells, the fovea is responsible for the most accurate vision.

Fig. 12. Retinal image

F. Preprocessing

1) Definition

Image pre-processing is an important and challenging factor in the computer-aided diagnostic systems. In medical image processing and especially in exudate segmentation task it is very important to pre-process the image so that segmentation and feature extraction algorithms work correctly. Proper detection and segmentation of the tumor leads to exact extraction of features and classification of those tumors. The accurate image segmentation is possible if image is pre-processed as per image size and quality.

2) Need for preprocessing

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- To classify the severity of the lesions using the PLS classifier.

The preprocessing of image comprises of two methods:

- Gray scale conversion
- Filtering

The eye retinal image is converted into gray scale image and is given as input to preprocessing stage. The pixel value of the gray scale image is with the pixels level range from 0 to 255, where 0 corresponds to black and 255 to white for instance. The gray scale image is a single channel image. The gray scale image is processed with the help of the filters. Filters are used to remove the noise from the given image. There are many types of noises that occur in the images mainly Gaussian noise and Impulsive noise. We are using two types of filters. There are:

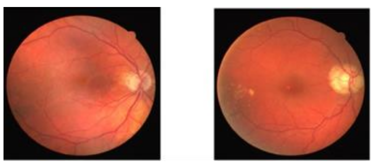
- Gaussian filter
- Median filter

Gaussian filters that are used to reduce or remove Gaussian noise from the gray scale image. The Median filter is used to remove the impulsive noise. Thus the image is free from the noises. Next step is smoothening. Blurring of the image to remove the noise is known as smoothening. The pixels are smoothened by this process. The smoothened image is given to the segmentation process. Segmentation is the process of extracting the Region of Interest (ROI) i.e. the location of the brain tumor in the image. The segmentation used in this project is k-means clustering process.

K-means Algorithm can group into k different classes and that is part of the reason why we chosen as segmentation method for this work. The classification is done by minimizing the sum of the squares of distances between data and the corresponding clustering centroid. Type of distance calculation compatible with K-means Algorithm includes Manhalanobis and Euclidean distance, etc. The preprocessed image is processed by the k means clustering algorithm. This algorithm is an optimal method of detecting the exudate in the image. The edges in the image are alone traced by this algorithm at the output image. Thus the Region of Interest (exudate) is segmented from the image. The image has many features like pixel value, color, texture, shape and etc., these features are extracted by the contour process. These values are given to the classifier. The classifier that used in this method is Partial Least Square (PLS). This PLS algorithm is used to classify the input image as normal or abnormal based on the features given to the classifier.

5. Result

Thus the input of retinal image with diabetes is acquired and preprocessed (gray scale conversion, filtering). Then it is segmented by K-means clustering process. The segmented image is classified by PLS classifier whether the exudates are normal or abnormal.



(a) Normal image (b) Abnormal image

Fig. 13. Normal and abnormal images

6. Conclusion

This paper presented implementation of detection of diabetic retinopathy from fundus images using python.

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