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RETINAL LESION DETECTION AND SEGMENTATION IN FUNDUS IMAGES USING MACHINE LEARNING

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***Abstract** - Obtaining the complete segmentation map of retinal lesions is the first step towards an automated diagnosis tool for retinopathy that is interpretable in its decision-making. However, the ground truth lesion detection in fundus images is more important factor. In this paper, we propose a novel approach for training adaptive threshold based architecture with supervised learning. The architecture is simultaneously trained for two tasks: detection and segmentation of retinal lesions. In addition, we analyses the different geometrical features of processed images like area, density, contrast, skewness for performing the segmentation of retinal lesions. Our complete system produces both detection and segmentation of retinal lesions in fundus images with better classification results.*

- ***Key Words***: Retinal lesions, Image Processing, Machine learning, Matlab, Pre-processing, Segmentation, Feature Extraction, Classification.

1. INTRODUCTION

With recent breakthroughs in machine learning, the promise of automatic disease screening is progressively getting more tangible. In the field of ophthalmology, the development of deep learning, as well as the ease of acquisition of retinal fundus images, has already led to the approval of an automatic diabetic retinopathy (DR) grading system by US health authorities. Fundus images give access to a highly detailed 2D representation of the surface of the retina, generally centered on the macula or the optic disc and containing several diagnostically relevant biomarkers. An abnormality in the retina can either be a manifestation of an eye disease (e.g. age-related macular degeneration, DR), a systemic disease (e.g. hypertensive retinopathy) or even a trauma (e.g. traumatic macular hole). From a clinical point of view, the presence or absence of a given lesion, as well as its shape, texture and location are essential indicators for assessment of the progression and the severity of diseases. For example, early detection of micro aneurysms (A) is essentialas their presence in the early stages of DR is the criterion to distinguish between non-healthy and healthy fundi. Therefore, the detection of A has been the object of an online challenge. As A are usually only a few pixels wide, the submitted approaches focus on detection rather than segmentation and share the same steps: preprocessing, candidates extraction, feature selection and candidates classification. Due to the circular shape of the A, candidates extraction can be done using morphological operations, followed by match-filtering with a prior on the Gaussian profile of A as introduced in, or with a multi-orientation gradient weighting scheme as in. However, this method remains sensitive to background noise, so an approach based on local contrast independent of the size and shape of the regional minimum was proposed in.

1.1 EXISTING SYSTEM

In this paper, they propose a novel approach for training a convolutional multitask architecture with supervised learning and reinforcing it with weakly supervised learning. In addition, they propose and discuss the advantages of a new preprocessing method. When they evaluated on the task of screening for the presence or absence of lesions in the image set.

Disadvantages

- Using of CNN takes more time to run the process.
- There is no better segmentation of lesions.

1.2 PROPOSED SYSTEM

In this paper, we propose a novel approach for training adaptive threshold based architecture with supervised learning for detection and segmentation of retinal lesions. In addition, we analyses the different geometrical features of processed images like area, density, contrast, skewness by using Region properties and gray level co-occurrence matrix for performing the segmentation of retinal lesions alone. After that we use Support Vector Machine for classification results.

Advantages

- The main advantage of using Adaptive threshold is going to reduce the system process which eliminates the masking operation lead to better segmentation of lesions.
- The run time speed is more when compared to CNN.

2. SCOPE OF THE PROJECT

In computer based retinal image analysis system, image processing techniques are used in order to facilitate and improve diagnosis. Manual analysis of the images can be improved and problem of detection of diabetic retinopathy in the late stage for optimal treatment may be resolved. The automatic detection of landmark anatomical structures and lesions are needed during the mass screening for the detection and diagnosis of diabetic retinopathy. The anatomical structures detection helps in characterizing the detected lesions and in identifying false positives. Lesion detection is essential for monitoring purpose and to classify the severity stages of the disease.

