Automated drusen detection from oct images using genetic algorithm.

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Abstract

Age Related Macular Degeneration (ARMD) is emerging cause of blindness in elderly peoples. ARMD is caused by drusens those are yellow or white spots on the retina. There are basically two imaging technologies widely used by ophthalmologist for retinal analysis, Fundus and Optical Coherence Tomography (OCT). Fundus which is 2D technology and it is lack in detecting early sign of ARMD.OCT Imaging technology is a 3D technique that helps to detect any change in retinal layer structure even in early stage. In this paper we are using OCT images to detect the drusen. Three major steps, image segmentation, feature extraction and classification has been used to diagnose the ARMD from OCT images. Genetic Algorithm (GA) is an optimization algorithm, which produced optimal feature values. In this paper we proposed Genetic Algorithm based optimize feature selection approach for automated diagnosis of ARMD. The overall proposed architecture of this system consists of image segmentation, Histogram Oriented Gradient (HOG) and Local Binary Pattern (LBP) based feature extraction techniques. As Principal Component Analysis (PCA) is used to reduce the dimensionality. This system used the PCA to obtained eign vector values which are further used in Genetic Algorithm. Then we used the Genetic Algorithm for the feature selection, which have produced very optimize value of the features. For classification purpose, we have trained these feature values through multiple classifiers. The proposed system achieved the, overall accuracy 92.5% while sensitivity, specificity are 90.9%, 95.5%. Our proposed Genetic Algorithm produced efficient results with very effective computational time and also with less space as compared to existing approaches. There are two major contributions of this paper. First a detailed survey along with the taxonomy of ARMD is presented and then an optimization algorithm (GA) is used.

Keywords: ARMD, genetic algorithm, OCT, segmentation.

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Introduction

Age Related Macular Degeneration (ARMD) is the 3rd leading cause of blindness worldwide with the main reason of being at old age. In this situation, the central area of eye retina is affected, known as macula.Retina is responsible for the eyesight (central vision). There are two main forms of ARMD, Dry and Wet forms. Dry (non-exudative) AMD is the more common and less severe form but is often a pioneer to wet AMD. While 80% of patients with AMD, have the dry form. The dry form has three stages, earlier, intermediate, and advances stage. Dry ARMD causes to thin the RPE layer and reduces the eyesight. Many techniques used to detect the ARMD, manually and automate. The wet form of ARMD where blood vessel pour out and leads to blindness under the RPE (Retinal Pigment Epithelium) retinal layer. The wet form is causes for 90% of simple loss of vision associated with AMD. Automated detection is possible for eye diseases by applying pattern recognition and image processing techniques. Different techniques used by ophthalmologists for retinal analysis which are topographic imaging, and tomographicimaging. Topographic imaging are mostly 2D and included ultra-wide field imaging; Fundus Auto Fluorescence and Adaptive Optics topographic. While Optical tomography is another latest imaging technique. Optical Coherence Tomography (OCT) has proven to be an essential imaging modality for ophthalmologists and is proving to be very important in neurology. OCT enables high-resolution imaging of the retina, both at the optic nerve head and the macula. Macular retinal layer thicknesses provide useful diagnostic information and have been shown to correlate well with measures of disease severity in several diseases [1].

Retinal layers segmentation using OCT images is very challenging and the main task in automated diagnosis system. Either this segmentation is manual or automated. Various algorithms were proposed for segmentation and classification of retinal layers using OCT images like graph theory, f-shape measurements etc.

In section II a detailed taxonomy is presented, which describe ARMD stages, used imaging technology (OCT) and various algorithms used for retinal layer segmentation, feature extraction, and classification for automated diagnosis of ARMD. Section 3 is a detailed review of various papers used to detect ARMD using OCT technology, and also presented, which described the overview of different paper's work and their contribution.

Taxonomy of ARMD

A detailed taxonomy of ARMD is described below. Which shows its two forms, also technologies used for it. The explanation of techniques and previously proposed

methodologies used to detect and classify the ARMD are also discussed.

