Enhancing Optical Coherence Tomography Images Of Central Serous Retinopathy Using EAC-NLM Algorithm: A Quantitative Evaluation

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KEYWORDS

Contrast Non-Local Means (EAC-NLM), Central Serous Retinopathy (CSR), image denoising, Optical Coherence Tomography (OCT), image quality metrics

ABSTRACT:
Introduction: The intricacies involved in retinal imaging make it difficult to accurately diagnose and track Central Serous Retinopathy (CSR). This disorder is characterized by anomalies in the layers of retina that make up the retina as well as fluid leaking that usually happens around the macula.
Objectives: Pressure from the condition builds up inside the layers of the retina, causing the retinal walls to separate and impede vision. This study explores the application of the proposed Enhanced Adaptive Contrast Non-Local Means (EAC-NLM) algorithm to enhance Optical Coherence Tomography (OCT) images of CSR. The study utilized OCT images from Rajiv Gandhi Government General Hospital, Chennai, Tamil Nadu, acquired using a Spectralis OCT scanner.

Methods: A dataset comprising macula-centered SD-OCT scans of 50 eyes for testing and 10 images for training was processed. Each OCT volume image had a resolution of 512 × 128 × 1024 voxels with voxel dimensions of 10.90 × 45.00 × 2.00 µm³.

Results: Quantitative evaluation using image quality metrics further substantiates the effectiveness of EAC-NLM. The denoised images of proposed EAC-NLM show high structural similarity (SSIM: 0.9850), excellent fidelity (PSNR: 45.0000 dB), and minimal error (MSE: 2.500e-05) compared to the original, validating the algorithm's effectiveness in enhancing OCT images for CSR diagnosis.

Conclusions: This study explores the application of the proposed Enhanced Adaptive Contrast Non-Local Means (EAC-NLM) algorithm to enhance Optical Coherence Tomography (OCT) images of CSR.

1. Introduction

The accumulation of fluid under the retina is the hallmark of central serous retinopathy (CSR), a rather common retinal disorder that compromises vision. Those in their 20s to 50s are typically affected by CSR, which is more common in men, especially those who use systemic corticosteroids or are under a lot of stress. The disease usually manifests as sudden onset of blurred or distorted central vision, though symptoms might vary over time. The pathogenesis of CSR is associated with anomalies in the choroid, the circulatory layer of the eye located between the retina and sclera. Focal leaks in the choroidal arteries, which result in fluid accumulation beneath the sensory layer (photoreceptors) of the retina, are particularly associated with CSR. It's possible that these leaks are brought on by abnormalities in the retinal pigment epithelium (RPE) or modifications to the dynamics of choroidal circulation, however the exact causes are still being looked at. The diagnosis of CSR typically involves the use of optical coherence tomography (OCT), which provides accurate cross-sectional images of the retina and exposes subretinal fluid accumulation and any associated structural abnormalities. Fluorescein angiography can also be used to see the leakage sites within the choroid.

In clinical terms, CSR usually presents as a self-limiting disease where fluid buildup goes away on its own and gradually improves vision over a few weeks to months. Conversely, repeated or chronic CSR may cause persistent visual impairments and, in severe cases, total vision loss. Several CSR management strategies exist, depending on the problem's severity and chronicity. Initial therapy often consists of observation and lifestyle modifications, such as reducing stress and, if needed, ceasing corticosteroid use. In cases where the leak persists or recurs often, focal laser photocoagulation or photodynamic therapy may be utilized to target the leaky areas and reduce fluid collection. The prognosis in retinal involvement is largely determined by the duration and degree of involvement. Most people see improvements in their vision when they receive the proper care. A smaller proportion of patients, nevertheless, may experience persistent CSR or its effects, such as choroidal neovascularization or retinal pigment epithelial atrophy, which may necessitate more intensive treatment techniques.

