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Research paper

Recent development on automatic computer aided diagnosis for early detection of diabetic retinopathy using k-means clustering and fuzzy logic

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Abstract

Diabetic retinopathy is a common disease caused among diabetic patients around the world. Resulting from diabetes mellitus, this disease is mostly caused by retinal microvasculature. If undetected, this disease may result in severe health loss and even blindness among patients. Researchers around the world are putting forth various developments for its early detection. Techniques like manual examination of structure images to find morphological changes in microaneurysms, exudates, blood vessels, hemorrhages are extremely a protracted task. Manual examination of structure pictures to discover morphological changes in microaneurysms, exudates, blood vessels, hemorrhages is terribly a long task. Other techniques include Optical Coherence Tomography (OCT), which is one of the most widely used technique for the detection of retinopathy due to its early detection of the disease. Inspired by these, the work presented in this paper is focused on comparing these two retinopathic detection techniques and analyze the results for the future resear ch. In the presented work, different retinal datasets are considered are analyzed for the detection of retinopathy. Moreover, various performance parameters are evaluated like specificity, sensitivity, and accuracy for overall assessment of the presented model.

Keywords: *Blood Vessels; Clustering; Computer Aided Diagnosis; Diabetic Retinopathy; Fundus Image; Fuzzy Logic; Optical Coherence Tomography (OCT).*

1. Introduction

Diabetic Retinopathy is one of the most threatning communal retinal diseases that are related to diabetes [1]. It is one of the main reason for blindness in middle and adult aged people around the world. According to the survey conducted by National Diabetes Information data (US) in 2010 [2] [3], more than 23 million folks of the US population have polygenic disease out of that but 17 million patients were diagnosed. Moreover, World Health Organization (WHO) estimated that there will be 91% people suffering from diabetes, which enumerates to 300 million diabetic people in the world by the year of 2025. Henceforth,early detection of the disease through careful review is significant to stop severe health loss and visual defect [4] [5].

a) Diabetic retinopathy: an overview

Diabetic people are classified in two types i.e. Type-1 (Non-preventable and rare cases) and Type-2 which is called insulin insensitivity diabetic, which can be avoided if detected at early stages [6] [7]. Diabetic retinopathy is the continual disease caused by Type-2 diabetes in the retina, which can lead to critical phase and even permanent vision loss, as discussed before. Diabetes is among a collective group of metabolic diseases during which patient has high levels of glucose in the blood, due to insulin production is insufficient, or because the patient's body cells do not respond properly to insulin, or both [1]. World Health Organization (WHO) predicted correctly that in early 2012, there would about 350 million diabetic people, more than 81% of diabetes deaths occur in different countries. WHO projects that diabetes will be the 7th major cause leading to death in 2030 [2]. Diabetes is associate health problem that influences veins at some point of the body, particularly within the kidneys and eyes. Blood vessels area unit affected owing to the high level of glucose. Within the early stage of this unwellness, it's not clearly pictured, because the changes area unit in metric linear unit level, additionally to early-stage color and size of lesions area unit matched with native blood vessels. As retinopathy will increase step by step, many distinct visualisation spots begin to occur as microaneurysm or DR lesions like hemorrhages, plant fibre spots, red lesions, and laborious exudates. However, it's necessary to send word that the retinal pattern conjointly changes owing to age-related unwellness like devolution (MD) that is distinct from diabetic retinopathy. Additionally to the current, as retinopathy contains a steady rate, the changes in retinal image texture are often simply detected by ophthalmologists supported in-depth retinal image analysis. Diabetic retinopathy is associate adverse results of polygenic disorder thathappens thanks to impairment of retinal blood vessels by leaky fluid. Regarding forty first of diabetic folks happen to own diabetic retinopathy, within which nearly five-hitter face the sight-threatening sort of this unwellness. It's the leading explanation for loss of vision in persons among a middle cluster of 25-74 years within the world [3].

