

REFLECTANCE-ORIENTED PROBABILISTIC EQUALIZATION FOR IMAGE ENHANCEMENT (SUPPLEMENTAL MATERIAL)

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This supplemental material provides more examples of image enhancement and briefly describes the advantages and disadvantages of the approaches compared. Similar to Section 3 of the paper, here we mainly compare our approach, ROPE, with LIME [1], NPIE [2], LECARM [3], and KIND [4].

Brightness Over-enhancement. In all approaches compared, LIME especially tended to excessively increase the brightness of the enhanced images when the images were taken under normal lighting conditions (Fig. 1). This phenomenon can also be observed in the first example in Fig. 4 in the paper. This is due to the fact that LIME removes most of the illumination component from the input. Since ROPE corrects, but does not eliminate, the illumination, this problem does not occur.

Over-saturation. One common shortcoming of the four previous studies can be seen from Figs. 3, 7, and 11: these approaches tended to over-amplify saturation if the color information was hidden in the dark areas of the input. This phenomenon can also be observed in the second example in Fig. 4 in the paper. This is also due to the over-removal or over-enhancement of the illumination component, which ROPE can easily avoid.

Insufficient Improvement of Brightness. Of all the approaches compared, LIME and ROPE were the most effective in enhancing the global brightness of dark images. In contrast, NPIE, LECARM, and KIND all tended to be somewhat inadequate in enhancing brightness, as shown in Figs. 2, 9, and 11. In particular, NPIE was the most deficient in enhancing image brightness because it suppressed the dynamic range of the image during HE.

Color Distortion. A close examination of the images in Figs. 3e, 7e, and 8e reveals that KIND is prone to color distortion. In comparison, ROPE achieved almost perfect color consistency in all examples.

Noise Amplification. As shown in Fig. 10, LIME and NPIE tended to amplify compression artifacts and noise hidden in the dark. Since the noise in this example is spatially smooth on the input image as well as on the reflectance component, ROPE successfully avoided this problem. However, when the noise is not spatially smooth (like salt-and-pepper noise), the noise revealed in the reflectance often results in large 2D histogram values that do not correctly reflect the contrast enhancement requirements. Consequently, the noise induces ROPE to amplify itself, as shown in Fig. 11f. We will address this issue in the future.

1. REFERENCES

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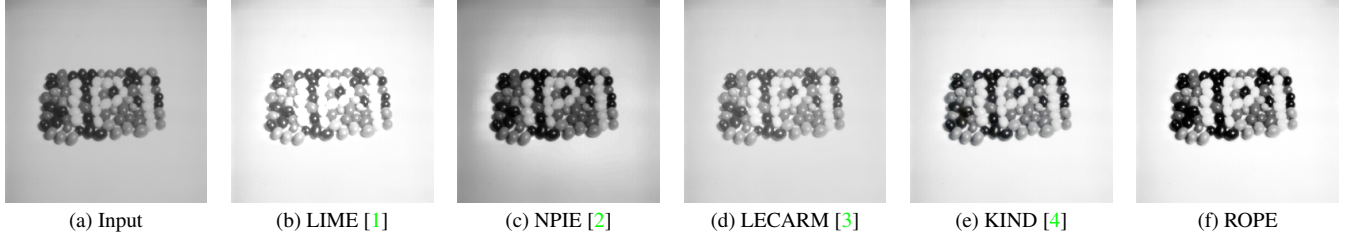


Fig. 1. Comparison of ROPE with state-of-the-art image enhancement. The image is from USC-SIPI [5].

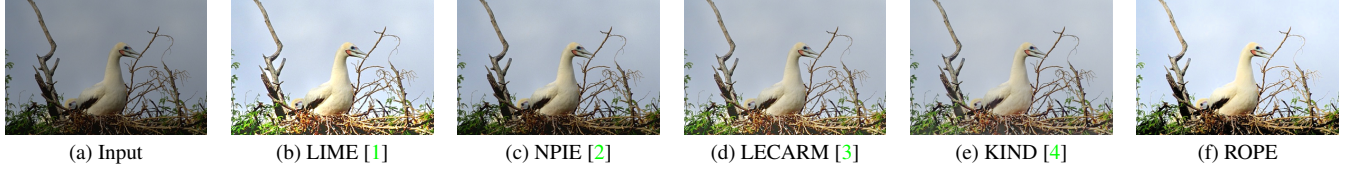


Fig. 2. Comparison of ROPE with state-of-the-art image enhancement. The image is from BSDS500 [6].