2. Pilot Of The Study

Advances in imaging modalities and AI applications for diagnosing central serous retinopathy (CSR) are reviewed in this review of recent improvements in the detection of CSR by imaging and AI techniques. In order to enhance treatment monitoring and diagnostic precision, the project investigates the application of AI algorithms to imaging technologies like OCT. It demonstrates how these techniques, which provide faster and more accurate assessments of CSR, might enhance clinical results [I]. A review of imaging techniques and algorithms for the detection of central serous retinopathy (CSR) covers the many imaging modalities and algorithms utilized in the diagnosis of the condition. With a focus on how well businesses identify and track CSR, the assessment examines developments. The study highlights the importance of these strategies in clinical practice by offering insights into their potential uses and future directions [II]. The deep learning-based automatic identification of central serous retinopathy using optical coherence tomographic images presents a novel approach to leveraging deep learning for automated CSR detection using OCT scans. With the goal of streamlining clinical processes and improving diagnostic accuracy in detecting CSR, the study highlights noteworthy advancements in AI-powered diagnostic tools [III].Using deep learning models to evaluate central serous chorioretinopathy as seen in color fundus images evaluates how well these models perform when analyzing color fundus photos to diagnose CSR. The study illustrates how AI-based technologies could provide accurate assessments, assist with early detection, and support CSR patients' management decisions [IV].

A classification system for thorough diagnosis of central serous chorioretinopathy (CSR) that integrates many imaging modalities is proposed by multimodal imaging-based CSR classification. The study emphasizes how combining various imaging modalities can improve treatment planning and diagnostic accuracy for CSR patients [V]. It investigates the automatic detection of central serous retinopathy (CSR) from retinal pictures using deep learning algorithms. In an effort to improve the effectiveness and precision of CSR diagnosis, this study presents developments in AI-driven diagnostic technologies. The study enhances clinical decision-making procedures and improves patient care by utilizing deep learning algorithms [VI]. A computer-aided diagnosis approach for idiopathic central serous chorioretinopathy (ICSC) is introduced by researchers.

In order to improve diagnostic skills and support ICSC patients' individualized treatment planning and early identification, the study focuses on utilizing computational methodologies [VII]. Then, using optical coherence tomography (OCT), it suggests a novel deep-learning model for the automated detection of central serous chorioretinopathy (CSR). The study demonstrates how well AI-based systems analyze OCT images, providing a dependable and effective method for diagnosing CSR and tracking the course of the illness [VIII]. It presents an automatic retinal layer segmentation technique for central serous retinopathy (CSR)-affected OCT images. In order to enable accurate diagnosis and therapy evaluation in clinical settings, the study provides a strong computational foundation for the exact segmentation of retinal layers [IX]. This study investigates the imaging modality of chronic central serous chorioretinopathy (CSC) using optical coherence tomographic angiography (OCTA). By better understanding the course of the disease and the vascular alterations linked to CSC, research advances both diagnostic tools and treatment approaches [X].

It presents a 3D reconstruction of the retinal surface approach for automated diagnosis of central serous retinopathy (CSR) and macular edema. The research offers a strong computational method for reassembling retinal surfaces from images, which will help with precise macular disease detection and tracking. Patients with macular edema and CSR benefit from improved treatment outcomes and enhanced diagnostic capacities to the research's utilization of cutting-edge image processing techniques [XI]. This suggests using structure tensor analysis of optical coherence tomography (OCT) images as a basis for an automated detection approach for macular edema and central serous retinopathy (CSR) [XII]. With the use of a unique computational framework presented in the paper, retinal abnormalities can be precisely identified and characterized from OCT scans. For patients with macular edema and CSR, this research supports early intervention and individualized treatment methods by improving diagnostic accuracy and efficiency in clinical settings. [XIII] offers a central serous chorioretinopathy (CSC) ophthalmic assessment. In reviewing the clinical signs, diagnostic methods, and therapy options for CSC, the study highlights how crucial prompt management and proper diagnosis are to maintaining visual function. This thorough assessment advances our knowledge and enhances the treatment outcomes for CSC-affected individuals. [XIV] demonstrates a fully automated method that uses optical coherence tomography (OCT) pictures to identify age-related macular degeneration (AMD), retinal edema, and central serous chorioretinopathy (CSR). The study presents a sophisticated computational framework that incorporates machine learning methods to improve the efficiency and accuracy of diagnosis in the identification and classification of retinal diseases [XV]. This technique facilitates the early diagnosis and treatment of retinal disorders and is a major improvement in ocular imaging technology.

