[Medical Image Enhancement based on CLAHE approach]

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Abstract

In this project, we discuss the Medical Image Enhancing Method based on the CLAHE approach. Medical image enhancement is crucial in digital image processing, as medical images often suffer from noise and low contrast issues. This paper proposes an advanced image enhancement approach that integrates Principal Component Analysis (PCA)-based fusion with multiple filtering techniques to improve image clarity and diagnostic accuracy. The process begins by extracting the three color channels from the retinal image. Each channel undergoes enhancement using Gaussian, CLAHE, Median, and Wiener filters, followed by PCA-based fusion to retain the most significant image features. This process is applied to all three color channels, and the final enhanced image is obtained through another PCA-based fusion step. The proposed method effectively reduces noise, enhances contrast, and preserves image details. Performance evaluation using metrics such as Peak Signal-to-Noise Ratio (PSNR), Structural Similarity Index (SSIM), Feature Similarity Index (FSIM), and Entropy demonstrates the efficiency of the approach. The results indicate that the method significantly enhances the quality of medical images, leading to improved visual perception and potentially aiding more accurate clinical diagnoses.

Background

- Implementing the Retinex-Centered Contrast Enhancement Method for histopathology images offers numerous advantages and can support a variety of use cases tailored to medical imaging and diagnostics. Here are some key uses:

- **Enhanced Image Contrast:** The Retinex-based method improves the overall contrast of histopathology images by balancing global and local contrast enhancement, making it easier to visualize critical tissue structures and details for accurate diagnosis.

- **Preservation of Natural Colors:** By utilizing Multiscale Retinex with Adaptive Weighting (MSRAW), the method preserves the natural colour of histopathology images, preventing over-enhancement and maintaining a realistic appearance.

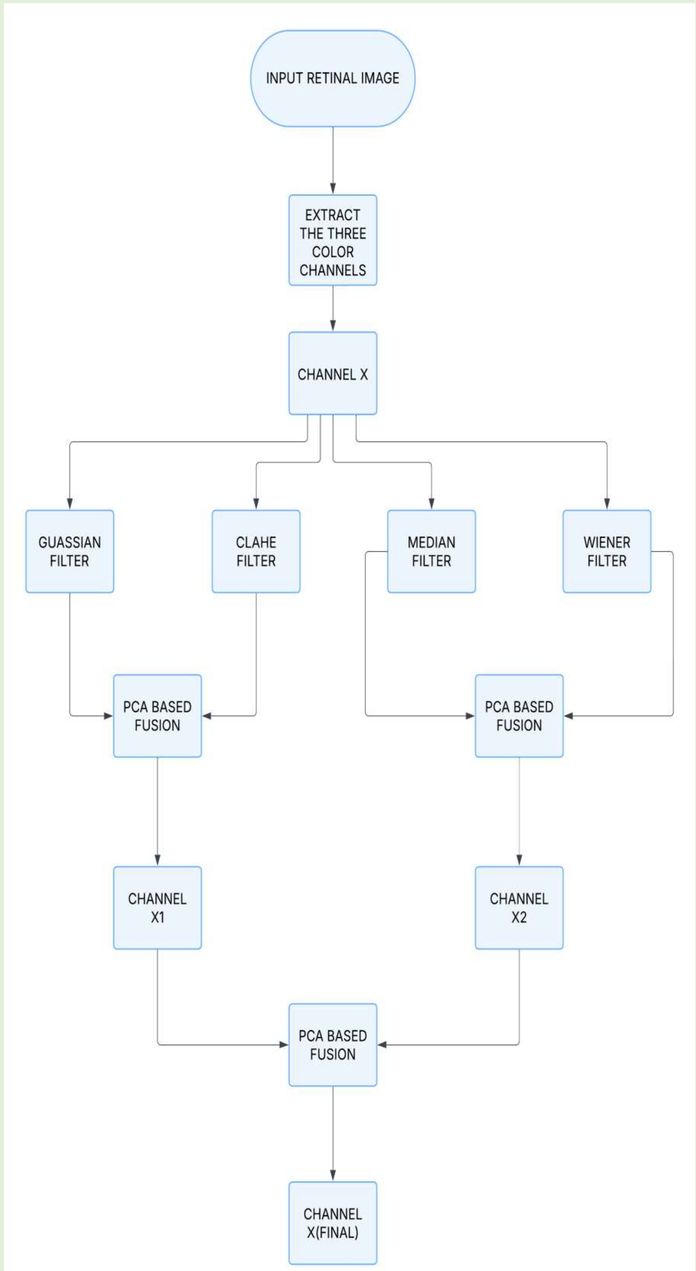
- **Improved Local Detail Visibility**: Weighted CLAHE (Contrast Limited Adaptive Histogram Equalization) is applied to enhance fine local details within the image, ensuring that important diagnostic information, such as cell and tissue structures, is clearly visible.