Drusen are shaped when the photoreceptors of the eye cell can cause a protrusion of RPE over Bruch's membrane which leads towards degeneration of the macula over time. Drusen in the macula are common initial sign of ARMD. It has mainly two kinds: hard drusen and soft drusen. Hard drusen are small and with different lesions and sharp borders, that may exist for the long period of time. Such kinds of drusen may not cause vision loss, and may normal with aging. But mostly people having age more than 40 have hard drusen. In contrast, soft drusen are those that have large lesions, in which clusters are close together. Soft drusen have unclear borders that is recognized as intermediate to advanced form of ARMD. Blindness is case in which a person can't see anything (loss of eye sight), for such type of the condition ARMD by itself does not causes. But this can obstruct the daily life activities, for example to watch the surroundings, reading and writing etc.

In this section we will discuss levels of ARMD. The detail is further explained below: In the early ARMD when drusen is diagnosed its existence showed its size which are about the width of an average human hair. In this level patience does not have vison loss. In the Intermediate stage of ARMD, drusen increase in the size which have pigment changes in the retina or both. But these changes only seen, while an eye is examined. On this level of ARMD, some patients may losses their eyes sight while on the other hand may some not.

People those facing the late ARMD, loss their vision completely. There are two main kinds of late ARMD. Dry ARMD also known as geographic atrophy, in which light sensitive cells in the macula brings visual information to the brain and the backup tissue beneath, these are slowly fail, which leads to the blindness.

Wet ARMD, also termed as neovascular ARMD, in this condition abnormal blood vessels grow beneath the retina. Basically "Neovascular" means that "new vessels". When these new vessels leaks the liquid and blood, this causes macula to damage and change in to the curved shape. A compared to the growth of geographic atrophy, the destruction of neovascular is much quick and severe. May be geographic atrophy and neovascular ARMD occur in the same eye and may be any one of both can present first.

Dry form of ARMD affects approximately 80 to 90% persons having ARMD [5] .In this type of macular degeneration extra cellular minor white or yellowish deposits which are made up of lipids and fatty protein called drusen. These are stored among the Retinal Pigment Epithelium (RPE) and the inner neighbor layer of Bruch's membrane (vitreous lamina). Mostly people are facing the dry form of the disease. The dry form of macular degeneration, can be reason to the more dangerous form, called wet, that, usually leads to more serious vision loss. Soft drusen are yellow-white bell shaped elevations, their central area shows lighter than its edge, and are typically 63 to ≥ 1000 □m in diameter [2].

Smaller soft drusen have a little influence on the RPE and IS/OS junction layer morphology. Cuticular drusen appear as a round and saw tooth pattern in SDOCT and are typically 50 to 75□m in diameter. But OCT subretinal drusenoid deposits are seen in the subretinal ARMD. The early diagnosis of the patients at higher risk for advanced ARMD allows earlier protective intervention and preventive treatment to reduce severe vision loss. Thus, it is more important to identify the main changes in drusen and the RPE morphology to inspect the progression of neovascular ARMD.

The previous studies on the Color Fundus (CF) images have shown that there is strong correlation between the maximum drusen size and total drusen area with the risk of progression of ARMD to its advanced form. Many different approaches and automated algorithms for soft and hard drusen grading and quantification from CF images have been developed However, detecting and locating the drusen in a color retinal image are difficult to measure because of their differences in size and shape and also irregular and blurred boundaries.

Different techniques used by ophthalmologists for retinal analysis are topographic imaging, and tomographic imaging. Topographic imaging are mostly 2D and included ultra-wide field imaging: Fundus Auto Fluorescence and Adaptive Optics topographic. While optical tomography is another latest imaging technique.

Optical coherence tomography

A newly invented Optical Coherence Tomography (OCT). It defines different information relevant to the objects inner structure, and to image numerous features of biological tissues like its information regarding to its structure, flow of blood, parameters etc. Since 1991, this development has been explored in the area of dynamic research. From the last decades, this technique has been fully discovered for the drusen detection. It is a challenging and at the same time most commonly required steps in OCT image analysis. Because there is no distinctive method exists for the detection that can be expected to work equally well for all tasks.

In OCT image disease detection the most challenging task is to design such a system which works well in experimental use. It is clear that, there are some limitation (some determinate anomalies or normal subjects) of algorithms and projects, which makes them fit for counter. These often requiring the utilization of 3D appropriate information, because OCT images are noisy. It is an increasing and important area, and needs lots of efforts, when went into designing algorithms for automatic segmentation of retinal OCTs.

