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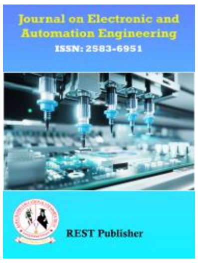

Illumination Map-Based Enhancement for lowlight Images

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Abstract: *Low-light images often suffer from poor visibility, which impacts their visual quality and hinders various computer vision applications. This paper presents an improved low-light image enhancement model aimed at increasing the Peak Signal-to-Noise Ratio (PSNR) by integrating advanced image enhancement techniques, specifically Image Adjustment and Histogram Equalization. The proposed approach first utilizes the LIME (Low-light Image Enhancement) method, which estimates illumination by extracting maximum intensity from RGB channels and refines the illumination map using a structure-prior-based regularization technique. Guided filtering is applied to achieve smooth illumination adjustments, followed by gamma correction and local adaptation using kernel filtering. Additionally, BM3D denoising is employed to suppress noise, enhancing image clarity. To further improve the enhancement quality, Image Adjustment and Histogram Equalization are introduced, effectively boosting contrast and brightness. Experimental evaluation using PSNR, Mean Squared Error (MSE), and Correlation Coefficient demonstrates that the enhanced model achieves superior visual quality and higher PSNR compared to the base model. This integrated approach proves effective in real-world low-light image enhancement applications.*

Keywords: *Image Processing Steps, Enhancement, luminance map and PSNR.*

1. INTRODUCTION

Images obtained under low-light conditions tend to exhibit characteristics such as low grey levels, high noise levels, and indistinguishable details. Image degradation not only affects recognition but also influences the performance of computer vision systems. The low-light image enhancement algorithm based on the dark channel prior de-hazing technique effectively enhances image contrast and highlights details. However, this technique neglects the effects of noise, leading to significant noise amplification after the enhancement process. In this study, ade-hazing-basedsimultaneousenhancementandnoisereductionalgorithmisproposedby analysing the essence of the dark channel prior de-hazing technique and bilateral filter. First, the initial parameters of the hazy image model are estimated using the de-hazing technique. Then, the parameters of the hazy image model are corrected alternately using an iterative joint bilateral filter. Experimental results indicate that the proposed algorithm can simultaneously enhance low-light images and reduce noise effectively. The algorithm also performs well compared to current communism age enhancement and noise reduction algorithms in terms of subjective visual effects and objective quality assessments. Retinex theory significantly contributes to enhancing dark or low-lit images. The Retime Image Enhancement Algorithm is an automatic method that improves digital images through dynamic range compression, colour independence from the spectral distribution of scene illumination. Images enhanced by this algorithm closely resemble those perceived by the human visual system under varying lighting conditions, outer forming other methods. Comparison so techniques show that Multi-Scale Retime with Colour Restoration (MSRCR) produces better results than Single Scale Retime (SSR), Multi-Scale Retime (MSR), or homomorphic filtering. Histogram equalization is another method used to improve contrast in areas with low contrast by spreading out frequent intensity values. For example, in digital X-rays, varying colours help physicians differentiate densities such as bone or air. In medical imaging, his tog Rame equalization enhances contrast to accurately delineate lesions or objects of interest, especially when structures overlap. Contrast enhancement in color images improves human perception and input quality for image processing techniques. Poor illumination during image capture often results in darker images with low contrast, requiring enhancement to match human observation of scenes. Techniques such as histogram equalization, homomorphic filtering, Retinex algorithms, and adaptive histogram equalization are essential for recovering useful information from degraded images.

FIGURE 1. low light images

FIGURE 2. Enhanced image

Retinex algorithms are inspired by human vision mechanisms for adjusting to lighting conditions. Derived from retina (eye) and cortex (brain), these algorithms enhance visual appearance through dynamic range compression, color rendition, and color constancy—the ability to perceive consistent colors under varying illumination conditions. For instance, an orange appears orange under both white afternoon light and red sunset light due to this constancy. Retinex algorithms mimic this feature while improving image quality better than other methods.

