Low Light Image Enhancement Based on Two-Step Noise Suppression

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Low Light Image Enhancement (LLIE)

- **Low light condition**: Low SNR, much noise, low contrast, weak color;
- **LLIE**: Over-enhancement, noise amplification in HVS after CE;
- **Our approach**:
  1. Two-step noise suppression;
  2. Adopt NLF and JND for perceptual CE;

Proposed Method

- **Noise Aware CE**
  - Noise aware histogram: Adjusting histogram by high contrast pixels from NLF (not corrupted by noise) [1][2];
  - Global CE by AGCW [3]
- **JND-Based Noise Reduction**
  1. Noise becomes obvious after CE due to the decrease of JND thresholds (luminance adaptation);
  2. Noise amplification is more severe in smooth regions than textural regions (contrast masking);
  - We perform noise reduction in detail layer using JND model (low contrast pixels) as follows [4]:
    \[
    d_{\text{out}}(x,y) = e^{-V(l_{s,\text{out}}(x,y)/V(l_{s,\text{in}}(x,y))}d(x,y)
    \]

Whole Framework

**Visual Comparison**

**Objective Evaluation**

<table>
<thead>
<tr>
<th>Method</th>
<th>Luminance</th>
<th>Contrast</th>
<th>Structure</th>
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</thead>
<tbody>
<tr>
<td>Proposed</td>
<td>1.5873</td>
<td>1.4754</td>
<td>0.9833</td>
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<tr>
<td>ACEWC [5]</td>
<td>1.7088</td>
<td>1.2886</td>
<td>0.9164</td>
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<tr>
<td>CADIE [6]</td>
<td>1.3170</td>
<td>1.1679</td>
<td>0.9875</td>
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</tbody>
</table>

Conclusions

- **LLIE based on two-step noise suppression**;
- **Noise aware CE** for high contrast pixels based on noise aware histogram;
- **JND-based noise reduction** for low contrast pixels using JND model (JND from luminance adaptation; Detail layer)
- Experiment results demonstrate that the proposed method successfully enhances contrast in low light images while minimizing noise amplification.

References


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