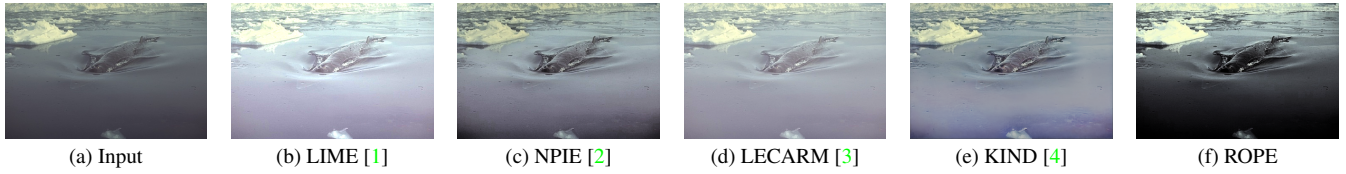


Fig. 3. Comparison of ROPE with state-of-the-art image enhancement. The image is from BSDS500 [6].



Fig. 4. Comparison of ROPE with state-of-the-art image enhancement. The image is from BSDS500 [6].



Fig. 5. Comparison of ROPE with state-of-the-art image enhancement. The image is from NPE [7].

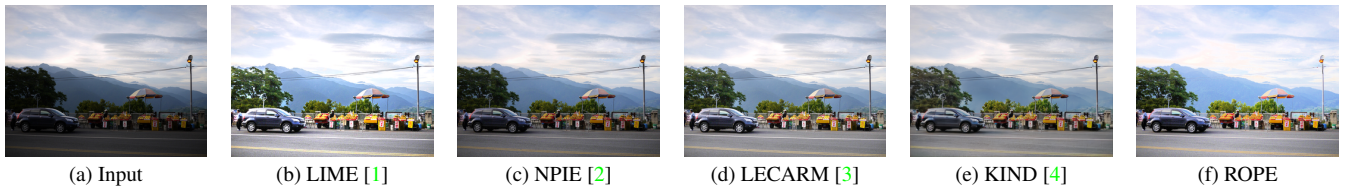


Fig. 6. Comparison of ROPE with state-of-the-art image enhancement. The image is from NPE [7].

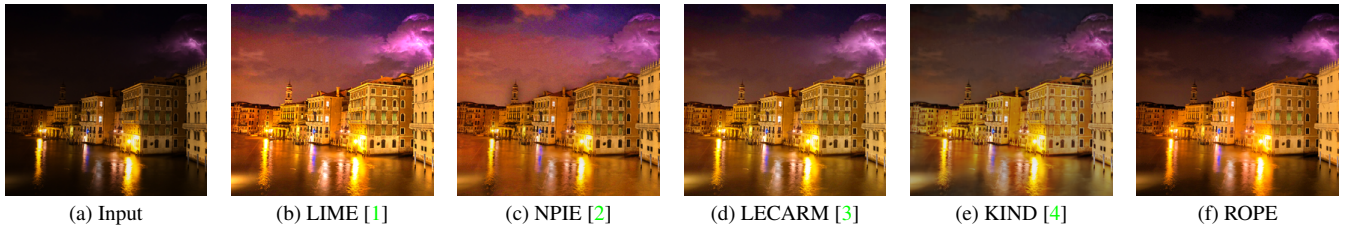


Fig. 7. Comparison of ROPE with state-of-the-art image enhancement. The image is from LIME [1].

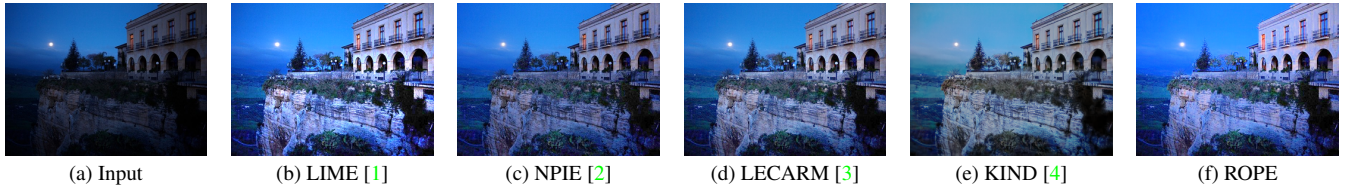


Fig. 8. Comparison of ROPE with state-of-the-art image enhancement. The image is from LIME [1].

