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Data Preprocessing Techniques for Retinal OCT and Fundus Images

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Abstract:- Central Serous Retinopathy (CSR) is a retinal disease that results in blindness and visual loss. The accumulation of watery fluid behind the retina causes the CSR. Detection and prevention of CSR disease is desirable, it helps to take preventive measures to avoid and overcome any damages to the human eye. For the purpose of detecting CSR disease and analyzing the results 2 imaging approaches are used. Optical Coherence Tomography Angiography (OCT), Fundus Imaging are the two imaging (dataset) techniques used in this work. Before classification of the input dataset pre-preparation of the image dataset plays an important role classification using machine learning methods. Image processing increases the accuracy in detection of disease. The preprocessing stage in our proposed system consists of four main phases, namely noise removal, gray-scale conversion, median filtering, and data transformation. Data transformation in the proposed system consists of five image transformation steps such as random horizontal flip, random rotation, random resizing, transforming to tensor and normalizing the data.

Keywords:- *Central Serous Retinopathy (CSR), OCT and Fundus imaging.*

I. INTRODUCTION

Retina found in the eye's innermost layer. Macular and ocular areas make up the retina. Inverted vision develops in the macular area of the eye. By the studies it shows that the central part of retina is frequently damaged by retinal abnormalities in the macular area, leading to blurred vision. If these macular disorders are ignored they can lead to anomalies that impair a person's central vision. In severe circumstances, these diseases can cause blindness by causing extreme visual loss. The effect of blindness is increasing yearly because of inadequate health infrastructure in many regions. Diabetes, stress, smoking, less sleep are the primary cause of these retinal abnormalities because it leads the blood vessels in choroidal area to thin and begin leaking fluid into the intraretinal space. Macular diseases are also the second-most prevalent cause of blindness worldwide, “Retinal or macular edoema” (ME), “age-related macular degeneration” (ARMD), and “central serous chorioretinopathy” (CSCR) or “central serous retinal disease” (CSR) are the three most common kinds of these macular diseases. If these diseases are caught early enough, they are easily treatable.

Retina is a thin layer which is made up of sensitive tissues that is located beneath the eyeball, near to the optic nerve. It takes the concentrated light signals which comes from eye lens, transforms to neural impulses, and then transmits those signals to the brain, so that brain can interpret the images. Photoreceptor cells is layer in retina that process light, these cells are light-sensitive cells those are responsible for identifying visual details like colour, distance, light intensity. The information collected from photoreceptor cells is then transmitted by the optical nerve to brain for visual recognition. As a result, the retina plays important role processing pictures, human brain identifies and recognises variety of nearby things. Any retinal injury might have a significant negative effect on vision.

Using imaging techniques including fundus photography, auto-fluorescence(AF), optical ccoherence ttomography (OCT) and angiography, one may diagnose retina and identify CSR diseases. The implementation and acceptance of the OCT approach has allowed for the efficient use of these techniques. Because of this, automatic fractioning of retinal pathology, intraretinal fluid, colour epithelial disintegration, drusen and topographical atrophy, may now be carried out with the same standard as manually done by human. Another area of study is creating a profoundly settled picture of retinal vasculature utilising OCT scans to produce several successively created images. The identification of retinal diseases such “diabetic retinopathy”, “hypertensive retinopathy”, “age-related macular degeneration”, and glaucoma have recently benefited from the development of various automated techniques. Clinical systems now often use the automated detection and diagnosis of retinal illnesses through the evaluation of retinal pictures. These automated methods give the doctors more precise and optimal outcomes.

Until recently, detection of retina related diseases required labour-intensive, incorrect, and wasteful manual approaches. In contrast, computer-aided retinal disease identification systems are quick, simple, accurate, and cost-effective. Additionally, they don't rely much on an expert ophthalmologist's capacity to recognise the disease from different scanned pictures. This review research is focused on specific retinal disease called “central serous retinopathy” (CSR) or “central serous chorioretinopathy” (CSC).