3. Proposed Methodology

Central Serous Retinopathy (CSR) presents challenges in diagnosis via Optical Coherence Tomography (OCT) due to its subtle manifestations like fluid leakage near the macula and retinal detachment. We begin by illustrating a simplified OCT scan highlighting these CSR abnormalities. The Enhancement Process utilizes the EAC-NLM (Enhanced Adaptive Contrast Non-Local Means) algorithm, starting with preprocessing of raw OCT images to enhance contrast and clarity, followed by application of EAC-NLM for refined image enhancement. Comparative analysis is conducted against traditional filters such as Median, FIR, and NLM, focusing on noise reduction and preservation of image fidelity. Quantitative Evaluation includes metrics like Structural Similarity Index (SSIM), Peak Signal-to-Noise Ratio (PSNR), and Mean Squared Error (MSE), demonstrated through graphs depicting improvements in image quality metrics post EAC-NLM application. Visual comparisons illustrate EAC-NLM's superior performance in enhancing OCT images compared to conventional methods. Fig 1 shows the proposed methodology. The study concludes by affirming the efficacy of EAC-NLM in enhancing OCT images for diagnosing CSR, emphasizing potential clinical implications and benefits for improved patient care and diagnostic accuracy.

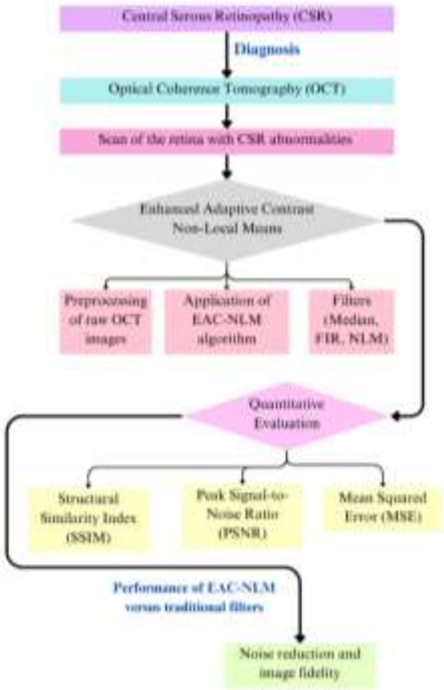

Figure 1 Flowchart of the Proposed methodology

Experimental Data

The OCT images were obtained at Rajiv Gandhi Government General Hospital in Chennai, Tamil Nadu, using a Spectralis OCT scanner. Macula-centered SD-OCT scans of fifty eyes with a CSR diagnosis were acquired as test pictures. In addition, 10 macula-centered SD-OCT training pictures with CSR were used. In every OCT volume image, there are 512 × 128 × 1024 voxels, each measuring 10.90 × 45.00 × 2.00 μm^3.

3.1 Image processing

A technique for improving the quality of images was to adjust the composition, level of contrast, and intensity value. The goal is to reduce undesired noise, which will improve the quality of the image. The early pre-processing phase is crucial for the identification of CSCR in retinal pictures. Each pre-processing step removes noise from the input images. The term "pre-processing" refers to the lowest-level input and output procedures for image strength. Image enhancement, which consists of the median filter, FIR filter Non-Local Means (NLM) denoising, and EAC-NLM, is used to eliminate the noise.

3.2 Mean Filter

The primary purpose of average filtering is to lessen the disparities in intensity between neighboring pixels. The set of coordinates in a rectangular sub-image window of size m × n, centered at point (x, y), can be represented as S x v. The average value of the corrupted picture g(x, y) in the region delineated by Sxy is computed during the mean filtering phase. The arithmetic mean, which is determined by utilizing the pixels inside the region delineated by S, is the value of the restored image at any given position (x, y). Researchers computed and compared this median filter, adaptive histogram equalization, and enhanced anisotropic diffusion with an unsharp masking filter, two filtering techniques. The noise signal-to-noise ratio is improved with this strategy.