Fundus images were used from the long times, to represent those golden standards which are used to define and to evaluate Drusen and the clinical levels of ARMD. For clinical use, Drusen detection is important to diagnosis the ARMD on the macula. But by using color fundus images it is difficult to measure the drusen accurately and quantitatively. Fundus pigmentation variability, also appearance of drusen as well as standard opacities and with large variations results showed.

Which independently assessing the area measurements by different specialists.

Imaging technology is used to evaluate the retinal layer thickness, as a spatial function position, which is important to identify retinal diseases. Because of different reasons, like speckle noise, low imaging contrast, irregular shape of features those are in morphological form. These forms of retinal detachments, macular holes, drusen and accurate segmentation is difficult. Using OCT images retinal layers segmentation is a challenging task. This layer segmentation can be performed either manually or automated. To overcome this problem OCT layers segmentation of retinal layer by using computer methods were presented in the literature. 3D graph search is firstly presented for the purpose to resolve what we will call the "numerous edges segmentation problem" to achieve the possible sets of edges, from multiple sets of edges with low cost. They presented two extensions layered graph search method for segmentation of six layers. The first extension is verifying feasibility constraints and secondly constraints for true region information. They applied graph theory and dynamic programing to segment the three retinal boundaries from SD-OCT image. This segmentation used for checking the drusen and Geographic Atrophy (GA). They used a graph based automated multi surface algorithm which internally used soft constraints to add prior information by learned base model. Which improved the segmentation accuracy and noise robustness were also increased. By applying smart segmentation scheme graph size were reduced. This paper used the random forest to segment out the eight retinal layers of OCT.A kernel based optimization scheme was used in to find out the location of retinal layers [3].

For automated diagnosis of ARMD, Drusen detection is known as the main step. For drusen detection different features are proposed up till now, these features further make it possible to separate drusenoid images from non-drusenoid image after classification. Therefore, feature extraction is known as an important part in many bioinformatics fields. Many methods are proposed for feature extraction by using machine learning and data mining techniques. This used intensity based threshold value and Polly fitting curve for drusen detection. Retinal pathological disease RE, CSCR and ARMD detected firstly fully automated decision support system of OCT images. Multilayered support vector machine was used to train data set.

Classification is used to categorized the image into their respective class.Retinal pathological disease RE, CSCR and ARMD detected. As a first step in fully automated decision support system using OCT images. Multilayered support vector machine was used to train the data sets. According to retinal layers automated segmentation is performed by pixel classification of OCT images. This classifier manual segmented data and features selected on the basis of simple Haar-like. Used the random forest classifier to learn the pixels of the border between the layers. This classifier provides the boundary maps accurately.

Literature Review

As an OCT image received, this will be the first level, on this level a label name assigned to each image to categorize the image into their specific category, when each image will be categorized these are further used in the classification stage, after this second phase will be start.

At the second phase each image will be cropped, that contained relevant region of an area which will be needs for OCT images. On the next level, image will have to resize as 750x 300 window size. This will be done by using the cropping method, which only takes the region of interest. Reason for using cropped images, because it is fit according to over selected algorithm. There are the following highlights that demonstrates the flow of the proposed scheme:

Firstly, original images one by one will be taken from the given data set. All the images from both classes were in the size 512 × 496.These all images will be cropped up to 750 × 300 window size to take the region of interest.

"Dividing an image into two (or more) classes of pixels, (foreground" and "background)"is called the thresholding. We used the automated intensity base thresholding, to segment out the most brighter part of the image. Because this brighter part is most relevant with our work.

"Distracting sections of an image" which is not relates to our work. As, according to this thesis requirements only retinal pigment layer is the region of interest. So, to remove the unnecessary part from the image, cropping will be used to get the RPE layer.

As HOG and LBP shows the very high feature vectors values, so to overcome this issue we used PCA to reduce the dimensionality of the features. And also used fusion to get the best required features. After fusion we get dimensionality in the form of 2x2 metrices. To fuse the images, both of the images from HOG and LBP were converted to same size. These are computed after, calculated covariance, eigen vector values and at the last taking their transpose.

As HOG and LBP produced feature values with high in dimension, so, to overcome this issue we used genetic algorithm. As, above stage describe the PCA base images fusion, which returned the PCA values of eign vector. We used these value in genetic algorithm to optimize the feature values. Following the detail working of Genetic algorithm [4].

