

Nighttime low illumination image enhancement

- Image Processing -

Cozma Rares

Group 30431

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Contents

1	Dual Channel Prior	2
2	Atmospheric Illumination	2
3	Transmission Estimation	3
4	Transmission Correction	3
5	Guided Filtering	4

1 Dual Channel Prior

The first step is to compute the dark and bright channel priors of the image. The dark channel prior is based on the observation that in most non-sky patches, at least one color channel has some pixels with very low intensity. Conversely, the bright channel prior identifies the pixels that are likely to be the brightest in any patch. These priors help us understand the distribution of light and shadows in the image.

The dark channel prior is computed using a min filter that identifies the darkest pixels in each patch of the image. Conversely, the bright channel prior is calculated using a max filter that highlights the brightest pixels in the same patches.

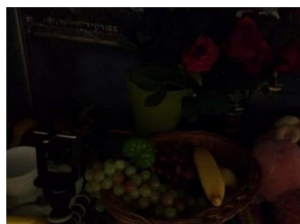


Figure 1: Input Image

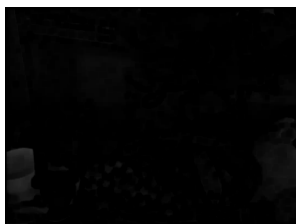


Figure 2: Dark Channel



Figure 3: Bright Channel

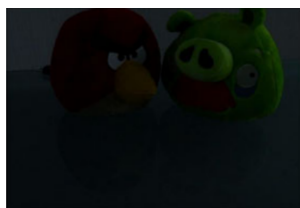


Figure 4: Input Image

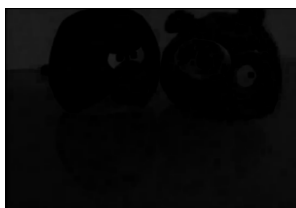


Figure 5: Dark Channel

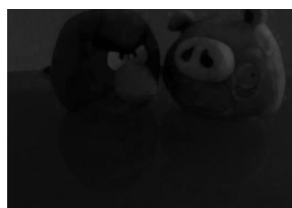


Figure 6: Bright Channel

Figure 7

2 Atmospheric Illumination

The atmospheric illumination is computed by first identifying the 10 % brightest pixels in the bright channel. Their positions are then used to find the corresponding pixels in the original image, and the average of their RGB values is taken to determine the overall atmospheric illumination.

3 Transmission Estimation

To compute the transmission map, the maximum intensity among the RGB components of the global illumination vector is computed, which represents the strongest ambient light in the scene. Then, the cloned bright channel prior is adjusted by subtracting the maximum illumination value, essentially accounting for the influence of ambient light. Following this adjustment, normalization is applied to scale the pixel values within the range of $[0, 1]$, providing an accurate representation of the proportion of light transmitted through the atmospheric medium.



Figure 8: Input Image



Figure 9: Estimated Transmission



Figure 10: Estimated Scene

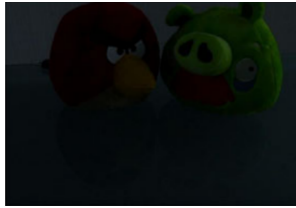


Figure 11: Input Image

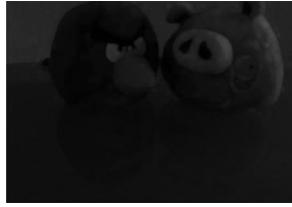


Figure 12: Estimated Transmission



Figure 13: Estimated Scene

Figure 14

4 Transmission Correction

By amplifying the image based on the inverse of the illumination values, you're effectively compensating for the global illumination present in the scene. Dividing each pixel's RGB values by the corresponding illumination values in amplifiedImage effectively normalizes the image, reducing the impact of ambient light.

After amplification, the dark channel of the amplified image is computed. By

deriving the correction matrix of the transmission from the dark channel, the low-intensity regions of the image that are likely affected by haze or fog are captured. The subsequent correction step, where the dark channel is multiplied by a coefficient and subtracted from 1, further enhances the correction map, effectively compensating for the influence of haze.

Then, for each pixel in the original transmission map, the difference of the bright and dark channels is computed. For pixels where this difference falls below a specified threshold, its value is multiplied with the equivalent pixel in the correction matrix.



Figure 15: Input Image



Figure 16: Corrected Transmission



Figure 17: Estimated Scene

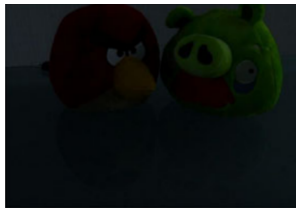


Figure 18: Input Image



Figure 19: Corrected Transmission



Figure 20: Estimated Scene

Figure 21

5 Guided Filtering

The guided filter is applied to the corrected transmission map, with guidance from the original image converted to grayscale. For each patch in the image, the mean and variance of the pixel intensities are computed for both the original image and the transmission map. These values are then utilized to calculate linear coefficients 'a' and 'b':

$$a_k = \frac{\frac{1}{n_\omega} \sum_{i \in \omega_k} I(i)T(i) - \mu_k T(k)}{\sigma_k^2 + \varepsilon}$$

$$b_k = \bar{t}_k - a_k \mu_k$$

$$T_{\text{guided}}(x) = a_k T(x) + b_k$$

where:

- ω_k is the patch centered around pixel k
- n_ω is the number of pixels in the patch
- I is the gray scale original image
- T is the transmission matrix
- μ_k is the mean value of the input image in the patch ω_k
- σ^2 is the variance of the input image in the patch ω_k
- ϵ is a regularization constant
- \bar{t}_k is the mean value of the transmission map in the patch ω_k

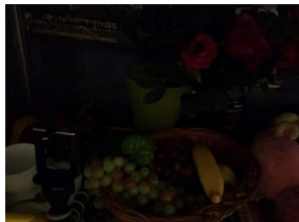


Figure 22: Input Image



Figure 23: Guided Transmission



Figure 24: Final Scene

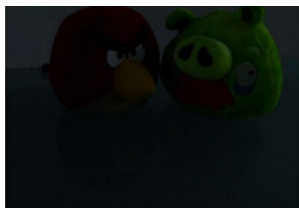


Figure 25: Input Image

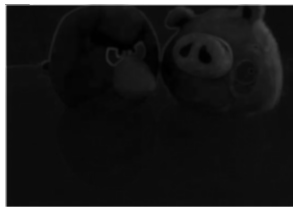


Figure 26: Guided Transmission

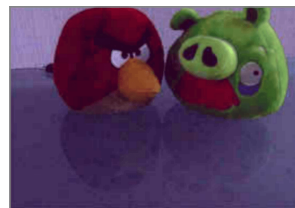


Figure 27: Final Scene

Figure 28