2. LITERA TURE SURVEY

D. Oneata, J. Revaud, J. Verbeek, and C. Schmid [1] proposed spatio-temporal action detection using unsupervised region proposals. Their method reduces computational cost by generating motion-based detection hypotheses, enabling efficient video analysis. By leveraging appearance and motion cues, it improves detection accuracy while maintaining real-time performance, benefiting surveillance and activity recognition. E. Pisano, S. Zong, B. Hemminger, M. DeLuce, J. Maria, E. Johnston, K. Muller, P. Braeuning, and S. Pizer [2] studied CLAHE's impact on detecting mammogram spiculations. Testing various clip levels and region sizes, they found CLAHE enhances spiculation visibility in dense breast tissue. This aids early malignancy detection, proving CLAHE's value in medical imaging preprocessing. Celik and T. Tjahjadi [3] proposed a contrast enhancement algorithm using 2D histograms and interpixel relationships. By mapping input histograms to smoothed targets, it preserves details while improving contrast. Evaluations show superior performance over existing methods, making it efficient for real-world applications. Xiaojie Guo, Yu Li, Haibin Ling [4] proposed a low-light enhancement method combining illumination estimation (using max RGB values) with structure-preserving regularization. The approach employs guided filtering for transmission map refinement, gamma correction for luminance adjustment, and BM3D denoising. Evaluated using PSNR/SSIM/LOE metrics, it effectively enhances brightness while preventing over-enhancement and noise amplification. The technique proves valuable for medical imaging, surveillance, and photography in challenging lighting conditions, delivering natural-looking results. K. Zhang et al. [5] introduced real-time compressive tracking, leveraging compressed sensing for efficient object tracking. Their method reduces computational costs by using sparse random measurements, enabling robust performance in dynamic scenes. It effectively handles occlusions and illumination variations while maintaining real-time processing speeds, making it suitable for surveillance and autonomous systems. H. Cheng & X. Shi [6] proposed a simplified histogram equalization (HE) technique for fast image enhancement. By optimizing the traditional HE processes, their method minimizes computational complexity while improving brightness and contrast. This approach avoids over-enhancement artifacts, making it ideal for real-time applications where speed and quality are critical. M. Abdullah-Al-Wadud et al. [7] developed dynamic histogram equalization (DHE), which adaptively adjusts intensity levels to prevent excessive contrast distortion. Unlike conventional HE, DHE preserves local details while enhancing global contrast, particularly in non-uniformly illuminated images. This results in more natural and visually appealing enhancements. C. Lee & C. Kim [8] introduced layered difference representation (LDR) for contrast enhancement. Their method decomposes images into multiple layers, refining details without amplifying noise. LDR effectively balances dark and bright regions, producing high-quality results with improved visibility and minimal artifacts. E. Land and D. Jobson et al. [9] pioneered Retinex-based methods, bridging human vision and image processing. Their work focuses on color constancy and dynamic range enhancement, simulating how the human eye perceives scenes under varying lighting. Jobson's refinements made Retinex practical for digital images, improving realism in low-light conditions. S. Wang et al. [10] proposed naturalness-preserved algorithms for uneven illumination correction. Their approach combines adaptive gamma correction with detail enhancement, ensuring visually natural results without overexposure or loss of texture. This method is particularly effective for images with mixed lighting conditions

