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An Improved Feature Extraction Model for Retrieval Images from Various Noise Image Sources by the Environmental Effects

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ABSTRACT: The purpose of image processing is to transform an image into various digital forms using multiple procedures and to get an improved appearance or retrieval image from different sorts of image sources, such as space probes, satellites, and photos in a day-to-day environment application development with trustworthy data presentation under adverse weather conditions, such as rain, snow, and fog. Diverse aspects, such as ecological situations during the picture selection and the quality of sensing elements themselves, change the efficiency of imaging sensors. This paper proposes an improved new algorithm model to extract images from various noisy image sources and characterize the haze and fog effects for different targets.

Key Words: WImage enhancement, haze, snow, PSNR, MSE, optic sensors, SDME.

Contents

1. Introduction

The public's attention has recently been drawn to the development of driverless automobiles and sophisticated driver support technologies [1]. One of the toughest challenges in developing unmanned vehicles and advanced driver assistance services operate in unpredicted climate conditions [2], such as rain, snow, and fog. Nevertheless, there is yet to be a study that gives a thorough and consistent analysis of the weather's impact on a variety of types of sensors used in autonomous vehicle [3].

Many outdoor computer vision applications benefit from improved visibility, contrast, and features of images/ video taken in unpredicted climate, such as video surveillance, long-range object discovery, tracking and recognition, self-navigating ground, air-based vision systems and so on. The internment scenes usually suffer from unfortunate visibility, contrast, and hazy color in unfavorable weather situations like haze and fog. Because haze and fog thickness is associated with scene depth, traditional image and contrast enhancement processes [16] function well for specific scenes but are unsuccessful for images with varied depth areas. In these adverse weather settings, obtaining a correct thickness of haze/fog since a simple picture is still a difficult operation, but the accurate virtual thickness of haze/fog is acquired from low incidence details of the scene. The future method transforms the luminance image into a hazy intensity image using a nonlinear function. We apply a haze/fog development model to obtain a haze-free image.

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Here exist numerous systems accessible for image handling based on Machine Learning [4], Edge Enhancement techniques [5], Region-based techniques, Statistical models [6], etc. However, these models generate less directional selectivity and possess less invariance. This indirectly reduces the clarity of the output images, and the impact of the outputs [7] can be better understood using medicinal images and Synthetic Aperture Radar (SAR) images.

In this Paper, several existing literature works on image de-noising are presented [8], [9], [10]. Based on this review of literature works it has been shown that there is a need for better image denoising scheme with improved performance in terms of performance measures. Thus, this survey of literature works has given a perceptive thought for the implementation of the proposed algorithms. Therefore, to overcome this disadvantage in this current work [11], we have proposed Fog Rectification based proposed Algorithm for image denoising.

For instance, the acquisition by a camera of CCD pictures significantly affects the measure of commotion in the subsequent picture, light levels, and sensor temperature. Pictures are fundamentally disabled during transmission by an obstruction in the transmission channel. For example, a picture sent through a remote organization could be harmed because of lightning or different aggravations of the environment. The processing of images is a challenge because they can generate objects and lead to extreme blurring of the image de-blurring Image envisioning [12] is important to boost the noise-impaired quality and structure of the original Image [13]. The main processes in different applications for the digital image processing [32], such as biomedicine, photography, etc., are to improve image and to remove noise. These two processing steps are essential to the processing of images during the visual perception process. For noise level assessment in different parts of the images, various algorithms are accurate. The detailed approaches to illumination use the photo real quality to produce a synthetic image. These approaches are based entirely on stochastic paths created by each pixel in the image.

In the past, higher levels were used to process images primarily to eliminate further image noise [14], [32]. These filters can preserve the edge information while eliminating noise. However, there is a risk of losing the desired data in this procedure, which is the fundamental weakness of linear filters. In comparison the nonlinear filters are for edge maintenance without any data loss. The images are generally altered by noise mainly because of the shortcoming of camera points. In general, noise is defined in two forms: random shot clamor and "Salt and Pepper noise". A random value of the noisy pixels can be given during the estimation of random valued shot noise. Whereas the sound pixels are only given minimal and maximal values in relation to the neighbor pixels in the estimate of Salt Pepper noise. Therefore, using linear filters to eliminate these forms of noise is a difficult task. This difficulty can be overcome by employing Fuzzy Set (FS) established filters, which are used to inspect the pixel variations in the spatial domain by applying a fuzzy rule set [32], [15].