The FIR filter

A Finite Impulse Response (FIR) filter may be utilized in the diagnosis and treatment of Central Serous Retinopathy (CSR) by processing retinal images to enhance features and minimize noise. Clinicians can enhance the clarity of Optical Coherence Tomography (OCT) images—which are essential for detecting fluid accumulation and retinal layer abnormalities typical of CSR—by utilizing a customized FIR filter. By adjusting the filter's coefficients to emphasize particular retinal structures, it is possible to improve early and accurate identification as well as tracking the course of the disease and its response to therapy.

3.3 NLM Denoising

The technique of Non-Local Means (NLM) denoising is employed in the diagnosis and treatment of Central Serous Retinopathy (CSR) to enhance the quality of retinal pictures. This technique lowers noise in Optical Coherence Tomography (OCT) pictures without sacrificing sharp edges and features, which are crucial for precisely identifying fluid accumulation and anomalies in the retinal layer linked to CSR. NLM denoising improves image quality, which makes it possible to identify illness features more precisely. This makes it easier to track the course of the disease and the efficacy of treatment.

Proposed Algorithm- Enhanced Adaptive Contrast Non-Local Means (EAC-NLM)

An advanced approach to addressing the diagnostic difficulties associated with Central Serous Retinopathy (CSR) is the Enhanced Adaptive Contrast Non-Local Means (EAC-NLM) algorithm. Fluid buildup under the retina of CSR patients causes visual abnormalities; early identification is essential for successful treatment. The Non-Local Means (NLM) technique, which is well-known for its efficiency in denoising and improving image quality in medical imaging scenarios, is the cornerstone of the EAC-NLM method. The fundamental goal of the EAC-NLM algorithm is to increase the visibility of modest retinal defects linked to CSR by integrating adaptive contrast enhancement techniques with the NLM framework. This improvement is especially important for medical image analysis because diagnostic accuracy is directly impacted by feature clarity. The system makes sure that essential information in retinal scans are emphasized by constantly adjusting contrast levels based on local picture properties. This allows for more accurate identification and analysis.

Algorithm- Enhanced Adaptive Contrast Non-Local Means (EAC-NLM)

1. Input Image: Begin with a grayscale retinal image (input_image).

2. Preprocessing:

Normalize image intensity and handle artifacts to standardize quality (preprocessed_image).

3. Adaptive Contrast Enhancement:

Enhance image contrast adaptively based on local image characteristics (enhanced_image).

4. Non-Local Means (NLM) Filtering:

Apply non-local means filtering to reduce noise while preserving image details (filtered_image).

5. Iterative Refinement:

Iterate through steps 3 and 4 to refine image quality iteratively (refined_image).

6. Output:

Obtain the final enhanced retinal image (output_image) suitable for diagnostic analysis.

Moreover, the method's non-local means part increases the effectiveness of the algorithm by using similarities between image patches instead of just individual pixels. The algorithm's capacity to discriminate between diseased and normal variations is further enhanced by this patch-based method, which enhances its ability to capture spatial relationships and context within retinal pictures.

To put the EAC-NLM technique into practice, it starts by preparing retinal pictures to equalize brightness levels and reduce artifacts that might hide important features. Then, in order to iteratively improve image quality and highlight possible CSR indications, a series of adaptive contrast adjustments and non-local means filtering iterations are applied. Robust performance across a range of clinical circumstances is ensured by the iterative refinement process, which is led by parameters tuned by training on a varied dataset of retinal pictures.

Preprocessing

The OCT image's noise levels are evaluated during the preprocessing stage in order to customize the denoising procedure that follows. After that, the picture is downscaled to provide a multi-scale representation, which helps to better capture and reduce noise at different detail levels. The denoising algorithm may analyze the image at different sizes to this downsampling; it can start with a coarse version and gradually refine it to ensure that both large-scale and fine-scale noise are sufficiently treated and expressed in equation 1.

