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Analysis of Wavelet Transformation Method for Image Denoising

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Abstract: *Visual information transmitted through digital images has emerged as a significant method of communication in contemporary society; however, the images often suffer from corruption due to noise during transmission. Consequently, these images require processing to achieve usability in various applications. Image denoising refers to the techniques used to manipulate image data in order to create visually high-quality images. This denoising process employs various methods, including wavelet transformation, Wiener filter, and mean filter, all of which are implemented using MATLAB. For comparative analysis of these image denoising techniques, input images such as the Barbara, Cameraman, and House images were utilized. The proposed method demonstrated superior performance compared to existing approaches, indicating its effectiveness in producing cleaner, higher-quality images.*
Keywords: *Edge detection, Wiener filter, Wavelet transformation, Image denoising, Matlab.*

1. INTRODUCTION

A significant portion of digital image processing focuses on image restoration, which encompasses both algorithm research and goal-oriented procedural application. Image restoration aims to address various degradations that occur during image acquisition, primarily caused by blurring and noise from both electronic and photometric sources. Blurring results from bandwidth reduction due to imperfect formation processes, such as when the camera moves relative to the scene or when an optical system becomes out of focus. In aerial photography, common sources of blur include atmospheric turbulence, optical aberrations, and the relative movement between the camera and the ground.

Noise presents additional challenges, arising from issues such as transmission through noisy channels, errors in the measurement process, and data quantization during digital storage. Each component of the imaging chain, including lenses, film, and digitizers, contributes to the overall degradation. Image denoising is particularly crucial in photography and publishing, where recovering degraded images before printing is necessary. Understanding the degradation process allows for the development of models that facilitate the inverse restoration process. Applications of image restoration are prominent in space exploration, where eliminating artifacts due to mechanical jitter or compensating for optical distortions is vital. Moreover, denoising is essential in fields like astronomy, where resolution limitations severely affect image quality, as well as in medical imaging, which demands high-quality images for critical analysis, and in forensic science, where damaged photographic evidence may contain vital information.

Digital images are represented as two-dimensional data arrays, denoted s(x,y), with pixel locations indicated by (x,y). The pixel values reflect the brightness at each coordinate. Common image types include binary, gray-scale, and color images. Binary images, which are composed of only two values (black and white), serve primarily in computer vision applications requiring shape or outline extraction. Gray-scale images, also known as monochrome images, lack color information and utilize eight bits per pixel, allowing for 256 distinct brightness levels, ranging from 0 (black) to 255 (white). Intermediate values from 1 to 254 represent varying shades of gray.

Color images are structured as three-band monochrome images, where each band corresponds to a different color—

most typically red, green, and blue (RGB)—with each band providing brightness data relevant to its spectral range.

2. DIGITAL IMAGE

Cloud Digital media provide numerous advantages over analog media, primarily in terms of quality and ease of manipulation. Digital audio, images, and video signals surpass their analog equivalents in quality, allowing for precise editing due to the ability to access specific discrete locations for modification. Copying digital media results in no loss of fidelity, a significant improvement over analog formats. Furthermore, digital formats can be easily displayed on computer monitors and modified as needed. Storage on devices like CD-ROMs or DVDs is straightforward, and the capability to transmit media via the internet or satellite facilitates rapid sharing. Additionally, compression options help save storage space and reduce communication times.

These advantages are especially vital in the field of medical imaging, where hospitals integrate their digital imaging systems into networks such as PACS (Picture Archiving and Communication Systems) and RIS/HIS (Radiological/Hospital Information Systems). These systems not only store images but also incorporate patient diagnosis and billing details. A two-dimensional digital image can be represented as a matrix of data U(i,j), where (i,j) identifies the pixel's location, and the pixel value indicates the brightness at that specific location.

In digital imaging, various types of images are frequently utilized, including binary, gray-scale, and color images. Binary images, the simplest form, can represent only two values: black and white, with black mapped to '0' and white to '1'. These images, often generated from gray-scale images, are essential in computer vision where shape and outline recognition are critical. Gray-scale images, alternatively known as monochrome images, consist solely of varying shades of gray, with each pixel represented by eight bits of data, allowing for 256 distinct brightness levels ranging from black to white. Consequently, these images are sometimes referred to as intensity images due to their focus on brightness representation. Lastly, color images can be viewed as three-band monochrome images, each band corresponding to a different color, providing a comprehensive representation of visual information.

3. PROPOSED WORK

As For a wavelet transform, two essential filters are employed: a low-pass filter for constructing low frequency components, and a high-pass filter for high frequency components. These filters are critical as they allow the reconstruction of the original signal through an inverse transform process that utilizes two reconstruction filters. A fundamental example is the Haar filter bank, characterized by its non-normalized low-pass filter [1, 1] and high-pass filter [1, -1]. This corresponds directly to the summation and differentiation of the signal.