The focal retina typically has central serous separation, occasionally with dull yellow stores, and rarely with a serous RPE separation, in certain CSR instances, a sub-retinal fluid accumulation persists for three months or longer, causing long-term visual problems. Sub-retinal fluid levels fluctuate regularly in situations with CSR like this. Majority of the patients will recover early. According to historical statistics, up to half of CSR patients may face relapses of the condition within one year, necessitating the patient to undertake variety of therapeutic procedures that might last up to few months in patients with chronic CSR, first-time CSR and recurrent CSR.

The objective of this work is to perform the pre-processing with suitable and accurate methods for OCT and Fundus Imaging, to reach the desirable accuracy in classification CSR disease.

II. LITEREATURE REVIEW

In literature review, CSR disease related study and researches are defined and elaborated. Numerous relevant and related CSR papers and publications were chosen for study and examination based on predetermined criteria for pre-preparation techniques for automated CSR identification system. In this paper, variety of techniques used for pre-processing and CSR detection methods were chosen for analysis. After assessing the content's quality, the studies connected to CSR disease are summarized. Here, several technologies are thoroughly assessed based on recent publications of the latest studies on the preprocessing techniques for CSR disease detection. Each article's methodology, titles, and abstracts are reviewed for accuracy and adherence to the study question.

The author [1] proposed a survey paper on all the recent publications and developments based on the classification, detection of CSR disease using AIML and Deep Learning methods, using both both the imaging technics, the author recommends that the recent AIML and deep leaning methods gives more prominent results. The author [2] proposed the method for an automated system for Central Serous Retinopathy (CSR) disease detection using Deep CNN for OCT scan images, here author done the work on only OCT imaging, our work comparison of the fundus images is also done. Author [3] proposed in the paper in 2020 IEEE conference paper exhibits an evaluation of the appropriateness of an as of late created spatially versatile difference improvement strategy for upgrading retinal funduspictures for vein division.

The author [4] proposed a survey paper, briefly explains preprocessing techniques for retinal image enhancement, methods used for segmentation of blood vessels and publiclyavailable retinal databases. The goal of the paper is to provide a comprehensive understanding of the current computer methods utilized for retinal image analysis and to point out potential areas of study for computer researchers working in ophthalmology.The Author [5] a new automatic method for preprocessing of digital color fundus images is proposed in 2021.

Author [6] provided the logical method to overcome problems for CSR detection, in the year 2020. The process isdivided into 3 steps. The thorough reconstruction of the 3-D OCT retinal surface are envisaged during the initial phase, next phase involves the formulation of two feature sets, one for cyst fluid and other for thickness profile. SVM classifier method is used to categorise the retinal topic. While various researchers experimented on OCT, fundus pictures, the lodged method used several OCT images for detection of CSR. Author concluded with good accuracy. The authors [7] suggested study that covers seven distinct preprocessing methods that are documented in the literature and identifies the best approach for enhancing retinal images. More than 1000 images from the DRIVE, STARE, and MESSIDOR datasets were used to test the effectiveness of each approach.

III. METHEDOLOGY

A. Data collection

Two publicly accessible CSR-related datasets were used and examined in this paper. These datasets are collection of OCT, fundus photos. These available datasets were used by numerous researchers and may be easily downloaded using their unique URLs. To accomplish testing objectives and train Machine Learning models, a fraction of the full-on images from these datasets are used in experimental research work. We briefly discuss two publicly accessible datasets.

➢ *OCT Dataset*

It is non-invasive imaging method that used to capture 3-D volumetric photographs, and it has emerged as the most preferred method for examining the retinal anatomy. The retina's cross-section picture is recorded using waves. By using OCT scans, the eye expert can diagnose of the retina's many layers and determine the thickness each layer.