As shown in Figure 1, the retina is a light-sensitive tissue in the eyes. Light rays are fixated onto the retina, where they are transmitted to the brain and interpreted as the images you see. The macula is a little territory at the focal point of the retina. The macula is the main part of the accurate vision, enabling you to peruse, sew or perceive a early detection of the disease through careful inspection is vital to prevent severe health loss and blindnessface.

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The encompassing piece of the retina, called the fringe retina, is in charge of fringe vision.

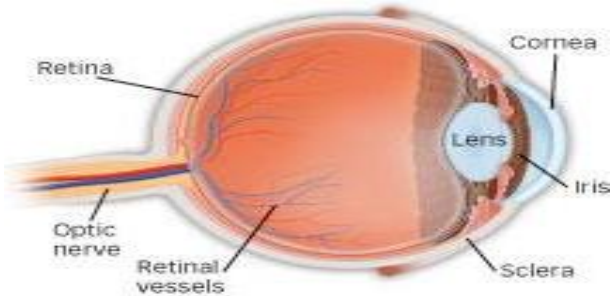


Fig. 1: Human Eye[8].

Diabetic retinopathy, the foremost common diabetic disease, happens once blood vessels within the tissue layer amendment. During high blood sugar levels, capillaries a tiny blood vessel can be damaged, that supply blood to the retina. Sometimes vessels leak fluid and shut fully. In alternative cases, the new blood vessels show the abnormality grows on the surface of the tissue layer [4]. The tissue layer showing signs of diabetic retinopathy and a normal retina is depicted in Fig 2 and Fig 3 respectively.

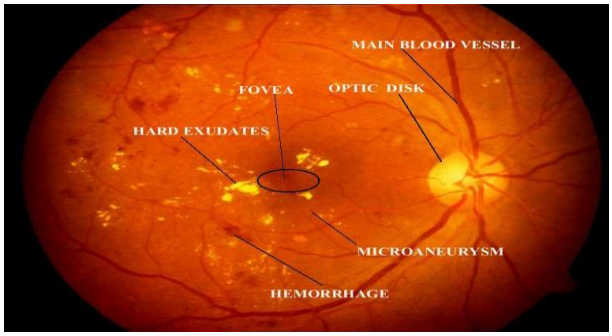


Fig. 2:.A Retina Showing Signs of Diabetic Retinopathy [4].



Fig. 3:.A Normal Retina [4].

b) Early detection of diabetic retinopathy based on fundus images

Color fundus images are one of the most readily available to all ophthalmologists to research many retinal diseases like diabetic retinopathy. Figure 2 depicts a general retinal image indicating numerous feature parts of Diabetic Retinopathy. Microaneurysms square measure very little saccular pockets caused by near distension of slender dividers and show up as little red specks. This cloud likewise prompts monumental blood clusters named as hemorrhages[9]. However, laborious exudates square measure the yellow macromolecule stores that show up as sensible yellow sores. The luxurious spherical district from wherever the veins exude is understood because of the optic circle. The fovea centralis characterizes the concentration of the tissue layer and is that space of most elevated visual keenness. The spacial circulation of exudates and microaneurysms and hemorrhages, significantly in affiliation to the fovea centralis is used to come to a decision the seriousness of diabetic retinopathy. Different Steps for Diabetic Retinopathy Detection for Fundus Images appear ahead.

Step 1: Input Colour Fundus Image of Retina of the Diabetic Patient

Initially, color images are provided from the structuring device resized to a universal size of 768 × 576 pixels although preserving the initial ratio. Then, the gray scale channels are selected for several operations as retinal images are saturated in the other colored channels. The gray scale channels are used because of the reason that the other colored channels have high complexity as compared to gray scale channels. Complexity includes contrast, edges, brightness. So to improve the intensity of the image, gray colored channels are selected for the detection of the diabetic retinopathy.

Step 2: Multi-Scale Blood Vessel Extraction

In the next step, various features are extracted from blood vessels for the identification of diabetic retinopathy. In fact, various spots are detected in the retinal images for the further processing of the retinopathy detection.