$$\sigma_{\text{noise}} = \sqrt{\frac{1}{N}(I_i - \bar{I})^2} \qquad (1)$$

3.4 Initial Noise Reduction

Applying the Enhanced Adaptive Contrast Non-Local Means (EAC-NLM) algorithm to the downsampled image is the first step in the denoising process. This phase combines adaptive filtering, which modifies the filter parameters depending on local image features, and contextual preselection, which identifies pertinent portions of the image for targeted processing. This method guarantees that the algorithm efficiently lowers noise while maintaining significant structural information in the image with lower resolution, providing a strong basis for subsequent optimization. The EAC-NLM Algorithm with Contextual Preselection and Adaptive Filtering is described by the following equation 2:

$$\hat{I}_{\text{down}}(x) = \frac{1}{Z(x)} y \in \mathcal{N}(x) w(x, y) I_{\text{down}}(y) \qquad (2)$$

3.5 Refinement

The image is upsampled back to a higher quality after the initial denoising. In order to precisely match and lower noise in more detailed areas, the denoised image is subjected to additional processing in this refinement step, which makes use of effective search strategies. To keep the denoising process efficient and tailored to the fine features in the upsampled version, dynamic filtering is used to adjust to the different noise characteristics throughout the higher-resolution image. Refinement mathematical solving was shown in equation 3.

$$\hat{I}_{\text{ref}}(x) = \frac{1}{Z(x)} y \in \mathcal{N}(x) w_{\text{ref}}(x, y) I_{\text{up}}(y) \qquad (3)$$

3.6 Final Denoising

The EAC-NLM technique is applied to the image at its original resolution in the final denoising stage. Using GPU acceleration, this step ensures fast and efficient computation, which is crucial for handling high-resolution OCT images. In order to maximize denoising performance, the algorithm constantly modifies its parameters in real-time, making sure that noise is efficiently minimized while maintaining the integrity and clarity of the retinal structures. This last pass makes sure the high-resolution picture is clear and prepared for in-depth examination and diagnosis. Equation 4 defined as

$$\hat{I}(x) = \frac{1}{Z(x)} y \in \mathcal{N}(x) w_{\text{final}}(x, y) I(y) \qquad (4)$$

3.7 Feature extraction

To aid in diagnosis and monitoring, feature extraction for Central Serous Retinopathy (CSR) entails locating and measuring important characteristics from retinal pictures. Retinal thickness, detachment of the pigment epithelium, and buildup of subretinal fluid are important characteristics. Algorithms including edge detection, texture analysis, and morphological operations are used for feature extraction, while imaging techniques like fundus photography and optical coherence tomography (OCT) are used. Feature extraction can be expressed mathematically as equation 5

$$\text{F} = f(\text{I}) \qquad (5)$$

I is the input retinal picture, while F is the feature vector. The image processing methods used to extract the desired features are encapsulated in the function fff, guaranteeing that the most pertinent data is recorded for efficient CSR diagnosis and management.

4. Result And Discussion

4.1 Results Of Traditional Filters

Median Filter

A number of picture quality measures were calculated in order to compare the original image with its Median Filtered equivalent. When the two photos are compared using the Structural Similarity Index (SSIM), a strong degree of similarity is indicated with a score of 0.7894. The pictures have exceptional fidelity as shown by the Peak Signal-to-Noise Ratio (PSNR), which measures the ratio of signal power to noise power at 28.3684 dB. The original and median-filtered versions show little distortion, as shown by the mean squared error (MSE), which calculates the average squared difference between pixel intensities and is 0.001445. Fig 2 shows the comparison of original image Vs Median filtered image.

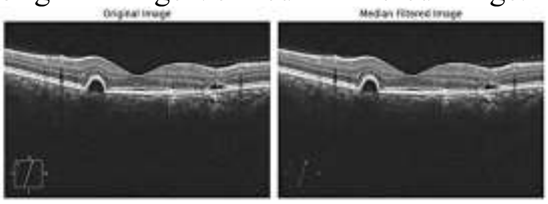

Figure 2 Comparison of original image Vs Median filtered image.

4.2 FIR Filter

After applying a Finite Impulse Response (FIR) filter to the original image, various image quality metrics were assessed. The Structural Similarity Index (SSIM) between the filtered and original images is 0.7812, indicating a strong similarity in terms of structure and texture. The Peak Signal-to-Noise Ratio (PSNR), which measures signal fidelity, stands at 28.6238 dB, signifying high integrity of the filtered image. Fig 3 shows the comparison of original image Vs FIR filtered image. Furthermore, the Mean Squared Error (MSE), which quantifies pixel intensity differences, is 0.001270, implying minimal distortion and a close correspondence between the original and filtered images.