Numerical and visual tests can help the measurement of the output of classic and fogging filters both for impulses and Gaussian noise. We will also research, inter alia, whether fuzzy filters work better than traditional filters and whether great mathematical outcomes are affirmed with acceptable visual outcomes.

Fog, haze and smoke are major causes of accidents in the transportation industry. Fog diminishes the image contrast level, lowering the image's visual quality [24]. Air lightweight and attenuation phenomena afflict the infield of computer vision, visual quality and visibility level of a picture [34]. Noise or unintended signal between viewer and object is affected by air particles that exist in the atmosphere and influence the visual level of any entity. Various image enhancement techniques are used to improve a picture's visibility and eliminate hazy noise [17]- [22]. The enhanced image is then restored using restoration techniques after the enhancement procedure is completed. This Paper is trying to implement an embedded optic flow device for UAV application through projected algorithmic rule (Digital Image Processing).

2. Objectives

The following are the current study attributes:

- To achieve the most accurate image denoising results.
- To identify various noise levels and/or other relevant information in digital images with the most efficient denoising mechanism.

- To develop a new hybrid de-noising approach.
- To improve an efficient "Image Noise Estimation Technique Using Fog Rectification based Proposed Algorithm".
- To compute the image performance measures like MSE, Noise variance, PSNR, Structural Similarity Index Metric and second derivative like a measure of enhancement, in order to endorse the improvement of various developed techniques.

3. Image Quality Metrics

The processed images in this study were quantitatively evaluated using four standard [25], [26] full-reference image quality metrics: Mean Square Error (MSE), Peak Signal-to-Noise Ratio (PSNR), Structural Similarity Index Metric (SSIM) [27], and the Second-Derivative-like Measure of Enhancement (SDME) [28] and metric functions:

- MSE and PSNR provide straightforward, error-based measures of image fidelity.
- SSIM offers a perceptually-motivated evaluation by considering changes in luminance, contrast, and structural information, aligning more closely with human visual perception.
- SDME, which quantifies local contrast improvement using second-derivative energy, is particularly suited for enhancement-oriented applications.

3.1. Peak Signal-to-Noise Ratio (PSNR)

PSNR is the ratio between a signal maximum power and the power of noise corruption that affects image security. It is known as the ratio of maximum signal power to the power of noise corruption that affects image security. The logarithmic decibel scale of PSNR is usually expressed since several signals have a huge dynamic range.
For a given image I, PSNR can be expressed as

$$\mathrm{PSNR} = 10 \cdot \log_{10}\left(\frac{I_{\mathrm{Max}}^2}{\mathrm{MSE}}\right) \tag{3.1}$$

where, I_{Max} is the maximum possible pixel value of the image. MSE means mean square error.

3.2. Mean Square Error (MSE)

MSE is a calculation of the estimator's mean squared variance. The average square difference between the expected value and the actual value can be defined. It is always non-negative; minimum MSE value (i.e., closer to zero) is desired. Generally, MSE can be expressed as,

$$\mathrm{MSE} = E[(X - \mu)^2] \tag{3.2}$$

$$\mathrm{MSE} = (\frac{\sigma^2}{n}) \tag{3.3}$$

where, μ is the mean, and σ^2 is the variance. For a given reference image I_{ref} and a test image I, both of size M x N, the PSNR and MSE can be defined as:

$$PSNR(I, I_{\mathrm{ref}}) = 10 \cdot \log_{10}\left(\frac{I_{\mathrm{Maximum}}^2}{MSE(I, I_{\mathrm{ref}})}\right) \tag{3.4}$$

$$MSE(I, I_{\mathrm{ref}}) = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}(I - I_{\mathrm{ref}})^2 \tag{3.5}$$

When the MSE reaches zero, the PSNR value becomes the maximum, implying that a greater PSNR value equals better image quality. However, a smaller the PSNR value means that images vary by high numbers i.e., a high MSE.