A practical instance is provided using the signal [1, 7, 7, 5, 4, 8, 7, 9]. When the circular convolution with the low-pass filter is applied, it results in [8, 14, 12, 9, 12, 15, 16, 10], while the high-pass filter generates [-6, 0, 2, 1, -4, 1, -2, 8]. By discarding the odd-indexed values, the filtered low frequency and high frequency components are [8, 12, 12, 16] and [-6, 2, -4, -2], respectively. Normalization by a factor of 0.5 yields average values [4, 6, 6, 8] and half-differences [-3, 1, -2, -1]. This approach demonstrates that the original signal can be recovered from the averages and half-differences, employing the same filters [1, 1] and [1, -1].

For longer sequences, this procedure can be defined as convolution, interleaving the low and high frequency signals into [4, -3, 6, 1, 6, -2, 8, -1]. Convolution applied on these returns the original signal. The discrete wavelet transform (DWT) can be executed multiple times on low frequency components, generating high frequency representations that are downsampled, denoted as $W\psi[J - n, k]$ for high frequency coefficients, while low frequency components continue to be processed.

The reconstruction process involves upsamping the highest level low and high frequency signals by inserting zeroes, applying the respective reconstruction filters, and repeatedly combining them to achieve the original signal. This multi-level decomposition is particularly advantageous for tasks such as denoising and compression. Since noise is predominantly found in high frequency components, a stronger denoising approach can be applied here, preserving vital information found within low frequency components, which generally carry more meaningful visual data. Thus, the integrity of the images can be maintained with fewer losses when noise reduction techniques are applied selectively based on frequency levels.

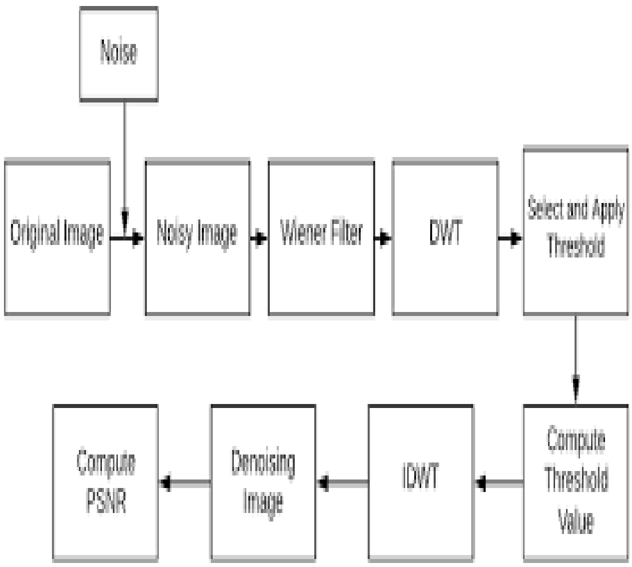

Fig 1: The present work block diagram.

4. EXPERIMENTAL RESULT

Microsoft In this section, the comparative performance of various image denoising techniques is assessed using specific performance parameters. The image denoising methods employed include wavelet transformation, Wiener filter, and mean filter, all implemented in MATLAB. The evaluation utilizes input images such as the Barbara image, Cameraman image, and House image, among others, to measure the effectiveness of these denoising techniques.

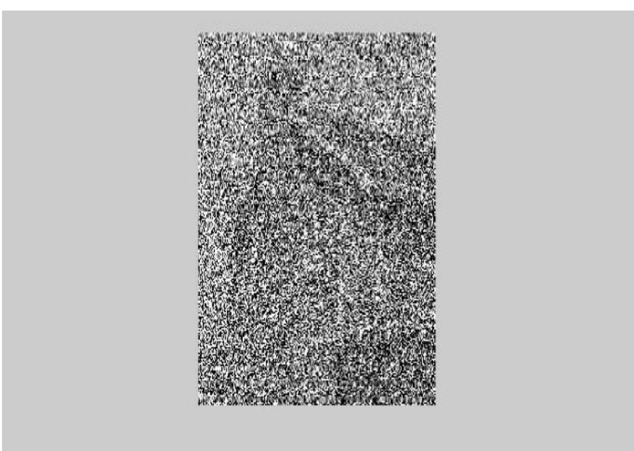

Fig 2: This picture presents the house processing image for experimental work using mean filter technique.