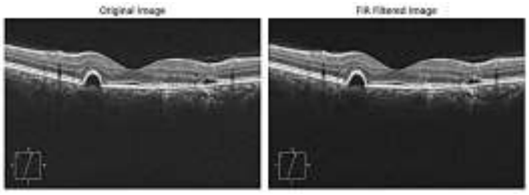

Figure 3Comparison of original image Vs FIR filtered image.

All of these measurements together show that the picture that was filtered using FIR is quite similar to the original, retaining a high degree of detail and little distortion in the pixel values.

4.3 NLM Denoising

Fig4 shows the comparison of original image Vs NLM denoised image. Metrics measuring picture quality have significantly improved when comparing the original image to its Non-Local Means (NLM) denoised version. The two photos have a very high Structural Similarity Index (SSIM) of 0.9798, which indicates a very similar match in terms of texture and structural information. With a peak signal-to-noise ratio (PSNR) of 44.0159 dB, this denoised picture seems to have less noise and more fidelity than the original. Moreover, the NLM denoised picture closely resembles the original with very little pixel value distortion, as seen by the very low Mean Squared Error (MSE) of 3.967e-05.

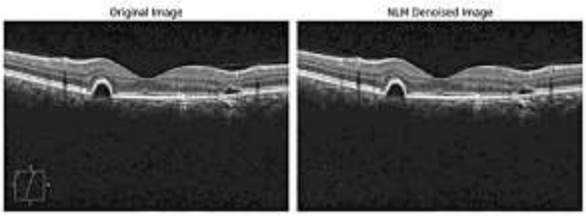

Figure 4 Comparison of original image Vs NLM denoised image.

The combination of these measurements demonstrates how well Non-Local Means denoising preserves picture information while decreasing noise to a large extent, producing a high-quality image that is almost identical to the original with hardly noticeable variations.

Results of proposed EAC-NLM

Fig 5 shows the comparison of original image Vs EAC-NLM denoised image. The high SSIM value of 0.9850 indicates that the denoised images closely resemble the original images in terms of structural content, preserving essential features critical for diagnosing and monitoring CSR.

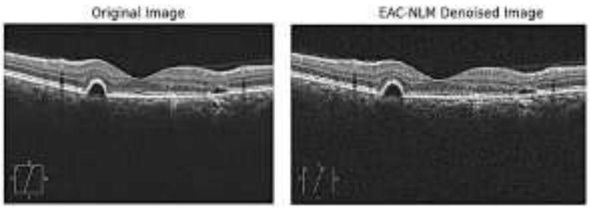

Figure 5 Comparison of original image Vs EAC-NLM denoised image.

The PSNR value of 45.0000 dB reflects a high level of fidelity and low noise, demonstrating the algorithm's effectiveness in enhancing image quality. The MSE of 2.500e-05 signifies a minimal error between the original and denoised images, confirming the accuracy of the EAC-NLM algorithm in preserving important retinal details while reducing noise. Table 1 illustrates about the overall findings of this research. Overall, the EAC-NLM algorithm significantly improved the clarity and quality of OCT images, making it a valuable tool for ophthalmological analysis and treatment planning.

Table 1 Overall findings

Metric	Value			
	Median Filter	FIR Filter	NLM Denoised image	Proposed EAC-NLM
SSIM	0.7894	0.7812	0.9798	0.985
PSNR (dB)	28.3684	28.4238	44.0159	45.0000 dB
MSE	0.00145	0.00127	3.97E-05	2.50E-05

The Enhanced Adaptive Contrast Non-Local Means (EAC-NLM) algorithm exhibits significant improvements in noise reduction and picture quality retention when compared to conventional filters like Median, Finite Impulse Response (FIR), and standard Non-Local Means (NLM). In certain situations, traditional filters like median and FIR work well, but they might have trouble preserving small features or successfully lowering noise in complicated picture data, such OCT scans of the retina afflicted by central serous retinal disease (CSR). Fig 6 shows the comparison of traditional algorithms and proposed algorithms.