3.3. Structural Similarity Index Metric (SSIM)

SSIM is another important measurement of the similarity of the two images. It is calculated as a correlation to the human visual system (HVS) perception of consistency. The SSIM describes any image distortion as a combination of three elements, such as correlation loss, light distortion and contrast distortion, rather than utilizing traditional error summation approaches. The SSIM can be represented as:
The Structural Similarity Index Measure (SSIM) between a test image I and a reference image I_{ref} is typically decomposed into three comparison functions: luminance (l), contrast (c), and structure (s).

$$SSIM(I, I_{\text{ref}}) = l(I, I_{\text{ref}})c(I, I_{\text{ref}})s(I, I_{\text{ref}}) \tag{3.6}$$

The light comparison function $l(I, I_{\text{ref}})$ in this scenario assesses the similarity of two pictures with mean μ_I and μ_{ref}, respectively. The maximum value of luminance is equal to 1 only if $\mu_I = \mu_{\text{ref}}$. It is expressed as

$$l(I, I_{\text{ref}}) = \frac{2\mu_I \mu_{\text{ref}} + C_1}{\mu_I^2 + \mu_{\text{ref}}^2 + C_1} \tag{3.7}$$

The term $c(I, I_{\text{ref}})$ is the contrast assessment function that calculates the intimacy of the contrast of the two images having standard deviations σ_I and σ_{ref} respectively. The maximum value for this expression is equal to 1 only if $\sigma_I = \sigma_{\text{ref}}$. It can be expressed as

$$c(I, I_{\text{ref}}) = \frac{2\sigma_I \sigma_{\text{ref}} + C_2}{\sigma_I^2 + \sigma_{\text{ref}}^2 + C_2} \tag{3.8}$$

The structural similarity function, $s(I, I_{\text{ref}})$, estimates the numerical correlation coefficient between images I and I_{ref}. It can be expressed as

$$s(I, I_{\text{ref}}) = \frac{\sigma_{I,I_{\text{ref}}} + C_3}{\sigma_I \sigma_{\text{ref}} + C_3} \tag{3.9}$$

where the term $\sigma_{I,I_{\text{ref}}}$ is the covariance between the images I and I_{ref}. The positive SSIM index values are in the range $[0, 1]$, where 0 indicates that there is no correlation between pictures and 1 indicates that $I = I_{\text{ref}}$. To avoid a null denominator, the positive constants C_1, C_2 and C_3 are used.

As the picture quality evaluation is essential, there are no clear criteria for picking the best SSIM or PSNR values. In official views and trust are also the ways the numerical values that are obtained during the assessment process are viewed.

3.4. Second Derivative like Measure and Enhancement (SDME)

An improved measure such as the second derivative [26] is a measure for visual operator [29] and image quality assessment [30]–[31]. This visual operator can be viewed as a second derivative analog of the Michelson ratio scale. Suppose image I is divided into $a_1 \times a_2$ blocks, and $B_{max,,j,i}$, $B_{min,,j,i}$ are the maximum and minimum values of the pixels in each block separately, and $B_{cen,j,i}$ is the intensity of the center pixel in each block, then SDME is defined by the equation:

$$\text{SDME} = \sum_{i=1}^{a_1} \sum_{j=1}^{a_2} \left| \frac{B_{\max,j,i} - B_{\text{cen},j,i} + B_{\min,j,i}}{B_{\max,j,i} + B_{\text{cen},j,i} + B_{\min,j,i}} \right| \tag{3.10}$$

By definition, SDME serves as a close and sensitive variable identifier for exploitation. Depth dissimilarities have led to neighboring pixels of sharp photographs when blurring takes vicinity. In preference to the use of direct contrast among the center pixel and its neighborhood pixel, SDME uses sequence information, including $B_{\max}$ and $B_{\min}$, to express the adequacy of the difference compared to using a direct comparison between the central pixel and its neighbors. For the digital spinoff spatial differentiation filters, the weights are $[1\ -2\ 1]$, and the change in this weight is made in the code of the SDME evaluation using the correct order and the weight of the main image pixels ($B_{\max}$) and the change in this weight is made in the code of the SDME evaluation using the correct order and the weight of the main image pixels ($B_{\max}$), B_{cen} is -2 and $B_{\min}$ is 1. The SDME is pretty in detail associated with the sharpness and comparison of the nearby vicinity.

4. Proposed Method for Fog Rectification

Figure. 1 illustrates a flow chart for the Fog Rectification Method's noise estimation algorithm. This algorithm takes a noisy input image and uses an efficient filter to eliminate the noise. Using a distinct set of chromosomes, we get a noise-free image and evaluate the system's performance. Here, the authors employ the genetic algorithm in a step-by-step procedure.

