CONTRAST-ACCUMULATED HISTOGRAM EQUALIZATION FOR IMAGE ENHANCEMENT

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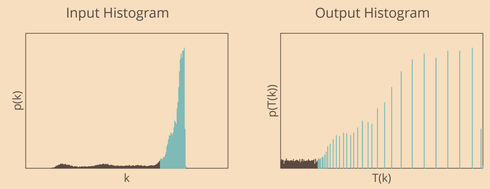
OBJECTIVE

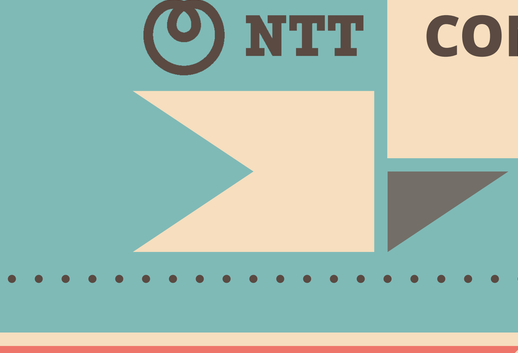
Increase the contrast within an image with a low dynamic range

RELATED WORKS

HISTOGRAM EQUALIZATION (HE)



Problem: It increases the contrast of noises that have large pixel populations, while decreasing usable signals with fewer pixels



Input

Enhanced images obtained using HE

PARTITION-BASED HE[1]

Problem: Produce unnatural gradients

Input HE BPDFHE[1]

INTRINSIC IMAGE DECOMPOSITION[2,3]

Problem: Loss of global contrast, low efficiency

Input LIME[2] NPEA[3]

IDEA

PROBLEM OF HE

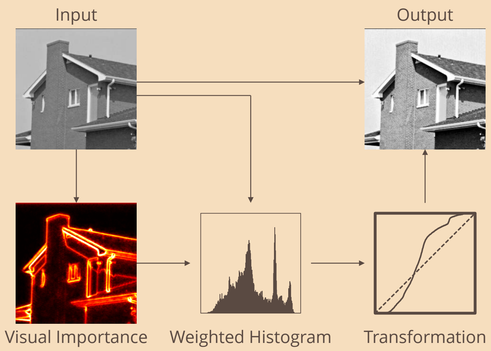
- For each pair of neighboring intensities in the input, their contrast in the output is proportional to their pixel population
- Pixel population is not necessarily correlated to visual importance in human vision

SOLUTION

Visual Importance Estimation: Propose a dark-pass filter, whose response defines the visual importance of each pixel
Histogram Reformulation: Propose an adaptive histogram construction and equalization strategy that gives an advantage to enhancing the contrast of usable signals

PROPOSED METHOD

PROCESS FLOW



HISTOGRAM REFORMULATION

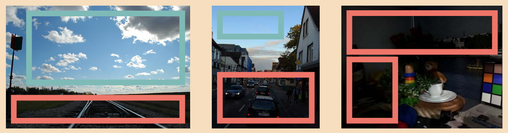
$$p_a(k) = \frac{n_k}{n} \Rightarrow \hat{p}_a(k) = \frac{\sum_x \sum_y \Phi(x,y)\delta(a(x,y),k)}{\sum_x \sum_y \Phi(x,y)}$$

Here, $\Phi(x,y)$ is a spatially variant function expressing the potential visual importance of each pixel and δ is the Kronecker delta. The equation on the right side indicates that each pixel contributes to the density estimation adaptively, and $\hat{p}_a(k)$ can be understood as the potential visual importance of an intensity given the input. Equalizing this equation instead of the equation on the left side naturally ensures that the contrast of neighboring intensities in the output is proportional to their expected importance. The proposed method thus replaces the equation on the left side with the equation on the right side from HE.

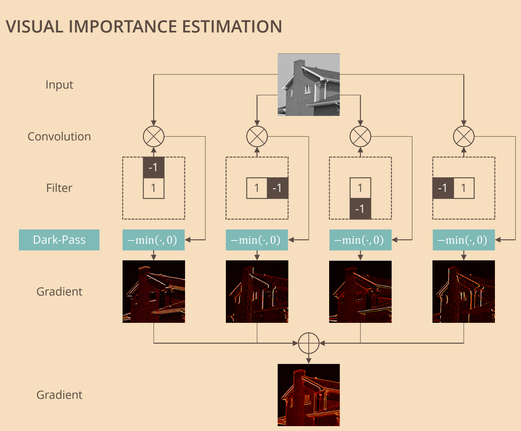
PROPOSED METHOD (CONT.)

OBSERVATION 1: Potentially important pixels usually have noticeable local differences

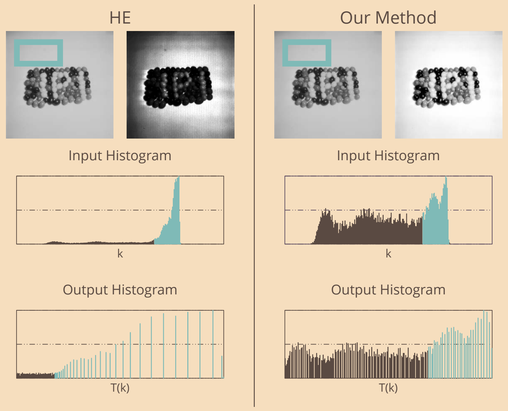
OBSERVATION 2: In natural scenes, image details are more likely to lie in darker regions



VISUAL IMPORTANCE ESTIMATION

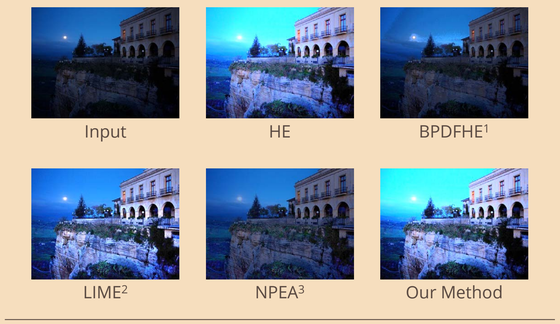


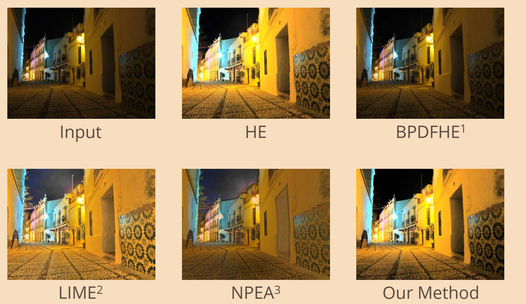
HE VS. OUR METHOD



RESULTS

COLOR IMAGE ENHANCEMENT





REFERENCES

1. D. Sheet et al., "Brightness preserving dynamic fuzzy histogram equalization," IEEE Trans. Consumer Electronics, vol. 56, no. 4, pp. 2475–2480, 2010
2. X. Guo et al., "LIME: Low-light image enhancement via illumination map estimation," IEEE Trans. Image Processing, 2016
3. S. Wang et al., "Naturalness preserved enhancement algorithm for non-uniform illumination images," IEEE Trans. Image Processing, vol. 22, no. 9, pp. 3538–3548, 2013