- **Noise and Artifact Reduction**: The combination of CLAHE outputs at different clip limits ensures that the image enhancement process avoids noise amplification and the creation of unwanted artifacts, providing clean, high-quality images.

- **Optimized for Diagnostic Tools**: The enhanced images produced by this method are ideal for use in computer-aided diagnosis (CAD) systems, improving the accuracy of disease detection algorithms, especially for tasks such as tissue segmentation and classification.

- **Applications in Medical Research:** The method supports medical research by providing high-quality histopathology images, enabling more precise analysis of diseases like cancer and contributing to advancements in pathology studies.

Methods



Results

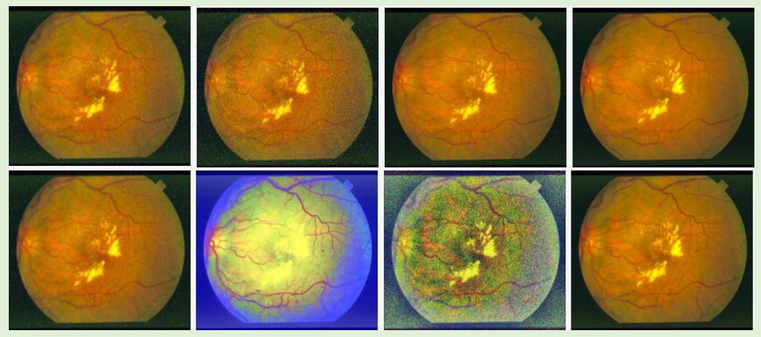
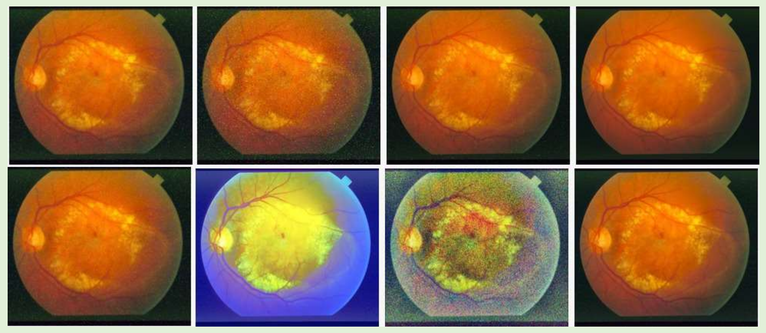


Fig.1.Original Image, Fig.2.Noisy Image, Fig.3.Gaussian filter, Fig.4.Median filter, Fig.5.Weiner filter, Fig.6.Histogram Equalization, Fig.7.CLAHE image, Fig.8.Proposed Image



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Conclusion

In this project, we compared different image enhancement techniques, including CLAHE, Gaussian, Histogram Equalization, and CLAHE, with our proposed method. The results clearly show that our method performs better in terms of image quality, clarity, and feature preservation. It achieved higher PSNR, FSM, and SSIM values, indicating better noise reduction and structural integrity. The improved entropy also suggests enhanced detail retention. Overall, the proposed method stands out as a reliable and effective approach for image enhancement, making it useful for applications where high-quality image processing is crucial.

Future Perspectives

- **Advancement in Medical Imaging:** PCA-based fusion methods can integrate with AI and deep learning to enhance medical images, improving diagnostic accuracy in retinal and histopathology images.
- **Real-Time Diagnostic Systems:** The proposed filtering and fusion approach can be optimized for real-time clinical diagnostic systems, assisting doctors with faster and more precise medical image analysis.
- **Integration with 5G Telemedicine:** Enhanced image processing techniques combined with 5G technology will enable high-quality, real-time remote diagnostics, advancing telemedicine and making healthcare more accessible worldwide.

Impact on Society

1. **Improved Medical Diagnoses** – Enhances retinal images, helping doctors detect diseases like diabetic retinopathy and glaucoma more accurately.
2. **Better Image Clarity** – Reduces noise and improves contrast, making medical images clearer for better analysis.
3. **Efficient Disease Screening** – Aids in early detection of retinal diseases, speeding up diagnosis and reducing manual effort.
4. **Enhanced Healthcare Accessibility** – Can be used in telemedicine, allowing remote diagnosis and better healthcare reach.

To know more

GitHub link: https://github.com/Bollineni-satish/Medical-Image-Enhancement-based-on-CLAHE-approach

Video link: https://drive.google.com/file/d/1wiyTy_D-j1oPOtniXtiZwymcEfzN62mj/view