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Design and Implementation of Anomaly Detection through Deep Residual Network

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ABSTRACT

The detection of diagnostically relevant markers in imaging data is critical in medicine and treatment guidance. This makes large scale annotation necessary which is often not feasible. In this paper, we are designing a robust detection model for anomaly localization in Retinal OCT images. OCT refers to Optical Coherence Tomography which produces cross-sectional images of the retina using the low coherence interferometry[4],[6]. The existing methods consist and consider normal dataset group only and also detects the deviation as an anomaly from the normal data. To overcome these issues, we propose an in-depth analysis to detect an anomaly. OCT consists of Super Luminescent Diode (SLD) as a light source wherein an infrared light is used[8]. The diode splits light into two parts, the first sent to sample and another to the reference arm with a known wavelength and an interferometer is used to study the back waves from the reference arm. The proposed method promotes the industrial anomaly detection as a part of its application. This technique of detecting an anomalous behavior helps in gaining useful insights in various industrial application. OCT artifacts could be related to patient, operator or software, OCT is used mainly for diagnosis, and for checking the functioning of optic nerve and retinal disorder[10],[14]s. Diseases like Choroidal Neovascularization, causing painless loss of vision, Diabetic Macular Edema, causing wavy vision along with washed out or faded color and Drusen, causing Metamorphopsia which are prevalent among the age group of 45-60 can be predicted[2].

Keyword: OCT, Anomaly detection, Deep residual network

INTRODUCTION

Diseases such as choroidal neovascularization, diabetic edema and drusen affect more than 300 million people globally. Among the existing diagnostic methods, we have chosen OCT (Optical Coherence Tomography) as it is a process of providing cross sectional image of the retinal part of an eye to detect anomalies. This scan uses light waves for the purpose of obtaining cross sectional pictures of the retina. Prior to the display of any symptoms in the patient, certain methods can be applied to detect the problems and diagnose them in the patients with the help of learning approaches[3],[5].The scan allows us to check and view each

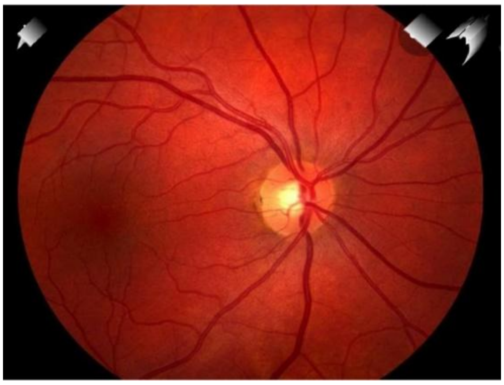

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Fig 1. Retinal OCT Image

of the individual layers of the retina, providing us the means and tools to check their thickness too, the results of which are further used in the diagnosis of the disease which exists. Cross sectional images of the retina as a form of ultrasound imaging are obtained by low coherence interferometry[11]. A super luminous diode is used for the emitting of infrared light, which is then divided into two parts: one part is reflected from a reference mirror and the second part is the one scattered by the biological tissue[18],[20]. Interference patterns are made to produce from the two reflected beams of light. Echo time delay is hence obtained along with the amplitude information, to further make up the A-Scans, which is an abbreviation for Amplitude Scan[4]. A cross sectional B-Scan may be achieved by combining a series of A-Scans. These A-Scans can also be used for measuring and diagnosing the masses in the eye. The A-Scans that are caught at adjacent retinal areas by transverse scanning methods are consolidated to create a two-dimensional picture[1]. A 3D perspective on the picture is produced which empowers the execution of cutting edge, complex examination, for instance, C-scan, topographic analysis, and cyst volume and gives a comprehensive perspective on the macula, which is the focal piece of the retina, known as the functioning center. The generally utilized protocols of scan for macular examining are three-dimensional scan, radial scan, and raster scan. Raster scan is a progression of equal line filters that can be situated in any point, though the spiral output comprises of 6 - 12 lines with equal angle along with a common axis[15],[18]. At the point when the axis concurs with the fovea, which is a little pit situated in the macula of the retina, the relationship of the injury to the fovea is archived. According to the length, density, or resolution, the scan protocols of the OCT differ. In order to obtain a good OCT image, a minimum pupil diameter of 3mm is required[5]. A proper scanning convention is chosen to check the retinal space of interest and a live OCT window is seen. When the fundus picture on the screen is focused, the OCT picture shows up on the screen, focus is enabled by rectifying refractive blunders[9]. It is guaranteed that the OCT picture is upstanding and straight and the reference examine design is fixated on the fovea or whichever the space of interest is[10]. The light is changed at the section point across the pupil to get the best signal strength. The technique is rehashed with other output conventions if fundamental. The saved OCT examines are broken down both subjectively and quantitatively for their analysis. Warm tones in the OCT Scan show thicker retinal regions and cool tones in it demonstrate more slender retinal regions. The OCT Scan is partitioned into areas based on the shading map[17]