Step 3: Localizing and Detection of Exudate

Exudates seemed as bright lesions in retinopathic images with sharp edges and high-level of background contrast. Most of the normal edge detectors provide a portion of noise and error in key edges during extraction of exudate edges. Therefore, are not suitable for this application. Henceforth, in this, the boundary detection is performed using morphological operations.

Step 4: Optic Disk Detection

The identification of the optic circle in fundus pictures is a critical assignment due to its closeness to brilliance, shading, and differentiation to the exudates. It constantly shows up in exudate recognition comes concerning and consequently, there's a necessity to veil it out. Also, the optic plate could be a vital retinal element and may be utilized for enrollment of retinal footage. It will likewise be utilized to research totally different ailments like eye disease.

Step 5: Microaneurysms and Hemorrhages detection

Microaneurysms are unit small blood clots that happen because of capillary burst. They're most tough to be detected. Hemorrhages are unit larger clots. Microaneurysms And Hemorrhages area unit thought of as holes and morphological filling is performed on the inexperienced channel to spot them. In grayscale, the filling operation is Associative in the Nursing extension of binary filling. The un-filled inexperienced channel image is then subtracted from the stuffed one and threshold within the strength to yield an image alongside microaneurysm patches. Step 6: Analyzing the disease severity

The spreading of the lesions around the region helps to analyze the severity of Diabetic macular puffiness. Authors in varied studies have divided the retinal image into varied sub-region on the region. The exudates happening within the macular venue area unit a lot of unsafe and need fast healthful thought than those a lot of distance away[10]. In addition, the size, check, and dispersion of microaneurysms and hemorrhages are likewise accustomed foresee the seriousness of retinopathy.

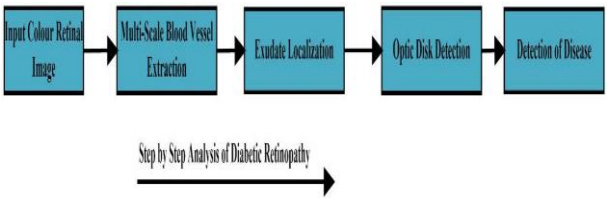


Fig. 4:. Flow Diagram for the Detection of Diabetic Retinopathy from Fundus Images.

c) Optical coherence tomography based early detection of diabetic retinopathy

Optical Coherence Tomography is a modern technology to obtain a cross-sectional retinal images with high resolution in a non-invasive manner. The retinal morphology is reconstructed by utilizing backscatter to the reflected light. In comparison to the conventional fundus images taken with the fundus camera, this technology provides in-depth information from which the scattered comes from. If the reflection is produced by the deeper retinal

layers, it has to go the deeper way to return to the detector as compared to the light reflected from the superficial layer. That is why it takes them longest to return to the deeper layers. Due to this characteristic, it is possible to accurately determine the retinal depth from where the particular signal is coming from. Henceforth, this technology is similar to the ultrasound with the only difference comprising of the utilization of the light instead of the sound. It gives higher axial utilization as compared to any other imaging techniques that are currently available in the medical world.

In the conventional technology based on optical coherence, the light is emitted by the superluminescent diode which is directed to the splitter for two different beams. One of them is projected onto the projected mirror, while other is directed onto the retina, which is backscattered from its morphological elements. The light waves that are reflected back from the retina and the mirror are superposed. The wave interference is possible only when the optical path between the beam splitter and the mirror is at equal distance from the surface and the splitter reflecting the light wave within the retina. In this case, the recording is performed by the detector in the form of light intensity. For other reflections, the position of the mirror is moved with respect to the beam splitter. This technique is termed as Time Domain optical coherence technique. It was the first optical coherence technique described in 1991.

