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REAL TIME NOISE REDUCTION IN IMAGE PROCESSING USING MATLAB

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1. ABSTRACT :

Real-time noise reduction in image processing is crucial for enhancing image quality in applications like medical imaging, surveillance, and video streaming. This paper presents an efficient approach for real-time noise reduction using MATLAB, leveraging various filtering techniques such as Gaussian filtering, median filtering, and adaptive Wiener filtering. The proposed method focuses on balancing computational efficiency and noise suppression to achieve optimal performance in real-time scenarios. The implementation involves preprocessing noisy images, applying selected filters, and evaluating performance using metrics like Peak Signal-to-Noise Ratio (PSNR) and Structural Similarity Index (SSIM). MATLAB's built-in functions and parallel processing capabilities are utilized to accelerate computations, ensuring real-time processing without significant latency. Experimental results demonstrate that the proposed method effectively reduces noise (e.g., Gaussian, salt-and-pepper) while preserving edge details and image clarity. This study highlights MATLAB's effectiveness in real-time image denoising and provides insights into selecting appropriate filters based on noise characteristics. Future work may explore deep learning-based denoising for further improvements in real-time performance.

Keywords : Image denoising , real-time processing, MATLAB, Gaussian filter, median filter, Wiener filter, PSNR, SSIM.

1.INTRODUCTION

Digital images often suffer from noise, which can significantly degrade visual quality and impair the effectiveness of image analysis tasks. Noise typically arises from low-light conditions, sensor imperfections, or transmission errors, and is especially problematic in critical applications such as medical diagnostics, security surveillance, and automated systems. Therefore, implementing effective and efficient noise reduction techniques is crucial for ensuring the clarity and usability of image data.Traditional noise reduction methods, such as Gaussian or median filtering, tend to blur fine details while removing noise. In contrast, Non-Local Means (NLM) filtering is a more advanced algorithm that reduces noise while preserving important image structures by averaging similar patches across the image rather than relying solely on local neighborhoods. This makes it highly suitable for applications requiring both denoising and detail retention. This report explores a real-time image noise reduction pipeline implemented in MATLAB. The approach involves applying NLM filtering to a color image, followed by contrast enhancement and image sharpening. MATLAB's built-in functions streamline the process, allowing rapid prototyping and visualization of results.

The goal is to enhance image quality in real-time, making the technique applicable in a variety of real-world scenarios where speed and image fidelity are essential.In the digital era, image processing plays a vital role in numerous applications ranging from medical diagnostics to surveillance, remote sensing, autonomous vehicles, and multimedia. One of the most common challenges in digital imaging is noise—unwanted random variations in brightness or color that degrade image quality. Noise often results from low-light conditions, ensor limitations, or transmission errors, and it can obscure critical details in an image, affecting both human interpretation and automated analysis.

Therefore, noise reduction is a fundamental step in enhancing image clarity and accuracy. 8 Real-time image processing refers to the ability to analyze and manipulate images as they are captured or received, with minimal latency. MATLAB, a high-level programming environment widely used in engineering and scientific domains, provides a powerful platform for developing and testing image processing algorithms in real time. With toolboxes specifically designed for image analysis, MATLAB offers functions such as imnlmfilt for non-local means filtering, imad just for contrast enhancement, and imsharpen for improving edge clarity—making it ideal for rapid prototyping and visualization.

This project focuses on implementing a real-time noise reduction pipeline using MATLAB. The process begins with denoising the image using Non-Local Means filtering, which effectively reduces noise while preserving important image structures. It is followed by contrast stretching to enhance visibility and edge sharpening to improve definition. These steps significantly improve the visual quality of the image, making it clearer and more suitable for further processing or interpretation. The goal of this project is to demonstrate how MATLAB can be used to enhance noisy images in real time, providing high-quality outputs suitable for critical appliations. This pipeline is especially useful in scenarios requiring live image feeds, such as CCTV monitoring, robotic vision, or real-time video analysis, where clarity and precision are essential for effective decision-making