3. PROPOSEDSYSTEM

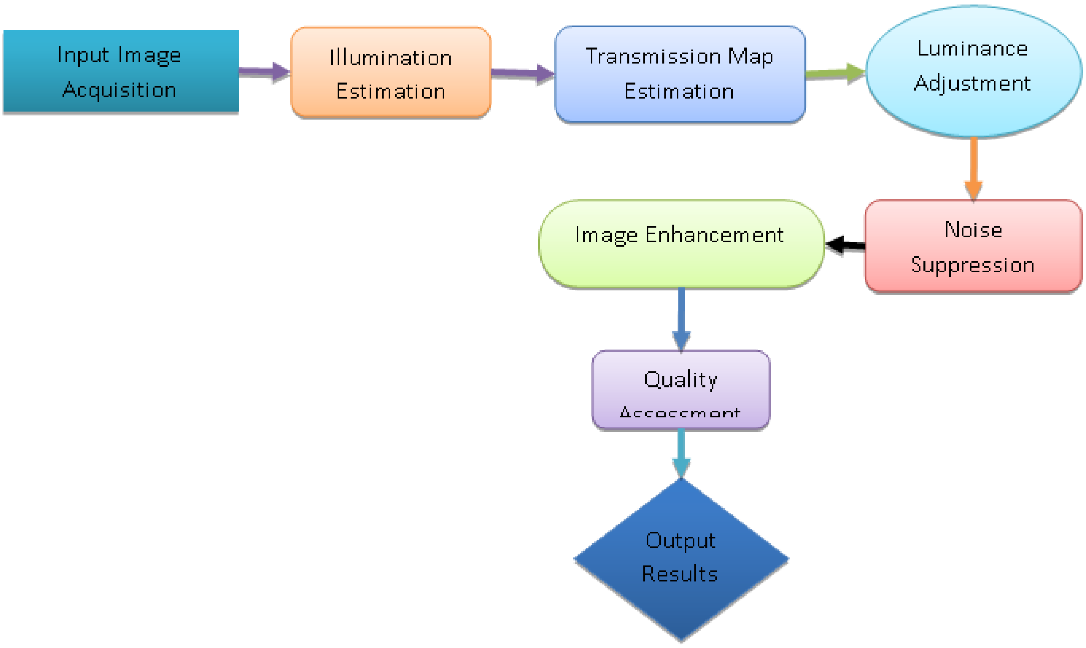

FIGURE 3. Block diagram of Proposed System.

The proposed methodology focuses on enhancing the Peak Signal-to-Noise Ratio (PSNR) of a base low-light image enhancement model by integrating additional image enhancement techniques, specifically Image Adjustment and Histogram Equalization. Initially, the input image is resized to a standard 256x256 dimension, ensuring consistency in processing. The illumination map is estimated by extracting maximum intensity values from the R, G, and B channels. The transmission map is then refined using guided filtering to achieve smooth illumination adjustments. Gamma correction is applied to enhance luminance, and local adaptation is conducted using kernel filtering. To further improve image clarity, BM3D denoising is employed, effectively reducing noise while preserving structural details. Image Adjustment is performed using contrast stretching, enhancing brightness and contrast. Subsequently, Histogram Equalization is applied to each color channel (R, G, and B) independently, balancing the intensity distribution and improving visual quality. The enhanced image is evaluated using performance metrics such as PSNR, Mean Squared Error (MSE), and Correlation Coefficient, confirming the effectiveness of the proposed enhancement techniques. By integrating Image Adjustment and Histogram Equalization, the methodology significantly improves PSNR, resulting in superior visual quality and enhanced contrast for low-light images, thus optimizing the overall image enhancement process