3. LITERATURE SURVEY

3.1. A novel weakly supervised Multitask Architecture for Retinal Lesions Segmentation Clement Playout, Renaud Duval, Farida Cheriet, Senior Member, IEEE-2019

In this paper, they propose a novel approach for training a convolutional multitask architecture with supervised learning and reinforcing it with weakly supervised learning. In addition, they propose and discuss the advantages of a new preprocessing method. When they evaluated on the task of screening for the presence or absence of lesions in the image set.

3.2. Retinal Microaneurysms Detection using Local Convergence Index Features Behdad Dashtbozorg, Jiong Zhang, Fan Huang, and Bart M. ter Haar Romeny, Senior Member, IEEE-2018

In this paper, a novel and reliable method for automatic detection of microaneurysms in retinal images is proposed. In the first stage of the proposed method, several preliminary microaneurysm candidates are extracted using a gradient weighting technique and an iterative thresholding approach. In the next stage, in addition to intensity and shape descriptors, a new set of features based on local convergence index filters is extracted for each candidate. Finally, the collective set of features is fed to a hybrid sampling/boosting classifier to discriminate the MAs from non-MAs candidates.

3.3. A review on exudates detection methods for diabetic retinopathy Shilpa Joshi, P.T.Karule-2018

The presence of exudates on the retina is the most characteristic symptom of diabetic retinopathy. As exudates are among early clinical signs of DR, their detection would be an essential asset to the mass screening task and serve as an important step towards automatic grading and monitoring of the disease. Reliable identification and classification of exudates are of inherent interest in an automated diabetic retinopathy screening system. Here we review the numerous early studies that used for automatic exudates detection with the aim of providing decision support in addition to reducing the workload of an ophthalmologist.

3.4. Joint Optic Disc and Cup Segmentation Based on Multi-label Deep Network and Polar Transformation Huazhu Fu, Jun Cheng, Yanwu Xu, Damon Wing Kee Wong, Jiang Liu, and Xiaochun Cao-2018

In this paper, they propose a deep learning architecture, named M-Net, which solves the optic cup OD and OC segmentation jointly in a one-stage multilabel system. The proposed M-Net mainly consists of multi-scale input layer, U-shape convolutional network, side-output layer, and multi-label loss function. The multi-scale input layer constructs an image pyramid to achieve multiple level receptive field sizes. The U-shape convolutional network is employed as the main body network structure to learn the rich hierarchical representation, while the side-output layer acts as an early classifier that produces a companion local prediction map for different scale layers. Finally, a multi-label loss function is proposed to generate the final segmentation map. For improving the segmentation performance further, we also introduce the polar transformation, which provides the representation of the original image in the polar coordinate system.

3.5. Disc-aware Ensemble Network for Glaucoma Screening from Fundus Image Huazhu Fu, Jun Cheng, Yanwu Xu, Changqing Zhang, Damon Wing Kee Wong, Jiang Liu, and Xiaochun Cao-2018

In this paper, they introduce a deep learning technique to gain additional image-relevant information, and screen glaucoma from the fundus image directly. Specifically, a novel Disc-aware Ensemble Network (DENet) for automatic glaucoma screening is proposed, which integrates the deep hierarchical context of the global fundus image and the local optic disc region. Four deep streams on different levels and modules are respectively considered as global image stream, segmentation-guided network, local disc region stream, and disc polar transformation stream. Finally, the output probabilities of different streams are fused as the final screening result.

3.6. A generalized method for the segmentation of exudates from pathological retinal fundus images Q1 Jaskirat Kaur, Deepti Mittal-2017

In this paper, a generalized exudates segmentation method to assist ophthalmologists for timely treatment and effective planning in the diagnosis of diabetic retinopathy is developed. The main contribution of the proposed method is the reliable segmentation of exudates using dynamic decision thresholding irrespective of associated heterogeneity, bright and faint edges. The method is robust in the sense that it selects the threshold value dynamically irrespective of the large variations in retinal fundus images from varying databases.