PROPOSED DEEP RESIDUAL NETWORK

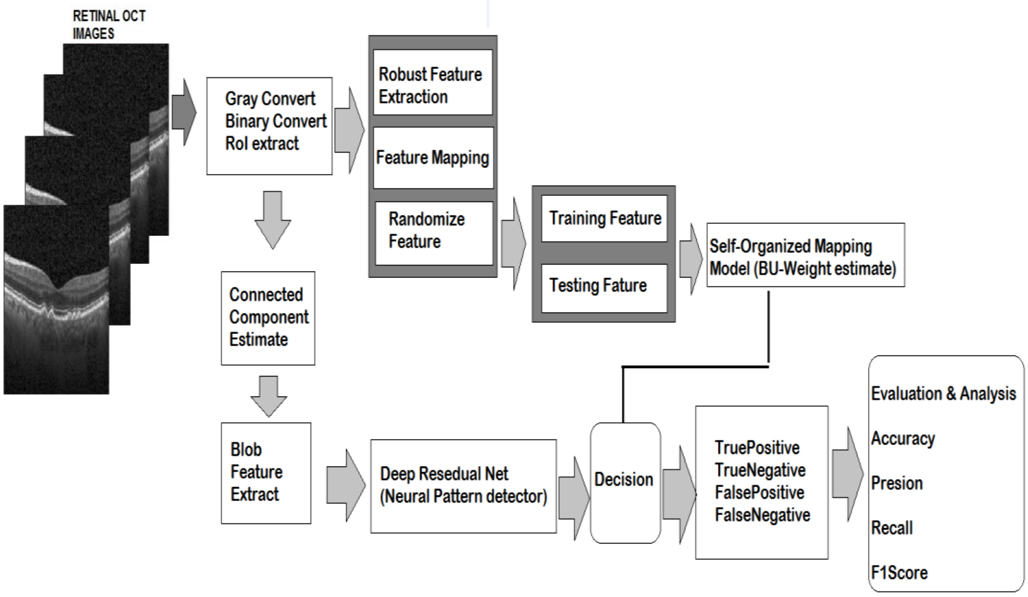

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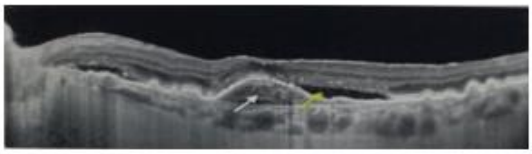
Fig 2. Flow Chart of Methodology

Process for anomaly localization in Retinal OCT images consists of some particular methods. OCT images should be preprocessed in order to read the input and resize those images into constant size. This helps to handle the pixel values for analyzing the image. Grayscale conversion also can be done by preprocessing those images. This removes all color content, leaving only the brightness of each pixel.The image undergoes normalization technique, done to properly prepare the date for further analysis. It changes the value of numeric columns in the dataset in order to use a common scale without losing any information. It uses median filtering, which is a non-linear digital filtering technique. It removes the noise from the image. By varying radiuses, it gives the output. Histogram equalization is done, which adjusts image intensities to increase contrast[4]. The probability mass function and cumulative distributive function of all pixels are to be calculated. The overall shape gets changed during the histogram equalization. Local binary feature learning is also one to extract the local information from different scales[17].

Feature mapping is done to represent features of the OCT image along with relevancy on a graph. Each and every feature from the image is considered as a node of a graph which is unidirectional. It uses certain formula using input volume size to plot in the graph. Feature values are trained and stored into the vector[11].Some particular image processing techniques are further used to get proper output. Color thresholding is used to delete the parts of the image of the same specified color range. It helps to convert the grayscale image into a binary image, which segments the image into different parts that extract data from OCT image.Edge detection is used for finding the boundaries of a particular object of the image. It checks the discontinuities in brightness. Now, the OCT image is tested after the required steps get completed. So, it is important to check if the image is ready for the classification and finally to get the required output[9],[12]. Deep residual network analysis takes place. The output of one layer gets added to the output of the layer after it in the residual block. It is repetitive in nature. Hence, it makes a residual network.We get the final result by finding anomaly in the OCT images. The testing data is compared with the original one, and if deviation is detected, the disease is diagnosed, specifically for the diseases Drusen and Choroidal Neovascularization. In case no deviation is detected, then the data or the OCT image is declared as anomaly free[11].