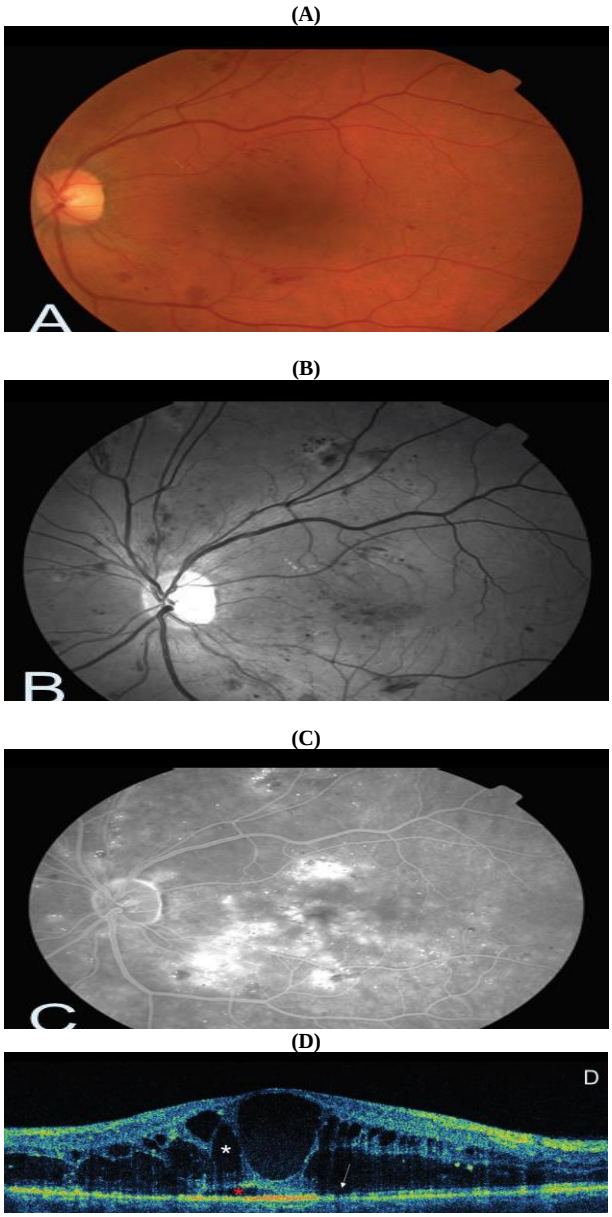


Fig. 5: (A) Color Fundus Image with Retinal Hemorrhages. (B) Red-Free Image of the Fundus. (C) Fluorescein Angiogram Depicting a Cystoid Pattern of Foveal Fluorescence with Surrounding Diffuse Leakage. (D) OCT Demonstrating Reflective Cystic Spaces within the Retina[11].

Another technique based on the frequency of light was developed termed as Frequency Domain optical coherence technique. It differs from the time domain technique in the way in which retinal image is constructed. In this technique, the reference arm of the detector is fixed and the optical path length difference is recorded between the considered sample and reference reflections obtained. There are two practical implementations of this technique[12]. The first is termed as a spatial domain optical coherence technique in which the light signal is detected using the spectrometer equipped with a light line of sight elements. In another method, termed as swept source based optical coherence technique, tunable lasers are utilized along with standard photodiode detector. As in the frequency based optical technique, the reference mirror is kept fixed and a better mechanical stability of the system is achieved. In addition to this, the interferometric signal that is created by a mixture of the sample and the reference light is sampled in terms of wavenumber and yield an entire depth scan one at a time. This makes it possible to acquire several hundred-fold increments in speed and the scanning sensitivity as compared to time-based optical coherence technique. Henceforth, large motion artifacts are avoided and multiple measurements are taken in short span of time that enables a three-dimensional retinal scanning. Moreover, these images can also be acquired at video rate as the real-time structure can be observed from them. The first of such devices were available in 2006 in Poland. A detailed view of optical coherence-based topography is depicted in Figure 4.

The presented paper is organized as follows. Section II reviews some of the important contributions in the area of detection of diabetic retinopathy. The Problem being formulated is being covered in Section III. Section IV comprises of the Objectives and methodology of the Proposed Work. Finally, VI concludes the paper with important discussion contribution in the current scenario.