4. BLOCK DIAGRAM

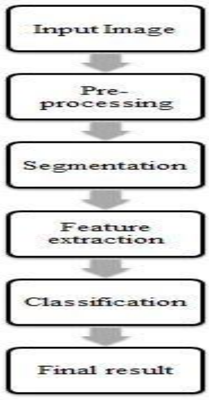

Fig -1: Block diagram of retinal lesion detection and segmentation

5. MATLAB

The MATLAB high-performance language for technical computing integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. MATLAB is a program that was originally designed to simplify the implementation of numerical linear algebra routines. It has since grown into something much bigger, and it is used to implement numerical algorithms for a wide range of applications. The basic language used is very similar to standard linear algebra notation; hence we have developed our codes for retinal lesion detection and segmentation using MATLAB 8.6 Version R2016a and C language.

6. METHODOLOGIES

6.1. MODULE NAMES

1. INPUT
2. PREPROCESSING
3. SEGMENTATION
4. FEATURE EXTRACTION
5. CLASSIFICATION

6.2. MODULE DESCRIPTION

1. INPUT IMAGE

Read and Display an input Image. Read an image into the workspace, using the imread command. In image processing, it is defined as the action of retrieving an image from some source, usually a hardware-based source for processing. It is the first step in the workflow sequence because, without an image, no processing is possible. The image that is acquired is completely unprocessed.

2. PRE-PROCESSING

Pre-processing is a common name for operations with images at the lowest level of abstraction both input and output are intensity images. The aim of pre-processing is an improvement of the image data that suppresses unwanted distortions or enhances some image features important for further processing. Image pre-processing methods use the considerable redundancy in images. Neighboring pixels corresponding to one object in real images have essentially the same or similar brightness value. Thus distorted pixel can often be restored as an average value of neighboring pixels.

- RESIZING THE INPUT IMAGE

All the input images are resized into same dimensions. If the specified size does not produce the same aspect ratio as the input image, the output image will be distorted.

- CONVERTING COLOUR FORMAT

For many applications of image processing, color information doesn't help us. If you get into the business of attempting to distinguish colors from one another, then one reason for converting RGB image to BLACK AND WHITE or GRAYSCALE formats in image.

3. SEGMENTATION

Image segmentation is a commonly used technique in digital image processing and analysis to partition an image into multiple parts or regions, often based on the characteristics of the pixels in the image. In computer vision, Image Segmentation is the process of subdividing a digital image into multiple segments (sets of pixels, also known as super pixels. Segmentation is a process of grouping together pixels that have similar attributes. Image Segmentation is the process of partitioning an image into non-intersecting regions such that each region is homogeneous and the union of no two adjacent regions is homogeneous Pixels in a region are similar according to some homogeneity criteria such as color, intensity or texture so as to locate and identify objects and boundaries (lines,curves,etc) in an image. Segmentation accuracy determines the eventual success or failure of computerized analysis procedure.

- COLOUR SPACE CONVERSIONS

Color space conversion is the translation of the representation of a color from one basis to another. This typically occurs in the context of converting an image that is represented in one color space to another color space, the goal being to make the translated image look as similar as possible to the original.

- MORPHOLOGICAL OPERATIONS

Morphological image processing is a collection of non-linear operations related to the shape or morphology of features in an image. Morphology is a broad set of image processing operations that process images based on shapes. Morphological operations apply a structuring element to an input image, creating an output image of the same size. Some segmentation techniques are,

A) ADAPTIVE THRESHOLDING

4. FEATURE EXTRACTION:

In machine learning, pattern recognition and in image processing, feature extraction starts from an initial set of measured data and builds derived values (features) intended to be informative and non-redundant, facilitating the subsequent learning and generalization steps, and in some cases leading to better human interpretations. Feature extraction is related to dimensionality reduction. When the input data to an algorithm is too large to be processed and it is suspected to be redundant (e.g. the same measurement in both feet and meters, or the repetitiveness of images presented as pixels), then it can be transformed into a reduced set of features (also named a feature vector). Determining a subset of the initial features is called feature selection. The selected features are expected to contain the relevant information from the input data, so that the desired task can be performed by using this reduced representation instead of the complete initial data.