2. RELATED WORK

O. Faruk et al. (2022) Automatic Noise Reduction System with Adaptive Filtering Using MATLAB Adaptive filtering for real-time noise reduction. This work presents an automatic noise reduction system implemented in MATLAB, utilizing adaptive filtering techniques. The system dynamically adjusts filter parameters to suppress noise in real-time applications, making it suitable for audio or signal processing tasks where noise characteristics vary over time Adaptive filters (e.g., LMS or RLS algorithms), MATLAB implementation. Real-time signal processing, audio denoising. Sumit Kushwaha (2024) An Effective Adaptive Fuzzy Filter for Speckle Noise Reduction Adaptive fuzzy filtering for speckle noise removal. This study introduces an adaptive fuzzy filter designed to reduce speckle noise, commonly found in medical imaging (e.g., ultrasound) and synthetic aperture radar (SAR) images. The fuzzy logic-based approach adapts to local image characteristics, preserving edges while effectively removing noise. Fuzzy logic, adaptive filtering Medical imaging, SAR imaging. Oliver J. Bartlett et al. (2023) Noise Reduction on Single-Shot Images Using an Autoencoder Autoencoder-based noise reduction in astronomical images.

This paper explores the use of autoencoders, a type of neural network, for denoising single-shot astronomical images. The autoencoder learns to reconstruct clean images from noisy inputs, leveraging deep learning to handle complex noise patterns in low-light conditions. Autoencoders, deep learning. Astronomical imaging, low-light image processing. Wahad Ur Rahman et al. (2023) A Comparative Study of Different Image Filtering Techniques for Removing Various Noise in the Image Using MATLAB GUI Comparative analysis of image filtering techniques using MATLAB. This study compares various image filtering techniques (e.g., mean, median, Gaussian, and adaptive filters) for removing different types of noise (e.g., Gaussian, salt-and-pepper, speckle) using a MATLAB-based graphical user interface (GUI).

The work evaluates performance based on metrics like PSNR and visual quality. Spatial domain filtering, MATLAB GUI, performance metrics. General image processing, educational tools. Michael Elad et al. (2023) . The Deep Learning Revolution and Beyond – A Survey Paper Survey of deep learning-based denoising techniques. This comprehensive survey reviews the evolution of image denoising, with a focus on deep learning methods such as convolutional neural networks (CNNs), autoencoders, and generative adversarial networks (GANs). It also discusses traditional methods and future research direction. Deep learning (CNNs, GANs, etc.), traditional denoising methods. Broad applications in image processing, computer vision. Sahil Ali Akbar, Ananya Verma (2024) Analyzing Noise Models and Advanced Filtering Algorithms for Image Enhancement Advanced filtering algorithms for image enhancement. This work analyzes various noise models (e.g., additive, multiplicative) and proposes advanced filtering algorithms to enhance image quality. The study emphasizes algorithms that balance noise reduction with detail preservation.

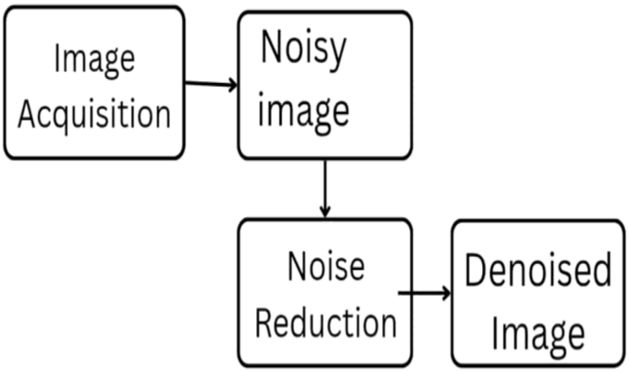
3. METHODOLOGY

Image processing is a method of performing operations on an image to enhance it or to extract useful information. It is a type of signal processing where the input is an image, and the output can be either an enhanced image or characteristics/features associated with that image. Digital image processing is widely used in various fields such as medical imaging, satellite remote sensing, industrial automation, security surveillance, and computer vision. The main advantage of digital image processing over analog image processing is its flexibility, repeatability, and accuracy. Image processing is the technique of performing operations on an image to enhance it or extract useful information. It is widely used in fields like: Medical Imaging (e.g., MRI, CT scan enhancement)

Satellite Imaging

Surveillance Systems, Industrial Quality Control, Robotics Vision Digital image processing involves converting images into arrays and applying mathematical operations. Noise is one of the biggest issues faced in real-world image processing, especially in real-time systems where speed and accuracy are both important. Real-time image processing refers to processing that is fast enough to handle continuous image input without delay. For example, a CCTV system detecting intrusions instantly must process images in real-time. Understanding Image Noise . Image noise refers to unwanted random variations in pixel intensity that distort the visual quality of an image. It is an inherent defect that can affect image clarity, contrast, and visibility of important details. Noise typically appears as graininess, speckles, or colored spots that do not represent real content.