2. Literature review

This section provides details of the important works that have been performed in the field of detection of diabetic retinopathy [13]. Moreover, various mechanisms are discussed that proposed by the researcher around the world to detect retinopathy art early stages.

Jahiruzzaman and Hossain [14] presented associate approach for detection of diabetic retinopathy grounded on totally different exudates and discharge discovery. They utilized k-means clustering rule to diminish shading measurement for division of exudates beside histograms supported thresholding with least computation. The precision of the finder was enrolled nearly 98.21% and 92.31% severally, in least time than another retinal vessel primarily based diabetic retinopathy location. The planned symbolic logic classifier had higher practicality with exactness up to 96.67%.

Rakshitha et al. [6] broke down the three upgrade strategies and the near investigation of every one of the three procedures are figured by utilizing the system of PSNR. The central issue in wavelet is the loss of information while reproduction of the picture. If there should arise an occurrence of curvelet change, the picture is essentially upgraded, supporting to open up the uproarious pictures. In any case, it loses its shape and data and it is extremely hard to perceive the edges and the commotions in the picture. Contourlet Transformation was utilized to defeat the detriments of these two changes. The contourlet system focusses on upgrading the detectable quality of the picture in perspective of measurements like Contrast Improvement Index, Peak Signal to Noise proportion and Edge Improvement Index. Tests have demonstrated that Contourlet change is best for the preservation of shapes over with various methods.

Venkatesh and Ramamurthy [4] had conferred an automatic technique to group the fundus retinal images. During this technique they used canny edge detector, bar

graph equalization ways for picture preprocessing, PCA was utilized for include extraction and spatial property reduction and eventually SVM and NN are utilized for ordering the unhealthy fundus image into either DRP or DRNP. From the preparatory results, they need clearly confirmed that the bar graph based for the most part pictures gave best outcomes thought about to canny. The test comes about demonstrate that the SVM classifier is a parcel appropriate than NN for this work.

Rajput et al. [15]recognized non-proliferative diabetic retinopathy sores utilizing wavelet and characterized it utilizing K-means clustering. The proposed calculation was tried on online databases like STARE, DRIVE, DiarectDBO, DiarectDBland SASWADE. The outcomes anticipated in the examination article were acquired on SASWADE database. The factual strategies were connected on NPDR injury to ascertain the mean, change, standard deviation, &correlation for order. K-means clustering was actualized on the dataset as the precision of 95% was accomplished in characterizing NPDR.

Kumar et al.[16]used the joining of the unpredictable largeness in the veins to distinguish surmised optic disk area. It was confined utilizing different shading pictures. Assessment of the calculation on numerous picture databases with various enlightenment and DR stages gave high achievement rate of 90% for hemorrhage. Furthermore, the more highlights removed and the extricated highlights had given accuracy concerning 95% for microaneurysm, 95% sensitivity and 94% specificity to ID of exudates and brought about 97% of achievement rate for point localization. They finished that geometrical relationship of options and lesions square measure used with alternative traditional morphological operations to supply a sturdy system for investigation of bodily structural images.

Manjula and Rajesh [7] built up a calculation for Micro aneurisms (MA)detection in view of Eigenvalue investigation utilizing the Hessian framework in retinal Fundus picture. MA is the main indication of DR. The Detection of MA is vital for the early discovery of DR. Eigenvalue investigation was viable in the identification of a dark lesion in the retinal Fundus image. This technique was assessed by utilizing 89 images of a database, the genuine positive rate of noticeable MAs is 91 % with eight false positive images. They utilized Lab VIEW programming to execute the calculation.Kasurde and Randive [17] had done an automatic discovery of Proliferative Diabetic Retinopathy. The PDR could be a level of retinopathy wherever blood vessels proliferate i.e. develops. PDR sign is neovascularization, the expansion of anomalous new vessels. Firstly, that they had done the vessel division by changing the picture into the paired image so vessel and non-vessel half may very much be separated. By suggests that of morphological activity and structuring element as a streak, standard vessels were detected and detached. Therefore remaining half was new vessels. These morphological procedures were taken for varied orientations like 45°, 90°, 135° and 180°. Standard vessels were isolated to separate novel vessels from the standard vasculature. Morphological decreasing was implemented for the thin vessels identification as it were. Highlight extraction was finished by windowing image into 50 by 50 so as to compute variety of vessel pixels in each window. As quantities of vessel pixels were registered higher than the prefixed threshold worth then PDR was identified.