- Shape features
- Geometrical features
- Texture features

A) SHAPE FEATURES:

Visual features of objects are called the shape characteristics or visual features. For example, circular object or triangular objects or other shapes, perimeter boundary of the object, the diameter of the border and so on. The visual features showed intuitively are all belongs to shape features.

B) GEOMETRICAL FEATURES:

Geometric features are features of objects constructed by a set of geometric elements like points, lines, curves or surfaces. These features can be corner features, edge features, Blobs, Ridges, salient point's image texture and so on, which can be detected by feature detection methods.

C) TEXTURE FEATURES:

An image texture is a set of metrics calculated in image processing designed to quantify the perceived texture of an image .Image Texture gives us information about the spatial arrangement of color or intensities in an image or selected region of an image.

Some feature extraction methods are,

A) GLCM (Grey level co-occurrence matrix)

B) REGION PROPERTIES

5. CLASSIFICATION

Image classification refers to the task of extracting information classes from a multiband raster image. The resulting raster from image classification can be used to create thematic maps. The recommended way to perform classification and multivariate analysis is through the Image Classification toolbar. There are many classification algorithms are available and some classification algorithm that are given below,

A) SVM (SUPPORT VECTOR MACHINE CLASSIFICATION)

7. ADAPTIVE THRESHOLDING

Adaptive thresholding typically takes a gray scale or color image as input and, in the simplest implementation, outputs a binary image representing the segmentation. An adaptive thresholding algorithm that separates the foreground from the background with nonuniform illumination.

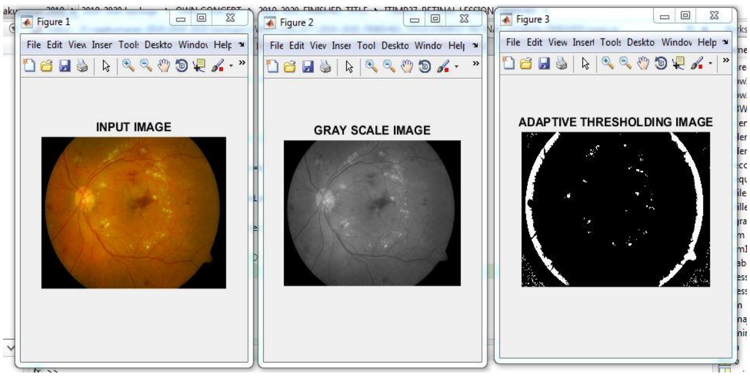

Fig -2: Adaptive thresholding image of a lesion detected retina

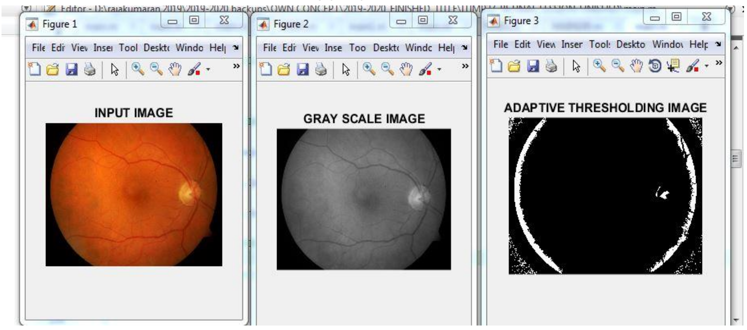

Fig -3: Adaptive thresholding image of a healthy retina

8. GLCM (Grey level co-occurrence matrix)

GLCM is a feature extraction method That functions characterize the texture of an image by calculating how often pairs of pixel with specific values and in a specified spatial relationship occur in an image, creating a GLCM, and then extracting statistical measures from this matrix.

9. SVM (SUPPORT VECTOR MACHINE CLASSIFICATION)

SVM is a supervised machine learning algorithm which can be used for both classification and regression challenges. Support Vectors are simply the co-ordinates of individual observation. Support Vector Machine is a frontier which best segregates the two classes (hyper-plane/ line).