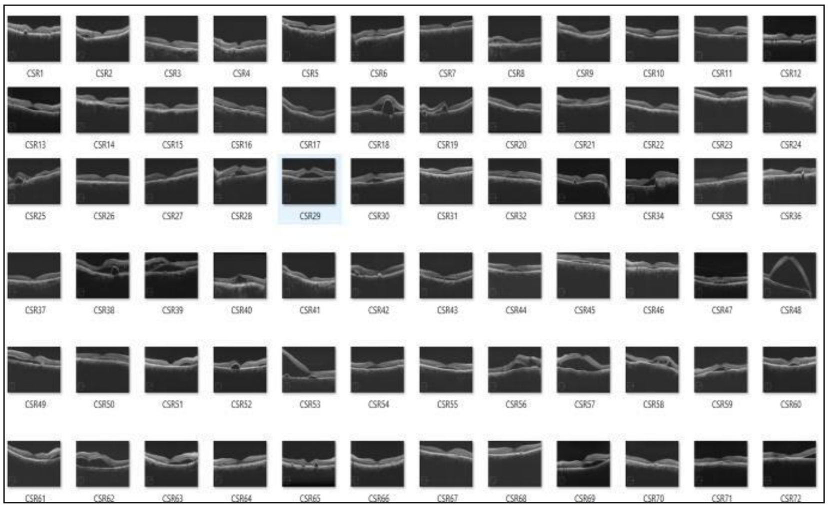

Fig. 1: Example of OCT Dataset

The labelled OCT pictures is found in Zhang's lab and also available in an OCT imaging database on the website of the "University of Waterloo" in Canada, this is opensource repository of OCT dataset. OCT image databases are widely accessible. It has been especially mentioned in relation to using image-based deep learning for medical diagnoses and curable diseases. Fig. 1 displays the OCT images Dataset of CSR diseases, here we used 340 OCT images.

➢ *Fundus Dataset:*

A method of acquiring the retinal red-free image known as "fundus photography" is regarded as a substitute for OCT imaging. A two-dimensional (2-D) representation of the three-dimensional retinal tissues cast onto the imaging surface is known as fundus imaging. This is done using reflected light, the amount of light reflected from the retinal tissue is directly linked to the picture intensity on the 2-D projection. This technology works based on color photographic film and the statistical methodology. Similar to this, digital representation of retina offers a fast, towering-resolution, and consistent image that is instantaneously available and managed for the creation of an image. Additionally, fundus photography is frequently used for clinical examinations and disease records, with the possibility for telemedicine and tolerant training. The photos produced by Fundus methods can also include ordinary and extended perspectives. Retinal scans produced using fundus photography images are as shown in Fig.2.

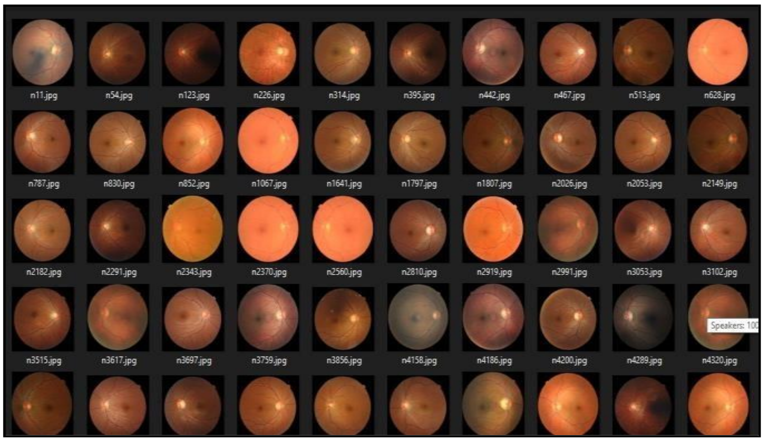

Fig. 2: Example of Fundus Dataset

B. Data Pre-preparation

Two publicly accessible CSR-related datasets are examined in this article. These CSR databases are the consists of OCT and fundus images, and a typical dataset constitute of a variety of records. These freely available datasets typically used and accessed by many academics, and may be quickly found using their unique connections.