Choroidal vascularization



Drusen

Diabetic edema

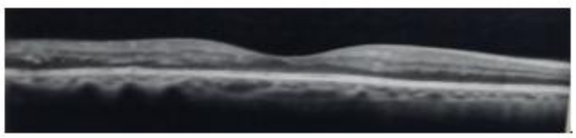


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Fig 3. Pictorial representation of deviated data

EXPERIMENTAL SETUP

OCT scan is done to detect the anomalies in the retinal part of the eye. OCT technology takes help of light waves. Then it becomes easy to get the images of someone's retinal part of the eye. Eye is a small part of human body. So, taking images of the inner part of an eye is crucial. Patient has to be sit in front of a small machine. And the chin of the patient has to be placed on a support attached to that machine[4]. Then using light waves, it takes the image of the retina without touching the eye. So, light waves play a major role[13,19]. The optical setup of the OCT technology consists of an interferometer and broad bandwidth light source. Coherency of that interferometer is low. Interferometer is used to merge two or more sources of light energy to make an interference model. To measure the accuracy of interferometer, it is important to install a sample in one optical path. OCT machine can also take a 3D scan of retina[3]. 3D images give the percentage of thickness in different levels of retina. Hence it becomes easy to make a map of an eye for analysis. There will be some tissue layers in retina. So, the thickness of those tissues can also be measured by this OCT scan. Then the thickness of the layers of the retinal part of an eye is compared with the normal data. After that it is detected which disease has occurred in the eye. It presents cross sectional images of retina. OCT scan also uses laser to get higher resolution of the layers of the retinal part. Laser is used here without any radiation. Updated version of OCT technology is frequency domain optical coherence tomography[7]. It has some advantages. It gives the signal to noise ratio. It makes the machine to get the signal from the light wave faster than before. Light wave is splinted into two parts[21]. These two parts are a sample arm and a reference arm. Sample arm is the combination of reflected light waves[7]. And reference arm is the collection of reference light waves. Hence, it helps to make an interference pattern. OCT scan is a painless process.

RESULT

The Retinal OCT images are taken as an input after which they are pre-processed (Read, Re-size, Gray Scale conversion), Normalized (Median Filter color thresholder) in which noise is removed and the diseases like Choroidal Vascularization and Drusen are detected in age groups from 40 to 50. After that Histogram Equalizer is used for the Local Binary Features, then feature mapping is done followed by the testing process. At last anomaly classification is done using the deep residual network [20].