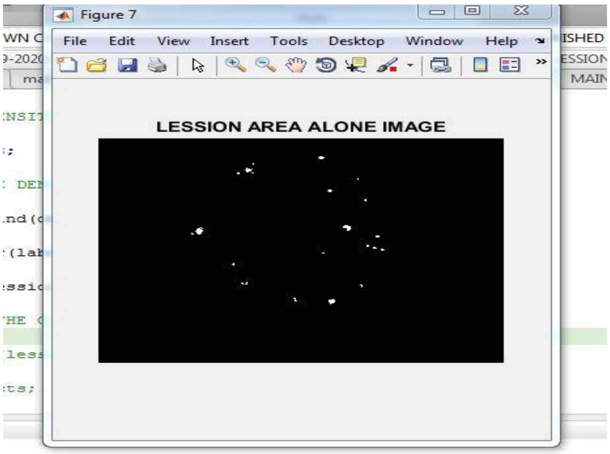

Fig -4: Output image of a lesion detected retina

Fig -5: Output image of a healthy retina

10. APPLICATIONS

- To support early detection, diagnosis and optimal treatment.
- In line with the proliferation of imaging modalities, there is an ever-increasing demand for automated vessel analysis systems for which where blood vessel segmentation is the first and most important step.
- Image segmentation plays an essential role in many medical applications.
- Low SNR conditions and various artifacts makes its automation challenging.
- To achieve robust and accurate segmentation.

11. FUTURE SCOPE

In future research, the results can be slightly improved through any latest algorithms for removal of noise and with improved accuracy and efficiency.

12. RESULT

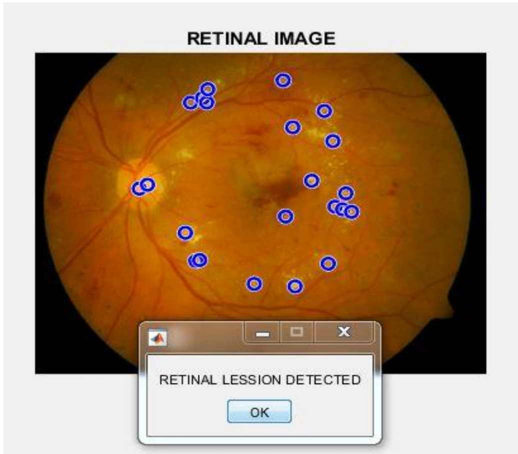

Fig -6: Final image of a lesion detected retina

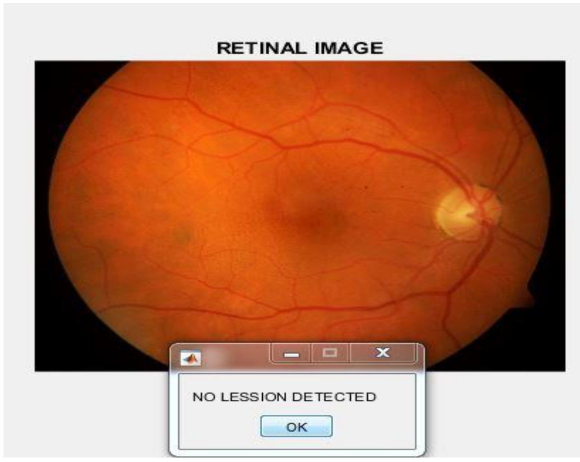

Fig -7: Final image of a healthy retina

13. CONCLUSION

The proposed approach provides a fully trainable model for segmentation of retinal lesions in retinal images and proposes a novel methodology of adaptive threshold based method for exploiting image-level labels to improve segmentation performance. The fast execution time makes the model suitable for clinical deployment. Consequently, future work will assess how it can accelerate the process of labeling data by a clinician, by providing lesion pre-annotations. Subsequent research will also focus on classifying the individual segmented lesions. This will serve two purposes: 1) building a detailed atlas of the retinal lesions, and 2) providing an automatic diagnosis established using a set of rules based on the detected lesions. Both of these developments will contribute to a computer-aided diagnosis system that is transparent in its decision-making.

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