4. RESULTS

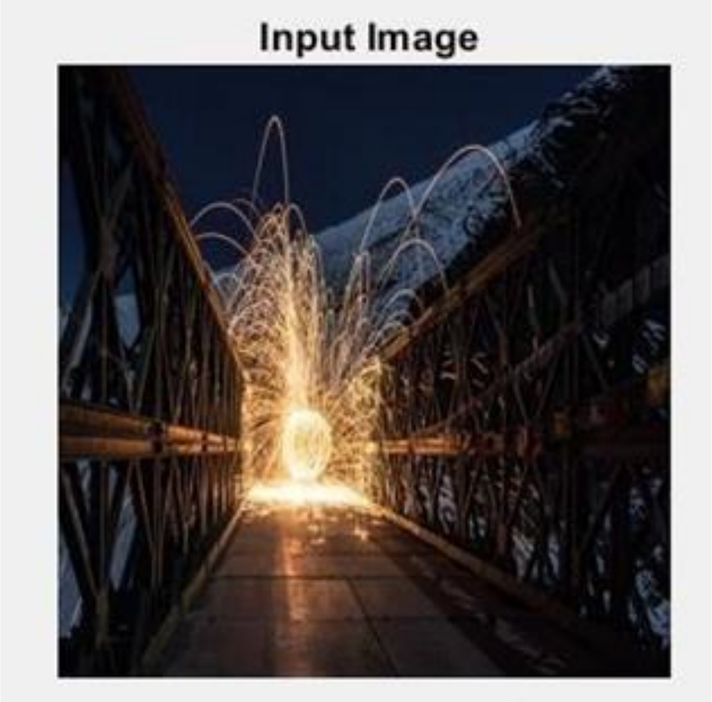

FIGURE 4. Input Image

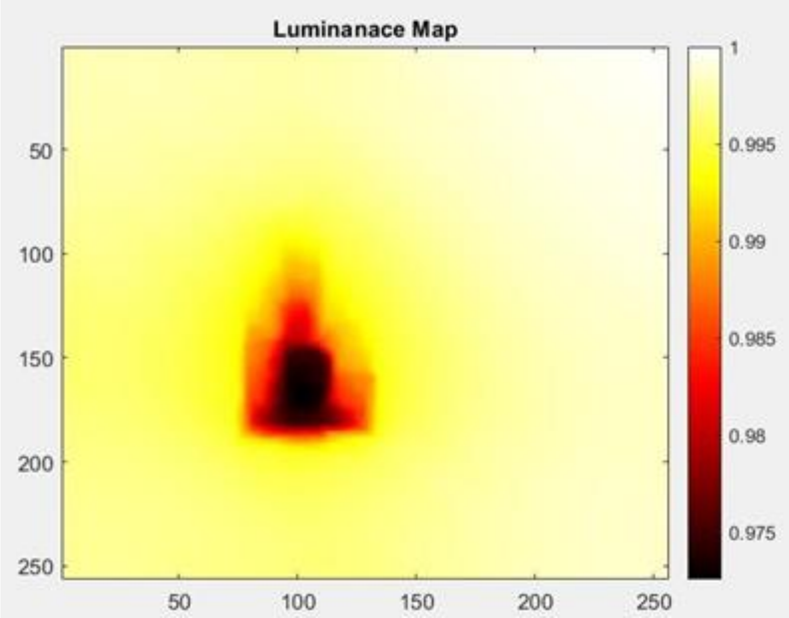

FIGURE 5. Luminance Map

Fig.6:Globalcontrastestimation

FIGURE 6.

