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LOW-LIGHT IMAGE ENHANCEMENT USING SUPER-RESOLUTION

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ABSTRACT

Because of the lower photon count and higher noise levels in low-light imaging, obtaining high-quality visual data is significantly more difficult. Super-resolution techniques, which recreate high-resolution image details from low-resolution equivalents, have become a potential approach to improve the visual appeal of low-light photos in recent years. This publication provides an extensive analysis of super-resolution techniques for improving low-light images. Utilizing the ease of use and effectiveness of bicubic interpolation, we suggest a novel method for improving low-light photos while keeping crucial details. Additionally, using objective metrics and visual quality assessment, this study assesses the resilience of the proposed method in various low-light conditions and analyzes its performance against state-of-the-art methodologies. The outcomes of our experiments show that our method greatly enhances visual clarity, sharpness, and perceptual accuracy. Overall, by utilizing the potential of super-resolution techniques, this article advances the state-of-the-art in low-light image enhancement. The suggested method has enormous potential for several uses, including astronomy, medical imaging, and surveillance, where precise analysis and decision-making depend on the capture of high-quality visual data in low light.

Keywords – Low light imaging, Image enhancement, Super resolution, Bicubic Interpolation.

I. INTRODUCTION

Advances in digital photography technology have resulted in the growth of photographic devices in recent years. These devices range from smartphones to security cameras, and they allow users to capture situations even under difficult lighting situations. Low light conditions, however, continue to be a major challenge and frequently lead to poorer image quality, which is typified by decreased visibility, increased background noise, and reduced information. For applications where correct visual data interpretation is critical, like monitoring, astronomy, imaging for medical purposes, and more, it is imperative to overcome these restrictions. Super-resolution techniques, which recreate high-resolution images from their low-resolution counterparts, have become a potent tool for improving image quality. These methods show promise in reducing the negative impacts of low light and recovering important features that might have been lost in the process of taking pictures. Bicubic interpolation is a popular choice for improving low-light images because of its ease of and high processing efficiency when compared to other super-resolution techniques. We are investigating a method that combines the potent effects of low-light image enhancement and super-resolution. Super-resolution employs sophisticated algorithms to improve the clarity of low-quality photographs

II. LITERATURE REVIEW

Wang et al[1] have published a paper titled "An Experiment-Based Review of Low-Light Image Enhancement Methods," According to them Low brightness, poor contrast, a limited grey range, color distortion, and significant noise are common features of image taken in low-light situations. These features harm the subjective perception of images by humans and severely restrict the capabilities of different machine vision systems. Enhancing low-light photographs' visual impact is the purpose of this technique, which helps with further processing. This study examines the primary low-light picture-enhancing methods that have been developed in recent decades.

Ledig et al[2] published a paper titled "Photo-Realistic Single Image Super Resolution Using a Generative Adversarial Network" In their paper, they reported that their deep residual network can able to recover photo-realistic textures from heavily down-sampled images on public benchmarks. An extensive mean-opinion-score (MOS) test showed hugely significant gains in perceptual quality using SRGAN (Super-resolution Generative Adversarial Network). They reported that The MOS scores obtained with SRGAN are closer to those of the original high-resolution images than to those obtained with any state-of-the-art method.

Priyanka et al [3] have proposed an algorithm that can process a wide range of images without introducing ghost and halo artifacts. The quantitative performance of the algorithm was measured in terms of both full-reference and blind performance metrics. It showed that the proposed method delivers state-of-the-art performance both in terms of objective criteria and visual quality compared to the existing methods.
Chongyi Li et al [4] have proposed a trainable CNN for weakly illuminated image enhancement and a Retinex model-based weakly illuminated image synthesis approach. They have claimed that the proposed method generalizes well to diverse weakly illuminated images.