Fog refinement is a critical preprocessing step for applications in autonomous driving and sighted. Pictures captured in foggy, noisy and hazy conditions have invisibility and poor distinction. These environments will cause poor vehicle performance. Fog rectification improves the standard of the input pictures and visibility level.

We improve the visibility of foggy input images, and the algorithmic program accomplishes fog removal and contrast enhancement. The flowchart shows the steps by step of algorithmic operations.

Improve the images by fog removal, and the algorithmic process estimates the dark channel of the image, calculates the air insubstantial map supported by the dark channel, and optimizes the air lightweight map by perception filters. The restoration stage creates a defogged image by extracting the developed air insubstantial map from the input image. The contrast enhancement stage evaluates the variety of intensity values within the image. It uses contrast stretching to broaden the variety of weights and create options that stand out a lot of visibility.

5. Results and Discussions

This article includes a genetic algorithm based fog correction technique, which is analyzed on different images with different noise levels and different parameters. The results conclude that noise estimation using the proposed method is more effective in terms of measures such as MSE, PSNR and SSIM values compared to other available method.

Figure 3 shows histograms of noisy and noise free images. Peak values were optimized using MATLAB with the support of practical algorithms. The results produced by the relevant tests can be obtained through good study. If an image quality measurement application is used, the Excel file containing the results is in the desired format for processing. After loading the original and distorted images, the main operation with all parameters adjusted in the section is shown in the results below.

Table 1: Image Quality Metrics Parameters for Proposed Algorithm Output Image

Noise Power	**MSE**	**PSNR**	**SSIM**	**Estimated Noise**
0.1	29.6085	33.4166	0.8908	1545.00
0.01	26.8276	33.8449	0.8961	82.9960
0.02	26.9234	33.8295	0.8957	331.663
0.03	27.1045	33.8003	0.8952	490.885
0.04	27.2395	33.7788	0.8949	642.006
0.05	27.4199	33.7501	0.8945	778.026

Table 2: Image Quality Metrics for Existing Noisy Input Image

Noise Power	**MSE**	**PSNR**	**SSIM**	**Estimated Noise**
0.1	30.4513	33.2947	0.8873	1558.7801
0.01	28.5820	33.5698	0.8907	89.3799
0.02	27.8256	33.6863	0.8925	342.6904
0.03	28.0873	33.6456	0.8916	495.2931
0.04	28.2548	33.6198	0.8914	651.9830
0.05	29.4868	33.4345	0.8887	786.3164

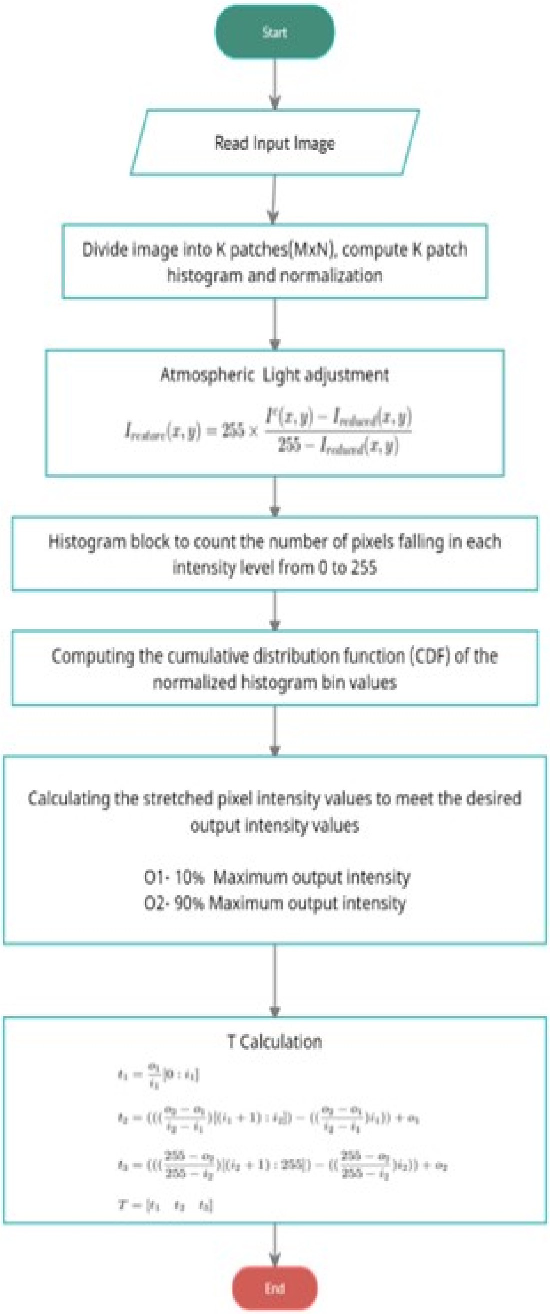

Figure 1: The flowchart of the proposed algorithm using Fog Rectification.