The preprocessing stage in our proposed system consists of four main phases, namely noise removal, gray-scale conversion, median filtering, and data transformation. Data transformation consists of five image transformation steps such as "random horizontal flip", "random rotation", "random resizing", "transforming to tensor" and normalizing the data. Image preprocessing flow is as shown in fig. 3.

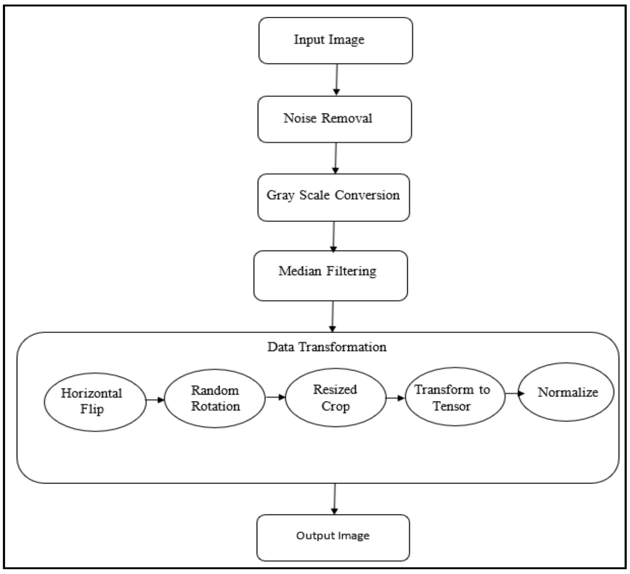

Fig. 3: Flow Diagram for Data pre-processing process

C. Methodology used in data preprocessing

The methods used for data preprocessing in proposed system are as follows:

- Noise removal
- Gray scale Image
- Median Filtered Image
- Data Transform/Augmentation:

The preprocessing stage in our proposed system consists of four main phases, namely noise removal, gray-scale conversion, median filtering, and data transformation.

➢ *Noise Removal:*

The removal of noise from images is a major task in the field of image processing, because it affects the quality of the image and leads to the loss of some of its important information through the impact of noise on it. To remove the noise in the images, different image filtering techniques are used.

➢ *Conversion from RGB to Grayscale:*

Captured images are in the RGB format. The pixel values and the dimensionality of the captured images is very high. As images are matrices and mathematical operations areperformed on images are the mathematical operations on matrices. Convert the RGB image into grey image using function and thus converting the grey image into Binary image, formula for convertion is as shown in equation (1). Technique is used on the Binary image to detect the hand region.

The Equation: 0.2989*R+0.5870*G+0.1140*B (1)

➢ *Median Filtering:*

The technique is used to eliminate noises in the image, it's a linear filtration technique. Medianfilter is calculated by using the formula below equation (2)

$$Median\ Filter = \frac{a\left(\frac{N}{2}\right)+a\left(\frac{N}{2}+1\right)}{2} \text{ ----------------------(2)}$$

➢ *Thresholding:*

The thresholding technique is used to eliminate noises in the image, considering each pixel values,if the pixel value is greater than or equal to the threshold T, retain it, else, replace the value by 0, inprposed system takenas T=100.

➢ *Data Transformation:*

Image data augmentation is the process of generating new transformed version of images from the given image dataset to increase its diversity. Zoom, shear, rotation, and other image augmentation attributes are frequently employed to enhance the number of data samples. When these parameters are used to train a deep learning model, images with these characteristics are produced. In general, image samples produced through image augmentation result in an expansion of the current data sample. For data transformation in the proposed work consists of five image transformation steps such as "random horizontal flip", "random rotation", "random resizing", "transforming to tensor" and "normalizing" the data. Fig. 4 depicts the flow chart for data transformation in proposed system.