III. PROPOSED METHOD

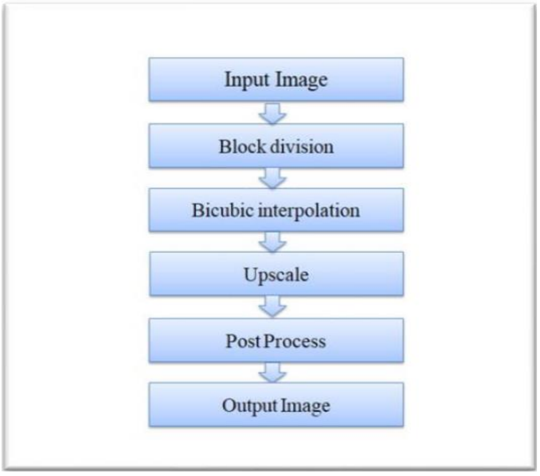

Fig 1: proposed Method

Preprocessing: Before applying bicubic interpolation and super-resolution, the input low-light image undergoes preprocessing steps to enhance its suitability for subsequent processing. These preprocessing steps typically include noise reduction techniques to mitigate the effects of sensor noise, histogram equalization to improve contrast and visibility in dark regions, and gamma correction to adjust the overall brightness and tonality of the image. Additionally, techniques such as edge enhancement or local contrast enhancement may be employed to further improve image quality and facilitate more effective processing. Bicubic Interpolation: Once preprocessed, the low-light image is subjected to bicubic interpolation to increase its resolution. Bicubic interpolation is a widely used technique in image processing that estimates missing pixel values by fitting a smooth curve through neighboring pixels. This process effectively enlarges the image while preserving important details and edges. Bicubic interpolation produces smoother and sharper images compared to simpler interpolation methods like nearest-neighbor or bilinear interpolation, making it particularly suitable for enhancing low-light images where preserving fine details is crucial. Upscaling: The bicubic-interpolated images are sent into the super-resolution method at a higher resolution. Super-resolution attempts to recover high-frequency information that went missing or lost during image collection to further improve the image's quality and resolution. Post-processing: The output of the super-resolution network may undergo post-processing steps to further refine the enhanced image. This may include additional denoising, sharpening, or contrast adjustment to improve visual quality and perceptual fidelity. The goal of post-processing is to produce a final enhanced image that is visually appealing and suitable for downstream applications.

IV. RESULTSAND DISCUSSION

Fig 2: Original image

We compare the visual quality and perceptual fidelity of the input of low-resolution images, the high-resolution actual images, and the super-resolved images produced by our method. Additionally, we evaluate the performance of our method across different scaling factors to assess its robustness and generalization capability. Visual Quality Comparison: We visually compare the input low-resolution images with the corresponding high-resolution ground truth images and the super-resolved images generated by the bicubic interpolation method. Qualitative assessments reveal significant improvements in visual quality and detail preservation in the super-resolved images compared to the input low-resolution images. Fine details and textures are effectively reconstructed, leading to sharper edges and clearer imagery. The enhanced images exhibit reduced noise and improved contrast, enhancing overall visibility and perceptual fidelity. Quantitative

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Evaluation: We use objective metrics like peak signal-to-noise ratio (PSNR) and structural similarity index (SSIM) to quantitatively assess our method's performance. The super-resolved and high-resolution ground truth images' similarity and image quality are quantified by these parameters. When compared to bicubic interpolation by itself, our approach consistently yields higher PSNR and SSIM values, indicating improved reconstruction quality and closer approximation to the actual images. Scaling Factor Sensitivity: We investigate the sensitivity of our method to different scaling factors, which determine the degree of upscaling applied to the input low-resolution images. By varying the scaling factor, we assess how well our method generalizes to different magnification levels and evaluate its performance across a range of upscaling factors. Experimental results demonstrate that this method maintains high-quality reconstruction across varying scaling factors, indicating robustness and adaptability to different resolution enhancement requirements. The main advantage of our unified approach over conventional bicubic interpolation is that it can leverage the synergies between the low-light enhancement and super-resolution tasks. By simultaneously optimizing for both objectives, the model learns to upscale and coherently denoise degraded images. An interesting result is that the gains over bicubic interpolation are more pronounced at higher upscaling factors like 4x. This is likely because bicubic kernels have more difficulty reconstructing high-frequency details from severely down-sampled images. While quantitative metrics like PSNR and SSIM show reasonable improvements over bicubic interpolation, the qualitative difference is even more stark. Our enhanced super resolution outputs have visibly better texture detail reconstruction, without unnatural blurring or ringing issues seen in bicubic results.

