Enhancing and Revealing Hidden Image Details

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1 Motivation

To see more in an image.

Forensic experts often rely on low-quality and widely varying surveillance sources to capture images of vehicles and subjects. Images face many sources of corruption:

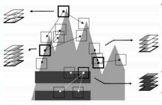
· Read Noise · Motion Blur · Poor Exposure · Low Resolution ·

The goal is to compile an image enhancement tool set to reveal image details while avoiding hallucinated artifacts.

2 Related Work

Techniques target single corruption source.

Read Noise



To denoise gaussian corruption of images, Dabov *et al.* groups similar 3D patches in images and thresholds the patches in the discrete cosine transform domain to filter noise.

Motion Blur

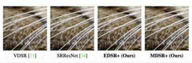
Weiner and RL deconvolution mitigate motion blur with known blur kernels; Krishnan *et al.* estimate unknown kernels via normalized sparsity measure.

Poor Exposure

Paris *et al.* normalize or enhance images using edge-aware Laplacian pyramids.

Low Resolution

Lim *et al.* super-resolve images via residual dCNNs.



5 References

· K. Dabov, A. Foi, V. Katkovnik, K. Egiazarian, "Image Denoising by Sparse 3D Transform-Domain Collaborative Filtering," IEEE Transactions on Image Processing, vol. 16, no. 8, pp. 2080-2095, 2007.

· D. Krishnan, T. Tay, R. Fergus, "Blind Deconvolution Using a Normalized Sparsity Measure," IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2011.

· S. Paris, S. Hasinoff, J. Kautz, "Local Laplacian Filters: Edge-Aware Image Processing with a Laplacian Pyramid," ACM Transactions on Graphics (TOG), Proceedings of SIGGRAPH, 2011.

· B. Lim, S. Son, H. Kim, S. Nah, K. M. Lee, "Enhanced Deep Residual Networks for Single Image Super-Resolution," Proceedings of IEEE Conference on Computer Vision and Pattern Recognition (CVPR) Workshops, 2017.

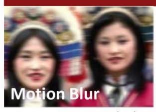
3 Methods

Evaluate image enhancement techniques on the different image corruption types and formulate pipeline.

1. Image Selection

BSDS300 50 Images

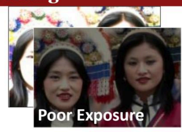
2. Noising



$$I_{blurred}(x,y) = (I * K)(x,y)$$

$$K(u,v) = \frac{1}{N}\begin{bmatrix} 0 & \cdots & 0 \\ 1 & \dots & 1 \\ 0 & \cdots & 0 \end{bmatrix}, \quad N = size(K)$$

$$I_{noisy}(x,y) = I(x,y) + N(x,y)$$
$$N(x,y) \sim \mathcal{N}(0,\sigma)$$



$$I_{exp}(x,y) = f \cdot I(x,y)$$
$$Underexposure:\ 0 < f < 1$$
$$Overexposure:\ f > 1$$

$$I_{lowpass}(x,y) = \sum_{u=-k}^{k}\sum_{v=-k}^{k} I(x-u, y-v)G(u,v,\sigma)$$
$$I_{down}(x', y') = I_{lowpass}(sx', sy')$$

$$G(u,v,\sigma) = \frac{1}{2\pi\sigma^2}e^{-\frac{u^2+v^2}{2\sigma^2}}, \quad \sigma = \frac{s}{2},$$
$$s = scale, \quad k = radius$$

Classify Noise via peak intensity, contrast, standard deviation, transform variance, and per pixel FOV area.

3. Denoising / Enhancement

Deconvolution

Filtering

Tone Mapping

Sharpening

4. Evaluation

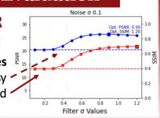
PSNR

SSIM

Across 50 Images

Clean vs. Noisy

Clean vs. Denoised



4 Results

Compiling tool set for images with multiple sources of corruption.

PSNR = 11.07 dB
SSIM = 0.19

1. Exposure Correction Histogram Equalization

PSNR = 14.27 dB
SSIM = 0.20

2. Noise Filter BM3D

PSNR = 16.20 dB
SSIM = 0.44

3. Deblur Bicubic Interpolation

PSNR = 16.22 dB
SSIM = 0.44

4. Tone Mapping Laplacian Pyramids

PSNR = 16.23 dB
SSIM = 0.44

5. Sharpening Unsharp Masking

PSNR = 16.26 dB
SSIM = 0.44

Denoising strategies are highly effective against their targeted corruption type but can inadvertently degrade image quality when applied to non-targeted distortions. In images with multiple corruption sources, assessing noise characteristics is essential for designing an optimal recovery pipeline with properly ordered stages and tunable parameters.