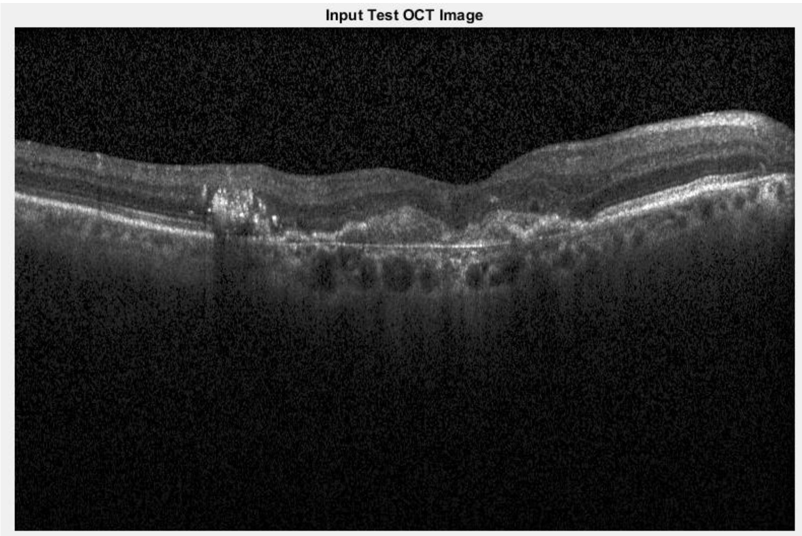

Fig 4. Input test OCT Image

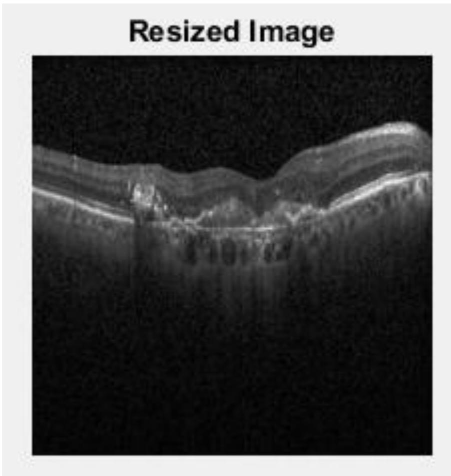

Fig 5. Resized Image

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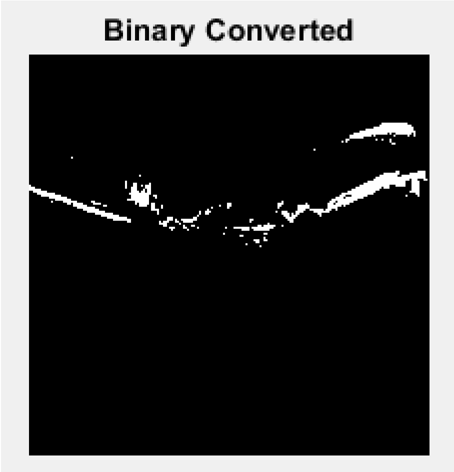

Fig 6. Binary Converted Image

Fig 7. Region of Interest

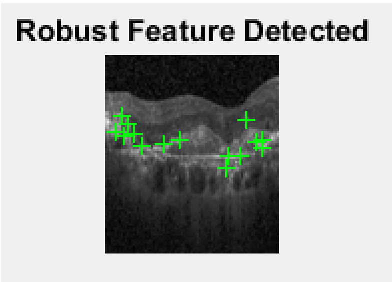

Fig 8. Robust Feature Detected

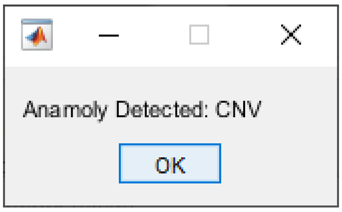

Fig 10. Anomaly Detection Screen

Fig 9. Neural Network Training

CONCLUSION

In this experimental study, we demonstrate an optimal way to detect retinal diseases such as choroidal neovascularization and drusen in the age groups ranging from 40 to 50 with the help of Optical Coherence Tomography (OCT), which provides 2D and 3D images of the cross-sectional area of the retinal part of an eye. OCT uses light waves to get images of patient's retina. It gives the percentages of thickness of different layers of the retina. Biomarker discovery and analysis incorporated with deep learning has previously been used for this purpose, with the help of linear discriminant analysis [20]. Data-driven methods that require manual construction

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methods were employed. In-depth learning strategies have also been widely used to diagnose ulcers and other symptoms. However, their downside is that they need training set up with personal annotations in the area of interest. Our proposed error detection method is an unregulated method based on the uncertainty that automatically detects incorrect authentication in the standard OCT Scan for the study [18]. Detects deviation from normal according to fed data. By identifying unfavorable regions in the new samples provided, pixel uncertainty estimates of pixel uncertainty were used during the test [6]. An extensive evaluation has been done to demonstrate that our methods are able to detect anomalies which correspond to these diseases under several conditions [7]. We thus evaluate an accurate system model using deep residual network and image processing techniques to obtain the required objective.

FUTURE SCOPE

The proposed method can also be extended using the deep learning algorithm by applying on the global patient data in retinal OCT and achieve higher accuracy after doing some modifications. Doppler OCT is an emerging technology, because it is solved in depth, such as the exact location of the vascular disorder can be localized using a shortcut image. Doppler OCT can monitor blood flow and retinal volume, and willcheck faults in the retinal and choroidal vasculature.One of the advancements that can be done is the En-face imaging. Using this method, certain retinal or choroidal layers at a given depth shall be inserted into the en-face view. Abbreviated images may help to determine the pathological features of retinal infections, as such, structural changes and retinal morphology and choroidal vasculature are difficult to diagnose using B-scans. It will improve in the near future as en-face imaging provides more information about the underlying causes of retina and choroid disease in diseased countries.Lastly, robotics has a tremendous scope in medical science. As it will be using artificial intelligence to make the process machine ready. Machine would be preprogrammed. Then OCT images would be fed to the machine for automatic analysis and detecting the disease within very less time and with highest accuracy.

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