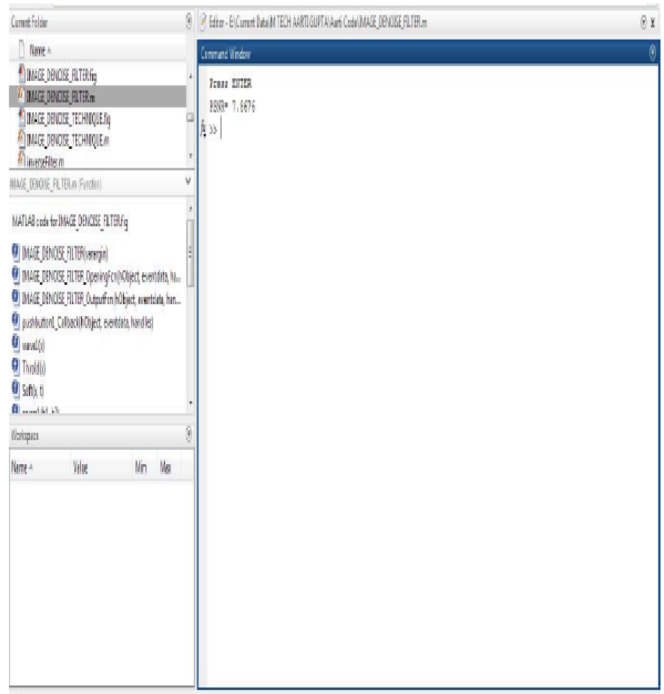

Fig 3: This picture presents the result of house processing image using mean filter technique with PSNR value.

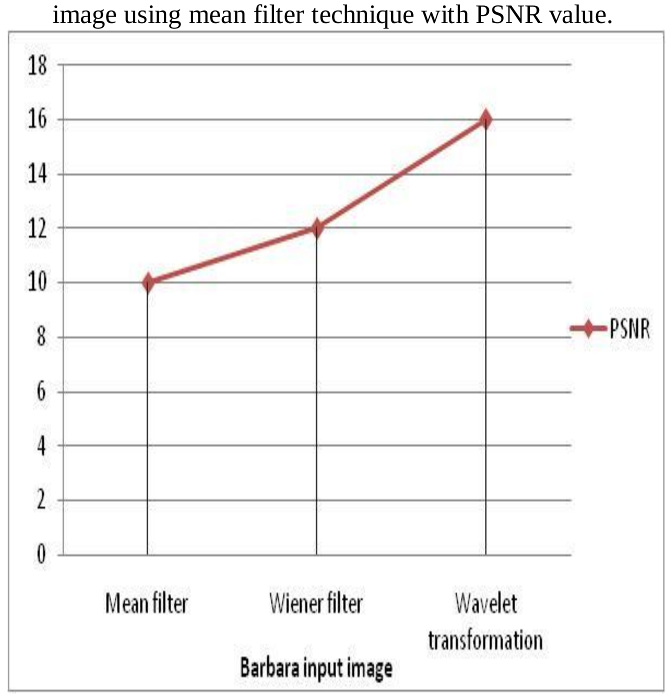

Fig 4: The above figure shows the comparative study between the image denoising techniques with barbara input image.

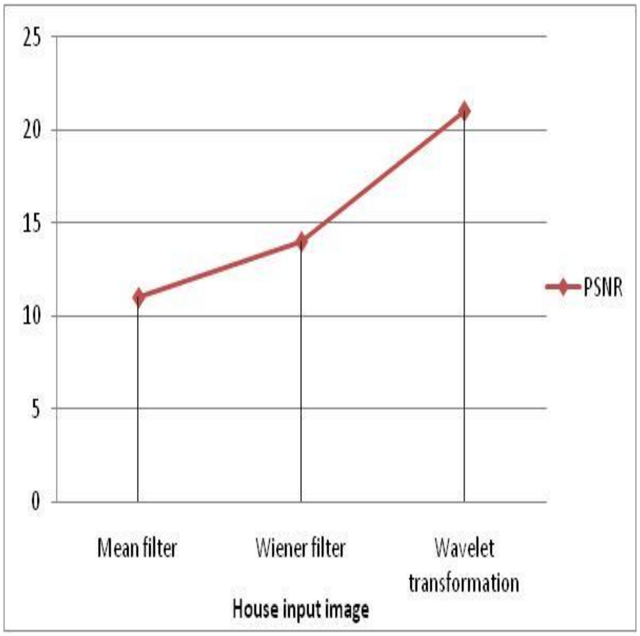

Fig 5: The above figure shows the comparative study between the image denoising techniques with house input image.

5. CONCLUSION

Image de-noising is a critical process utilized across various domains, including astronomy, where high-resolution imaging is essential, medical imaging, which demands high-quality visuals to analyze specific events, and forensic science, where the quality of photographic evidence may often be subpar. This dissertation evaluates and compares the performance of several image denoising techniques, specifically focusing on wavelet transformation, Wiener filter, and mean filter, with the performance assessed through specific parameters. The methods were implemented using MATLAB on input images such as the Barbara image, Cameraman image, and House image. The findings indicate that the presented techniques yield superior results compared to existing methodologies, highlighting advances in image denoising for diverse applications.

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