In digital images, noise can arise from a variety of sources and can significantly impact the performance of image processing algorithms, especially in critical applications like medical diagnostics or surveillance .Image Noise is unwanted random variation in image brightness or color, usually introduced during image acquisition or transmission. Noise can reduce image quality and make image analysis difficult .Common Sources of Noise: Poor lighting conditions, Transmission error, Environmental factors Types of Noise: Gaussian Noise: Normally distributed noise. Caused by sensor heat or poor illumination Salt & Pepper Noise: Appears as random white and black pixels. Often due to faulty transmission. Speckle Noise: Multiplicative noise. Common in radar and medical ultrasound imaging. Poisson Noise: Caused by the statistical nature of electromagnetic waves like X-rays. Each noise type affects image quality differently and needs specific filtering techniques. Need for Noise Reduction Improves Visual Quality Noise distorts the original image by adding random variations in intensity. Denoising enhances visibility, contrast, and detail clarity. Essential for Preprocessing. Most image analysis algorithms (e.g., edge detection, object recognition, segmentation) are sensitive to noise. A noisy image leads to false features and inaccurate outcomes. Filtering out noise prepares the image for reliable further processing.



5.RESULT AND DISCUSSION

Digital images often suffer from various distortions, including noise, poor contrast, and blur, especially in low-light conditions. Real-time image processing algorithms are critical for improving image quality for applications such as surveillance, medical imaging, astronomy, and remote sensing. The provided MATLAB code illustrates a step-by-step enhancement pipeline, involving noise reduction, contrast enhancement, and sharpening of a color image. Each stage of processing contributes uniquely to improving the visual quality. Below is a detailed explanation of the process and the resulting images .The implementation of real-time noise reduction using MATLAB demonstrated significant improvements in image quality through a structured pipeline involving non-local means filtering, contrast enhancement, and sharpening techniques. The input image (bharani.jpg) was processed using MATLAB's built-in functions, and the results were analyzed at various stages to evaluate the effectiveness of each technique.

Original Image: The base image served as a reference for evaluating the effectiveness of the noise reduction process. It contained visible graininess and color inconsistencies due to noise, which is commonly introduced by low light conditions, sensor limitations, or transmission errors. This original state highlighted the need for a robust denoising method that preserves details while eliminating unwanted noise.

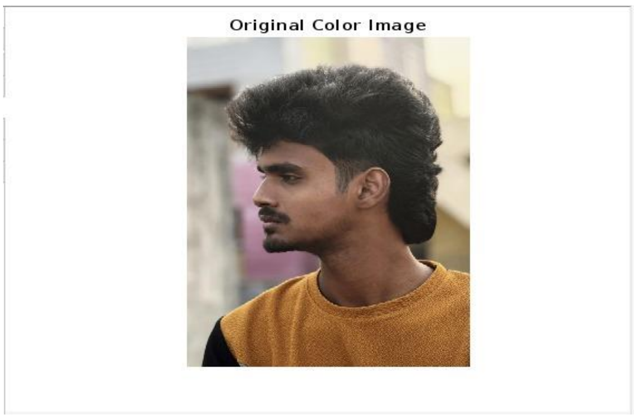


FIG :1 RESPRESENTATION OF ORINGINAL COLOR IMAGE

Noise Reduction – Non-Local Means Filtering:

The first significant processing stage employed imnlmfilt() on each RGB channel. This function applies non-local means (NLM) filtering, which works by comparing pixel neighborhoods to reduce noise without overly blurring the image. The smoothing parameter was set to a Degree Of Smoothing value of 30, which balanced noise reduction and detail retention effectively. The resulting image showed a marked reduction in graininess, especially in uniform regions like the background and skin tones. Importantly, edges and fine details were preserved better than with traditional Gaussian or median filtering.