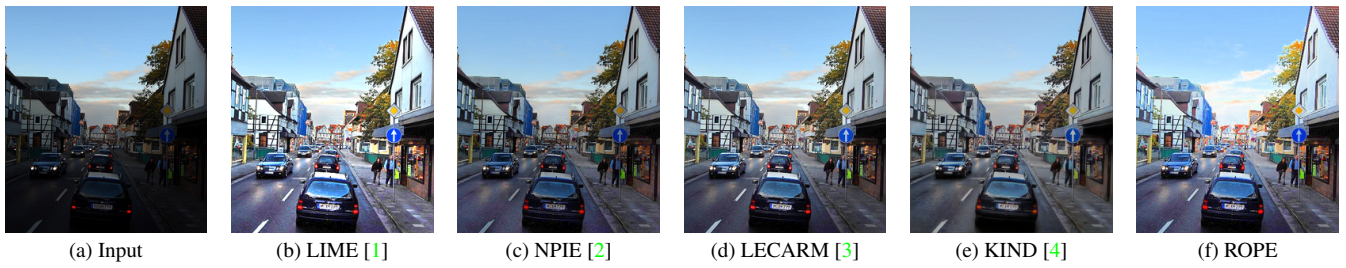


Fig. 9. Comparison of ROPE with state-of-the-art image enhancement. The image is from LIME [1].

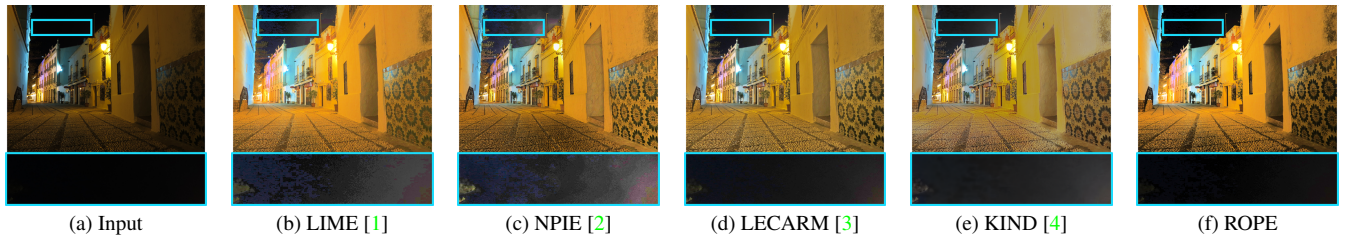


Fig. 10. Comparison of ROPE with state-of-the-art image enhancement. The image is from LIME [1].

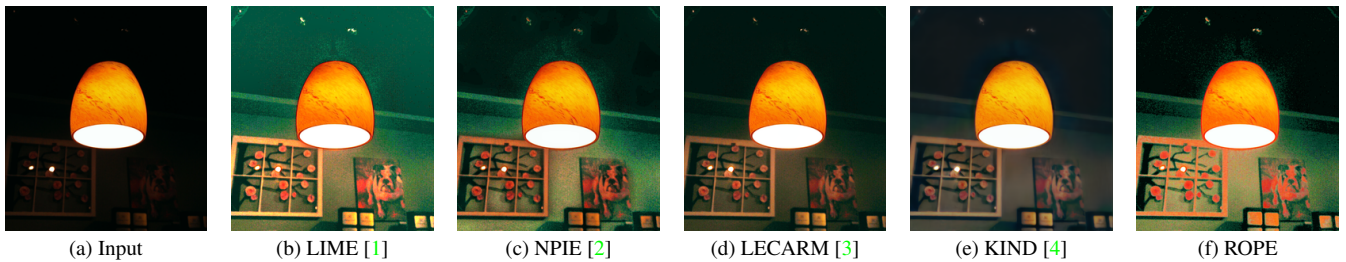


Fig. 11. Comparison of ROPE with state-of-the-art image enhancement. The image is from LIME [1].