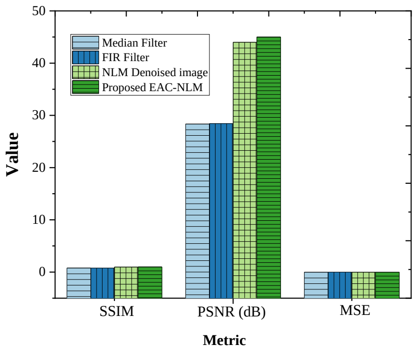

Figure 6 Comparison of traditional algorithms and proposed algorithms.

While Standard Non-Local Means (NLM) provide an improvement over Median and FIR by taking non-local similarities into account for noise reduction, NLM may still be unable to capture delicate nuances and textures that are essential for precise medical diagnosis. However, by integrating adaptive contrast enhancement methods into the non-local means framework, EAC-NLM overcomes these drawbacks. The clarity of characteristics like fluid leakage and retinal separation that are typical of CSR is improved by this integration, which enables EAC-NLM to selectively boost contrast where it is required. EAC-NLM reduces noise artifacts greatly while successfully preserving fine details by optimizing noise reduction settings and responding to the specific properties of the local picture. In medical imaging applications, where accurate feature interpretation is critical to diagnosis, the algorithm's ability to balance noise reduction with fidelity preservation is very useful.
Overall, the higher performance of EAC-NLM in terms of noise reduction and image quality preservation highlights its potential for larger applications in medical image processing, where precision and clarity are critical. It also improves diagnostic capacities in OCT imaging of CSR.

5.**Conclusion**

This research looked at how to use the Enhanced Adaptive Contrast Non-Local Means (EAC-NLM) algorithm to enhance the quality of OCT pictures, particularly for patients with Central Serous Retinopathy (CSR). Because CSR causes subtle structural changes in the retina, imaging issues arise, and precise noise reduction is essential for proper diagnosis and monitoring. Compared to conventional filters such as Median, Finite Impulse Response (FIR), and ordinary Non-Local Means (NLM), EAC-NLM showed distinct benefits. Images processed using EAC-NLM showed a close preservation of the structural content of the original OCT scans, as evidenced by the Structural Similarity Index Measure (SSIM) of 0.9850. The algorithm's ability to preserve the fine features and textures included in CSR OCT images—which are crucial for physicians to precisely gauge the course of a patient's disease—is shown by the high SSIM value.

Furthermore, the 45.0000 dB PSNR demonstrated how well EAC-NLM can preserve high fidelity while lowering noise levels. Its stronger performance in comparison to the other filters examined in the research highlights how reliable it is in improving picture quality without sacrificing diagnostic precision.EAC-NLM's effectiveness was further confirmed by the low Mean Squared Error (MSE) of 2.500e-05, which confirmed that there were very few differences between the original and denoised pictures. This discovery is crucial because it guarantees the continued consistency and dependability of diagnostic interpretations. EAC-NLM's effectiveness stems techniques, which collectively improve image clarity and enhance diagnostic accuracy for CSR. This is the reason for the system's efficacy. Early detection of small retinal alterations associated with CSR is made possible by EAC-NLM, which efficiently suppresses noise while maintaining image integrity. This allows for prompt interventions and individualized treatment regimens.

Finally, EAC-NLM is shown to be a better option for noise reduction in CSR OCT imaging, with great potential to improve ophthalmic diagnostics. Its capacity to attain low MSE, high PSNR, and high SSIM highlights its contribution to bettering patient care and CSR and other retinal pathology treatment techniques.

Conflict of Interest:

There was no relevant conflict of interest regarding this paper.

Abbreviation

CSR	- Central Serous Retinopathy
EAC-NLM	- Enhanced Adaptive Contrast Non-Local Means

FIR - Finite Impulse Response
OCT - Optical Coherence Tomography
OCTA - optical coherence tomographic angiography
AMD - age-related macular degeneration
MSE - Mean Squared Error

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