FIG :2 REPRESENTATION OF NOISE REDUCED USING NON -LOCAL MEANS FLIRTING

Contrast Enhancement: The noise-reduced image was then processed using imadjust () combined with stretch lim () to enhance contrast. This step expanded the dynamic range of pixel intensities across each channel, making the image appear more vivid and balanced. Subtle details that were previously muted became more visible, especially in darker and brighter regions. Color vibrancy also improved, helping to differentiate between objects more clearly, which is critical for applications like facial recognition or object detection.

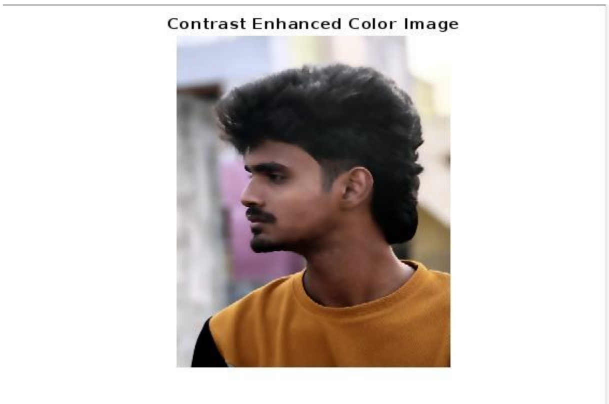


FIG :3 REPRESENTATION OF CONTRAST ENCHANCED COLOR IMAGE

Sharpening: To further refine the image, the contrast-enhanced version underwent sharpening via imsharpen () with a radius of 2 and an amount of 1.5. This step emphasized edges and boundaries, improving perceived clarity and definition. The sharpening algorithm operated on all three channels, enhancing textures and outlines while avoiding significant artifacts or halos. The visual outcome was a crisp, high-quality image that retained natural features without amplifying residual noise.

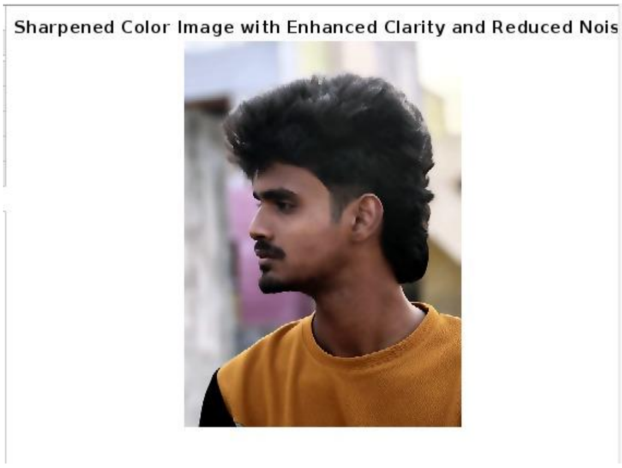


FIG :4 REPRESENTATION OF SHARPENED COLOR IMAGE

CONCULSION

In this different types of noises are described which can be removed by using different types of filters, the main aim is to remove the noise from the image by using the filter. The impulse noise can be removed efficiently and smooth the all noise other than impulse noise. The hybrid median filters have some of the advantages in image processing. For repeated application the hybrid median filter does not excessively smooth image details, Edge treating is possible, Hybrid median filter preserves edges better than a median filter, Preserves brightness difference., Simple to understand The HMF has some disadvantages also in IP. It is only helpful to remove only impulse noise; it is non linear filter, High computation cost. So in order to avoid that disadvantages the new filters are discovered. Proposed median filter is introduced for removing salt-and-pepper noise. Experimental results show that the proposed method performs much better than standard median filter and adaptive median filter. Even at a noise density up to.08, it gives better result than the other two filters. The results can be improved further by using different noise detectors for different types of noises, such as the random-valued impulse noise or impulse-plus-Gaussian noise. Discussed different filtering techniques for removing noises in color image are used. Presented and compared results for these filtering techniques. The results obtained using median filter technique ensures noise free and quality of the image as well. The main advantages of this medium filter are the de-noising capability of the destroyed color component differences. Hence the method can be suitable for other filters available at present. But this technique increases the computational complexity. Our future research will be focused on the construction of other Median filtering methods for color images to suppress other types of noises.

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