Final stage of our work scheme is classification. As we gets our optimize feature values through genetic algorithm, then we gave these all values (values of all selected images) to MATLAB tool, classification learner to check , how accurately our values are obtained. Now, as we have our data in numeric form, instead of images. So, we stored each image feature values to excel sheet with their relevant class label name. And classify through SVM, and gets better accuracy.

These results are computed and classified on Intel Core m3 7th Gen processor with 8GB RAM. As in above section it is discussed at first stage, OCT original image were taken.

Following are the 2 examples of original image with size 512x496.We resized these image upto 750 × 300 image size.

As, at this phase we applied thresholding and then cropping to extract the RPE layer.When we applied automated thresholding on images, we gets images like below shown.By using HOG and LBP we get, images in the following form. As shown below that is an image of LBP. While is an image of HOG.

As mentioned in chapter 4, we used classification learner to classify our GA based feature values. We obtained 1x100 feature value of each image, and then stored these value in excel with their class labels. Then it is classify through MATLAB classification so, features values of data set from 2014 BOE Srinivasan - Modified2 dataset of Duke University, given to the classifier and gets overall accuracy 92.5%.

Is the detailed calculation of the sensitivity, specificity and accuracy. This first calculates the both classes true positive rate, false positive rate, false positive rate and false negative rate. Row 1, shows the overall accuracy which is 94.5%, row2 calculates the overall sensitivity of the system which is 98.90%.Simlarlry row 3 calculates the specificity of the system which 88%. correctly, while 1238 images from 1407 images of normal class are classified correctly.

The following confusion matrix is taken from MATLAB 2017b classification learner, after training the 2119 images, where belongs (d) to drusen class and (n) from normal class. This matrix shows that 704 from 712 images are classified

The difference between the dimensionality of HOG , LBP and GA. As we seen in the graph LBP and HOG present feature data the high dimensionality whether GA low in dimensionality.

The above shows the comparison of the accuracies, sensitivities and specificities of PCA with GA and PCA without GA. By this we can observed that PCA with GA shows the all three results higher than the PCA without GA. As PCA shows accuracy 65% when GA have 92%. Similarly, sensitivity of PCA is 75% and specificity is 33%, while PCA with GA shows the Sensitivity 75% and 33% specificity. By this we can observed that PCA shows better results when it is used with GA.

The above demonstrate that PCA shows the accuracy 65% while, genetic algorithm 92.5%. By this comparison, it is observed that after using GA with PCA function values, shows the accuracy better than PCA without GA. Accuracy comparison with previously.

Discussion

After training data set of duke university which is publicly available on duke university website. From which 440 images were trained for this thesis. As we mentioned above, that we cropped all images into 750 × 300, then applied automated thresholding on this data set. After segmentation HOG and LBP were used for feature extraction. But these both technique gives features values with high dimensionality. To reduce the dimensionality we used PCA based image fusion , so we gets its highest eign vector values in 2 × 2 matrix form. We put these vector values in Genetic Algorithm function to select the optimize 100 feature values of each scan of both categories. At the end we trained these values through MATLAB classification learner, gets different accuracy by different classifiers. They all trained classifiers accuracies are mentioned. In we calculates the confusion matrix of true class, and predicted class. In overall accuracy, specificity and sensitivity is calculated, where overall system accuracy is 94.5%, while sensitivity, specificity are 99.9%, 88%. After obtaining over results accuracy, we compared over results with existing techniques, which almost same in accuracy. Also by using genetic algorithm we obtained, very optimize feature values, very low rate of null values. Also it efficient with respect to time, low in space [5].

Conclusion

ARMD is most the dangerous eye diseases in current era, which causes for blindness. There are basically two imaging technologies widely used by ophthalmologist for retinal analysis. One of them is Fundus, a 2D technology, as it is lack in detecting early sign of ARMD. So, OCT a 3D technology is invented. Which helps to detect any change in retinal layer structure even in early stage. These techniques used either machine learning or statistical approaches. There are two major contributions of this paper. First a detailed survey along with the taxonomy of ARMD is presented and then an optimization algorithm is used.

Conflict of interest

All authors have not any conflict of interest.

Author Contributions

Dr Samina Khalid proposed initial idea, implementation of proposed solution was done by Asma Nawaz. Dr Tehmina Shehryar helps in literature review and results generation.

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