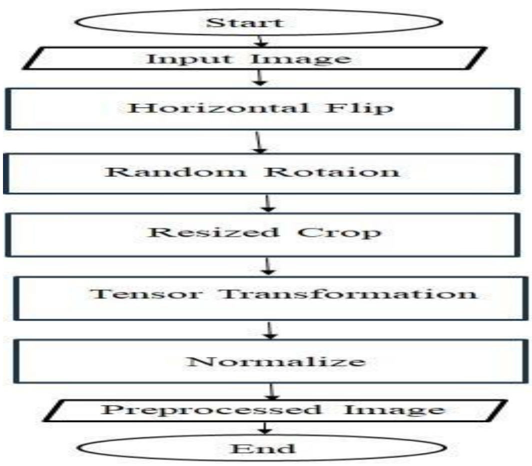

Fig. 4: Flowchart for data Transformation of input data

D. Splitting of data

Dataset is divided into two parts (i) Training Data, (ii) Test Data using the built-in library known as "sklearn".

➢ *Training Data:*

A for this work uses 80% of the original dataset and this numbers may vary depending on the needs of the experiment. This data is used to train the model, which tries to learn from the labeled dataset. Both the input and the predicted result are included in the trainingdata.

➢ *Test Data:*

The test dataset is 20% of the original dataset and used to evaluate the model. It is used for the model's evaluation process after it is fully trained.

IV. RESULT AND DISCUSSIONS

The open source Streamlit framework and Python are used to implement the suggested work. Streamlit is a Python-based toolkit that makes it easier to construct and share machine learning web apps. We performed the experiment on a local a personal computer with an 8GB RAM and Core i5 processor.

The proposed enhancement technique is implemented, trained, and validated on the training and validation set of the OCT and Fundus dataset using a CNN classification model and evaluated on the test set to identify the presence or absence of retinal abnormalities. The model performance is evaluated by calculating accuracy, Precision, Recall and F1 score. Accuracy is calculated as the ratio between the total number of correct predictions to the total number of predictions. F1 score is defined as the harmonic mean of precision and recall. Visual image analysis of the result is carried out in RGB colour space and as well as in Gray-scale. Fig. 5 shows the comparison of the original input, stage 1 output, and stage 2 output in colour space, along with a comparison between the Gray-scale of the input image vs. the output of the proposed technique.

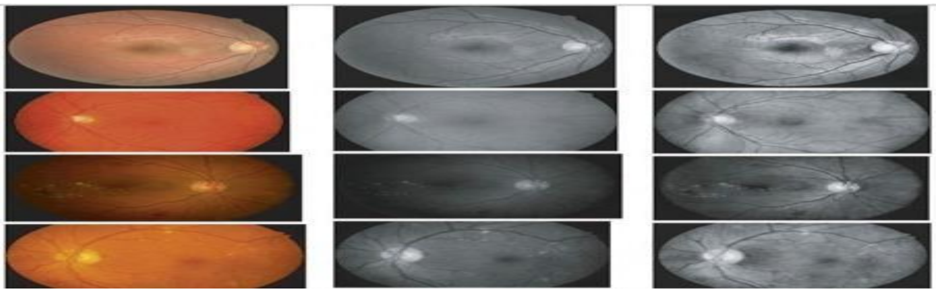

Fig. 5: (a) Input Image (b) Preprocessed Output (c) Transformed output

V. CONCLUSION

Retinal image enhancement is an essential step under thepre-processing stage to better view the retinal anomalies for identifying the type of disease a patient suffers. This paper proposes an efficient retinal image preprocessing for OCT and Fundus imaging dataset and enhancement technique. The proposed enhancement technique is implemented, trained, and validated on the training and validation set of the OCT and Fundus dataset using a CNN classification model and evaluated on the test set to identify the presence or absence of retinal abnormalities. The model performance is evaluatedby calculating accuracy, Precision, Recall and F1 score. The model exhibited better using above preprocessing techniquesfor OCT and Fundus dataset.

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