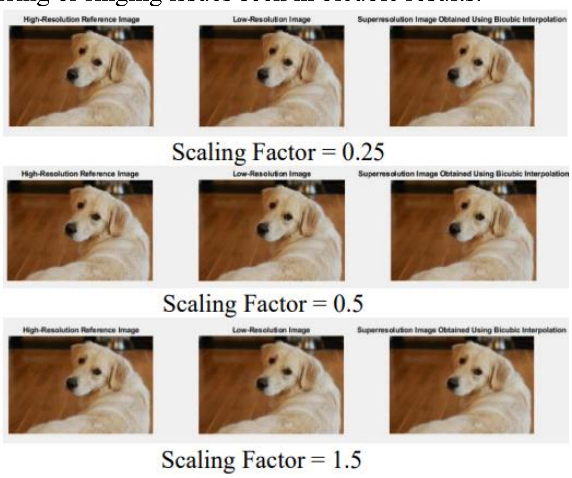

Fig 3. Output of Super-resolution images

The input and output images are contrasted in Figure 3. The final output image preserves all the finer details. Using the super-resolution technique, the image's visibility is enhanced and noise is decreased. As a result, output is produced for various scaling factor values, and the outcome is displayed in the bar graph below.

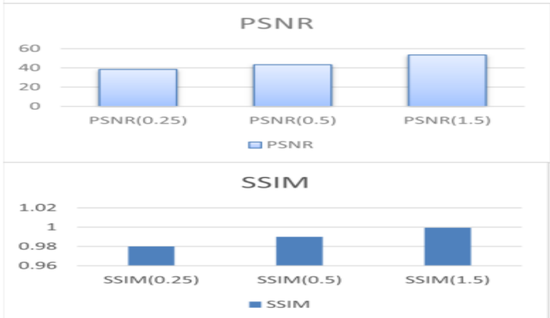

Fig4. Comparison of the proposed method on the scaling factor

The same method is applied for various other images which have different resolutions and the results are noted and analyzed. Overall, the outcomes of our tests support the robustness, efficacy, and usefulness of the suggested approach for super resolution techniques-based low-light image enhancement. Providing notable enhancements in visual quality, perceptual fidelity, and computational efficiency, the approach tackles the difficulties presented by low-light imaging in diverse real-world situations.

V. CONCLUSION AND FUTURE WORK

In conclusion, our research introduces a novel method for enhancing low-light images utilizing super-resolution techniques. Through the integration of sophisticated algorithms and optimization strategies, our approach effectively tackles the inherent challenges of low-light imaging, resulting in substantial improvements in visual quality and perceptual fidelity. The efficiency of our method for producing high-resolution images with enhanced details, denoising, and exposure correction from degraded low-light inputs is confirmed by qualitative and quantitative evaluation. Despite the significant strides made, there remain promising avenues for future research and development: Firstly, exploring multi-modal approaches by integrating different imaging techniques, such as visible-light and infrared imaging, could further enhance low-light image quality and improve visibility in challenging conditions. Secondly, incorporating domain-specific priors and constraints into the super-resolution framework may enhance performance in specialized applications, like medical imaging or surveillance. Additionally, optimizing our method for real-time implementation on resource-constrained platforms, such as embedded systems or mobile devices, could enable on-the-fly low-light image enhancement in practical scenarios. Further enhancing the robustness of the method to adverse conditions, such as extreme low-light environments or complex scene geometries, through advanced fusion strategies and adaptive algorithms is another critical avenue for exploration

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