

Local Contrast Enhancement in LDR Images via Adaptive Distribution of Clipped-histogram Excess

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Abstract— We propose a multiscale histogram excess redistribution framework addressing key limitations of contrast-limited adaptive histogram equalization (CLAHE) and Retinex methods—poor dark-region recovery, block artifacts, and color distortion. The method exploits coarse scales for global contrast, fine scales for local details, and medium scales for balanced fusion. At each scale, the redistribution ratio is adaptively determined by tile brightness: coarse scales redirect excess to originally occupied bins while finer scales regulate enhancement for smooth transitions. Scale-specific lookup tables (LUTs) are interpolated and fused with background restoration, chroma compensation, and asymmetric Gaussian offset ensuring natural tone. Results demonstrate superior detail preservation and color fidelity in low-light and high-dynamic-range (HDR) scenarios compared with LLE-NET, Retinex-CLAHE, and Kwon et al.

I. INTRODUCTION

Image contrast enhancement improves dark-region visibility and structural detail, yet CLAHE and Retinex variants often cause detail loss, noise amplification, halos, and color shifts in complex luminance scenes. Deep-learning methods (e.g., LLE-NET) are dataset-dependent and generalize poorly, sometimes producing globally dark, distorted outputs. This paper proposes a multiscale excess-redistribution framework guided by tile-level brightness, combining weighted redistribution, bilinear LUT interpolation, and background restoration. Without denoising or large datasets, the method robustly enhances low-light and low dynamic range(LDR) images, preserving details and natural color while outperforming existing techniques.

II. PROPOSED METHOD

Fig. 1 illustrates the processing pipeline: multiscale histogram redistribution, interpolation/restoration, scale fusion,

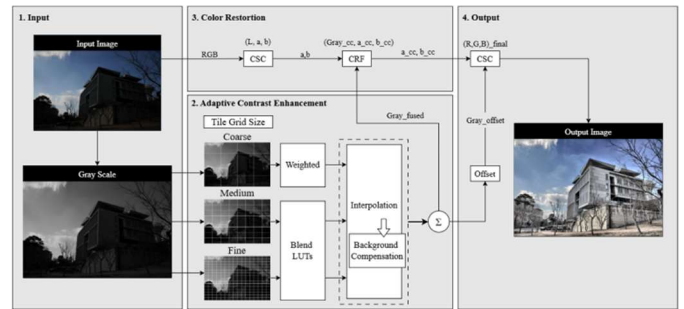


Fig. 1. Flow chart of the proposed method.

chroma compensation, and nonlinear post-processing.

The input undergoes grayscale conversion and partitioning into 4×4 , 8×8 , and 16×16 tile grids.

At each scale, the algorithm computes a blending map from tile luminance statistics to determine redistribution ratios and redistributes excess histogram bins. Neighbor-tile adjustment mitigates luminance discontinuities across boundaries. Bilinear interpolation generates smooth lookup tables, suppressing blocking artifacts. Background restoration corrects excessive contrast regions using original intensities.

Scale fusion averages fine-scale decompositions for local features and coarse-scale for artifact suppression. Asymmetric Gaussian offset then attenuates highlight oversaturation, enhances mid-tones, and preserves shadows.

For chromatic processing, ratio-based scaling adjusts chromaticity components proportional to luminance changes with saturation clipping, followed by color restoration. The enhanced luminance combines with compensated chromaticity channels in LAB space before RGB conversion.

The framework operates autonomously.

III. SIMULATION RESULTS

Fig. 3, 4 and 5 show that conventional methods produce color distortion, poor tone compression, weak detail enhancement, oversaturation, and unbalanced contrast, failing to achieve proper brightness and clear structure. The proposed method restores fine details in dark areas, preserves bright region structure, and maintains better color consistency with distinct luminance and color separation throughout the image.

IV. CONCLUSIONS

This paper presents a multiscale adaptive histogram redistribution technique that addresses key limitations of conventional enhancement methods, including dark-region detail degradation, tile-boundary discontinuities, and chromatic distortions. The proposed algorithm integrates brightness-dependent redistribution weighting, bilinear LUT interpolation for spatial continuity, and background restoration with chromatic compensation. Without requiring preprocessing or manual intervention, the method systematically mitigates enhancement artifacts through multiscale decomposition, while preserving structural fidelity and perceptual quality under low-illumination conditions.

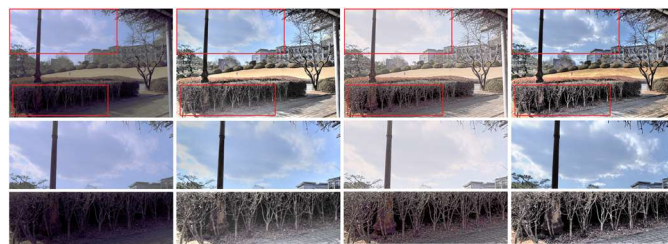


Fig. 2. Input images.



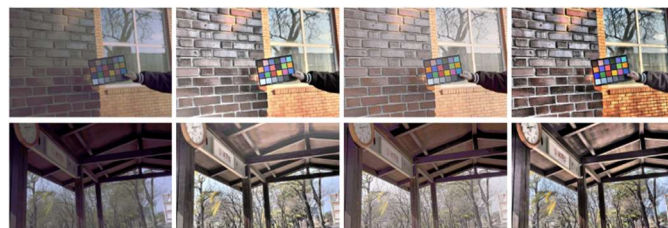
(a) (b) (c) (d)

Fig. 3. Result images: (a) LLE-NET, (b) Retinex-CLAHE, (c) Kwon et al., and (d) proposed.



(a) (b) (c) (d)

Fig. 4. Result images: (a) LLE-NET, (b) Retinex-CLAHE, (c) Kwon et al., and (d) proposed.



(a) (b) (c) (d)

Fig. 5. Result images: (a) LLE-NET, (b) Retinex-CLAHE, (c) Kwon et al., and (d) proposed.

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