Figure 2: The proposed technique employed the noisy image as input for de-noising and the proposed approach denoised the image.

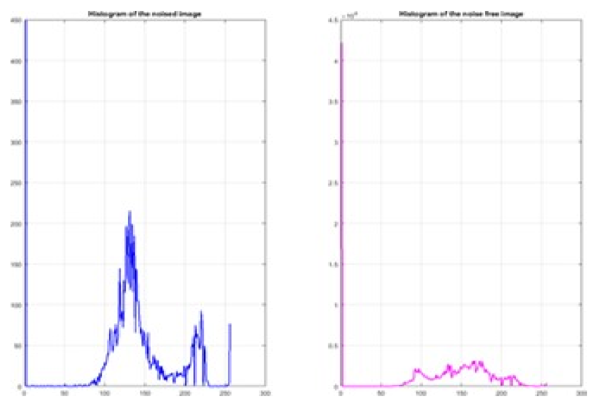

Figure 3: Histogram of the Noised Image and Noise Free (De-noised) Image

Figure 4: Noise estimation at noise power is 0.1

Figure 5: Noise estimation at noise power 0.2

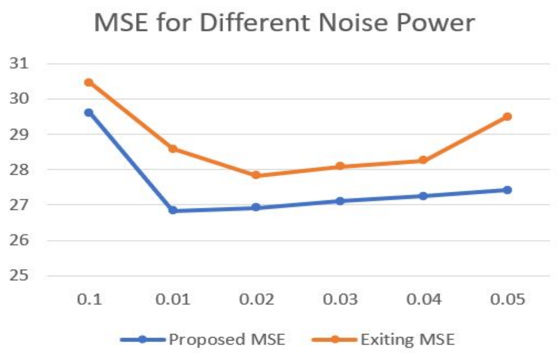

Figure 6: Evaluation of MSE Value

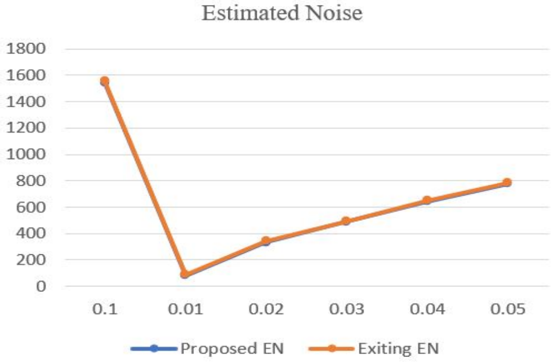

Figure 7: Comparison of Variance Value

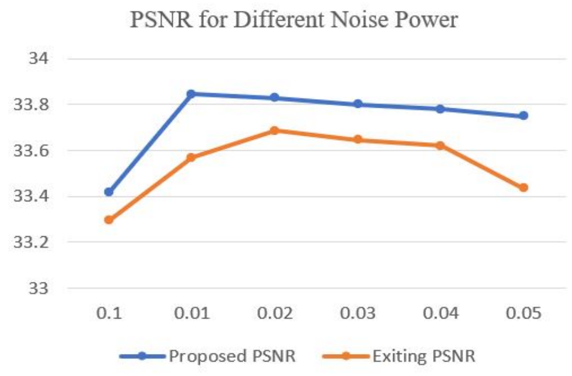

Figure 8: Comparison of PSNR Value

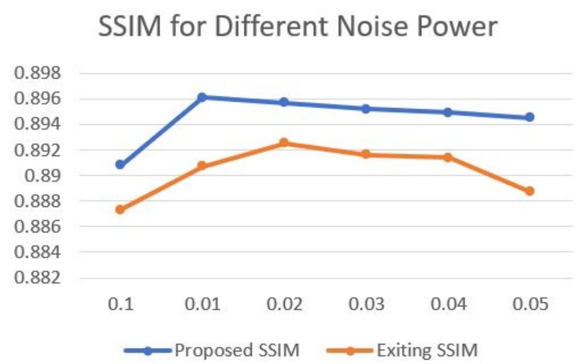

Figure 9: Comparison of SSIM Value

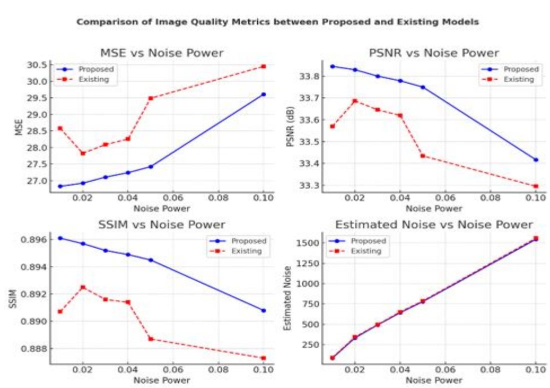

Figure 10: Comparison of Image Metrics between Proposed and existing Methods

Table 3: Comparison of MSE v/s Noise Power

Noise Power	MSE (Proposed)	MSE (Existing)
0.01	26.8276	28.5820
0.02	26.9234	27.8256
0.03	27.1045	28.0873
0.04	27.2395	28.2548
0.05	27.4199	29.4868
0.10	29.6085	30.4513

Table 4: Comparison of PSNR v/s Noise Power

Noise Power	PSNR (Proposed)	PSNR (Existing)
0.01	33.8449	33.5698
0.02	33.8295	33.6863
0.03	33.8003	33.6456
0.04	33.7788	33.6198
0.05	33.7501	33.4345
0.10	33.4166	33.2947

Table 5: Comparison of SSIM v/s Noise Power

Noise Power	SSIM (Proposed)	SSIM (Existing)
0.01	0.8961	0.8907
0.02	0.8957	0.8925
0.03	0.8952	0.8916
0.04	0.8949	0.8914
0.05	0.8945	0.8887
0.10	0.8908	0.8873

Table 6: Comparison of SSIM v/s Noise Power

Noise Power	Estimated Noise (Proposed)	Estimated Noise (Existing)
0.01	82.9960	89.3799
0.02	331.663	342.6904
0.03	490.885	495.2931
0.04	642.006	651.9830
0.05	778.026	786.3164
0.10	1545.00	1558.7801

The overall performance is shown in Figure 6, 7, 8 and 9. Compared to existing methods, the proposed MSE value and estimated noise are small as shown in Figure 6 and Figure 7. also, the PSNR value and SSIM value of the this method increase compared to the current method as shown in Figure 8 and Figure 9.