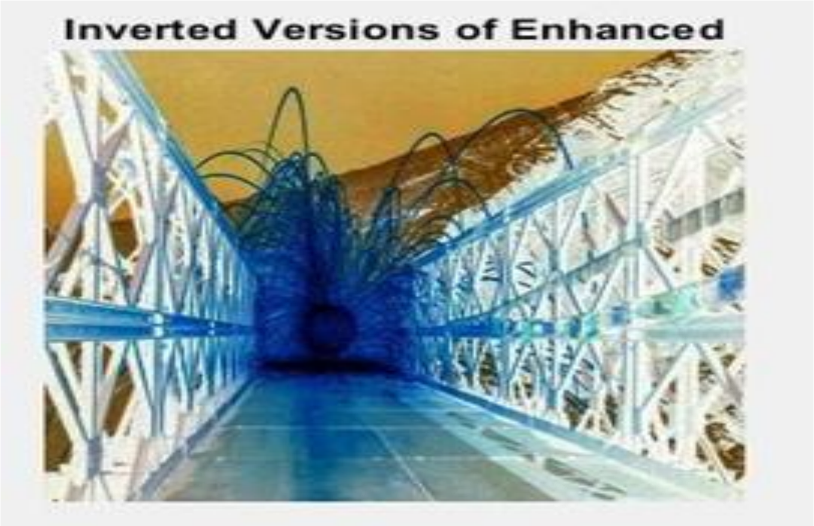

FIGURE 7. Inverted Version of Enhanced

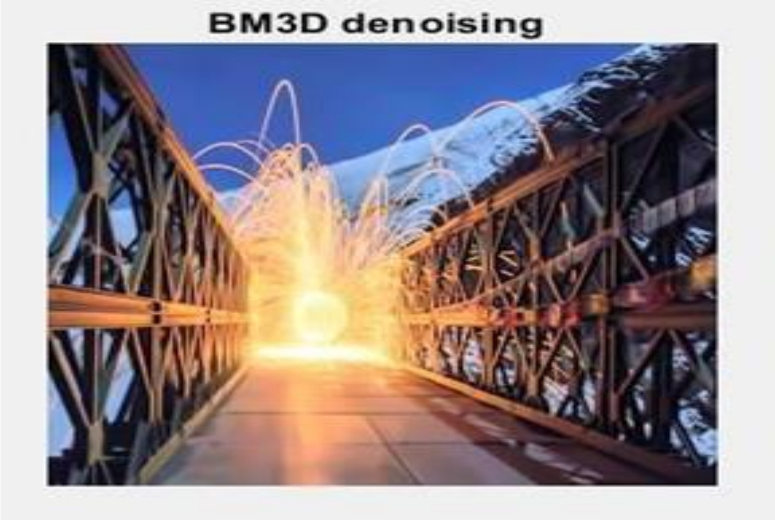

FIGURE 8. BM3D Denoising

FIGURE 9. Image Adjust

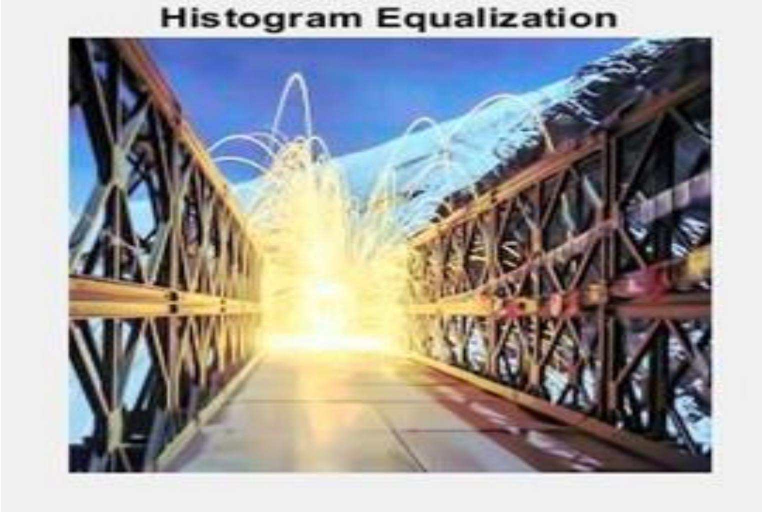

FIGURE 10. Histogram Equalization

5. CONCLUSION

In conclusion, the proposed low-light image enhancement model effectively improves visual quality and Peak Signal-to-Noise Ratio (PSNR) by integrating advanced techniques such as Image Adjustment and Histogram Equalization. By utilizing the LIME method for illumination estimation, guided filtering for smooth adjustments, and gamma correction for luminance enhancement, the model achieves balanced brightness and contrast. The inclusion of BM3D denoising preserves structural details while reducing noise, ensuring image clarity. The combination of Image Adjustment and Histogram Equalization further boosts contrast and brightness, resulting in superior visual quality. Experimental evaluations using PSNR, Mean Squared Error (MSE), and Correlation Coefficient confirm that the enhanced model outperforms the base model, making it a reliable solution for real-world low-light image enhancement. This integrated approach not only enhances visibility in challenging lighting conditions but also maintains image naturalness, proving its effectiveness for computer vision applications.

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