3. Problem formulation

Diabetes can be classified as a long-lasting upsurge of insulin level in the blood. Diabetes has resulted in most popular growing threats to health globally[2]. Conferring to the Diabetes Information data, an overall 20.8 million people i.e. 7 % of the established countries people have diabetes in that only 14.6 million cases are identified [9].

Diabetic retinopathy is the most threatning public diabetic eye disease, happens when blood vessels within the membrane fluctuate uncharacteristically. Diabetic retinopathy (DR) is of into 2 types: Non-proliferative diabetic retinopathy (NPDR) and Proliferative diabetic retinopathy (PDR) [6].

It is the main reason for blindness subjects to 25-90 years. Initial recognition of the disease with the help of steady compulsory screening is of utmost importance to abstain the loss of vision. The aim is to provide a system that is capable for the identification of diabetic retinopathy at its earlier stage so that it can be preserved as soon as possible. The technique helps in determining and categorizing the retinal images.

4. Objectives and methodology of proposed work

The objectives of this work are given below:

i) Study and analyze Retinopathy for diabetic detection

In the foremost step, the retinal images data is being collected from the various online portals and several operations are performed on the data set.

ii) To categorize the retinal images among normal or abnormal images by using Fuzzy logic:

In the next step, the pre-processing is being done and various features are extracted for the further classification and the identification of exudates from the retinal images.

iii) To compare the performance of an algorithm

Segmentation of the OCT images is performed with the help of K-means technique of clustering for the detection of the exudates and thus the computational cost is reduced. In this method number of components are reduced and thus the redundant components are neglected which contributes to group the similar colors for the image compression.

iv) Performance measured in terms of accuracy and sensitivity, with the previous techniques:

These performance technique are based on the effective attribute choice. The region properties attributes are contained by the the segmentation of the image.With the help of this technique, we likely to apply and develop the fuzzy interface system with the help of the effective attributes.

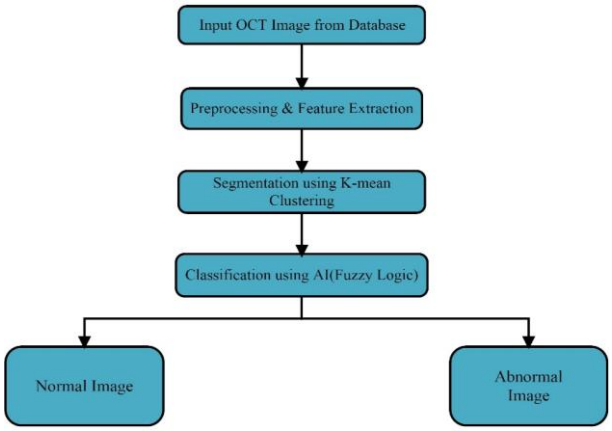


Fig. 6: Flowchart for the Diabetic Retinopathy Detection.

5. Conclusion

In the presented paper, we thought about the two non-intrusive eye testing methods that are utilized to distinguish Diabetic Retinopathy i.e. Fundus Photography and OCT imaging.

We thought about the after effects of both fundus and OCT pictures and with the assistance of master ophthalmologists. Both OCT and fundus pictures were typical for the instance of each of the 49 sound patients. In this way, we presume that OCT pictures give an exact and target assessment of ME when contrasted with fundus pictures.[15] Also, OCT pictures are touchy to little thick-

ness changes in the sub-retinal layer and the seriousness of DR can be effectively assessed utilizing OCT pictures while fundus pictures can demonstrate the conspicuous side effects of DR, for example, swellings and hard exudates yet it is exceptionally hard to recognize early DR from fundus pictures.

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