The Comparative data for the Proposed and Existing Models are presented in the tables below. These comparisons quantify performance differences across four critical metrics—MSE, PSNR, SSIM, and Estimated Noise—relative to variations in Noise Power. The comparative plots presented in Figure 10 illustrate the performance of the Proposed Fog Rectification–based Hybrid Denoising Algorithm versus the Existing Model across a range of noise power levels.

From the Figure 10 MSE vs Noise Power graph demonstrates that the proposed model consistently yields lower error values than the existing approach. This signifies superior noise suppression and enhanced image reconstruction accuracy. Correspondingly, the PSNR vs Noise Power results show that the proposed model maintains slightly higher values (above 33.7dB at all tested noise levels, confirming its improved image fidelity. For perceptual quality, the SSIM vs Noise Power curve for the proposed algorithm exhibits minimal variation and remains higher (≈ 0.895) than the existing model (≈ 0.891). This outcome demonstrates a stronger preservation of structural and textural details. The Estimated Noise vs Noise Power trend confirms that the proposed method effectively identifies and corrects noise components, showing a stable and nearly linear relationship with the increasing environmental noise levels.

6. CONCLUSION

This work proposed an Improved Feature Extraction Model for Image Retrieval from environmentally degraded noisy sources using a Fog Rectification–based Hybrid Denoising Algorithm. Through systematic experimentation, the model demonstrated superior performance in terms of quantitative and perceptual image quality. Lower MSE and higher PSNR values indicate minimized distortion and better reconstruction accuracy. Enhanced SSIM confirms improved preservation of texture and structure, while consistent noise estimation validates the model's adaptability across varying environmental noise levels.

Acknowledgments

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