Tone Mapping for HDR Images with Dimidiate Luminance and Spatial Distributions of Bright and Dark Regions

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Abstract

Proposed method

- Novel tone mapping method
  - Considering characteristics of human visual perception for HDR image
    - Dimidiated luminance
    - Spatial distribution of bright and dark region

- Proposed method
  - Dividing HDR image into bright and dark regions
  - Applying different tone mapping function to each region
Introduction

- High dynamic range imaging
  - Purpose of HDR image
    - Attracting much attention to capturing image
    - Precisely representation about real scenes
  - Producing HDR image
    - Combination of multiple images
      - Capturing low dynamic range (LDR) image with different exposure setting

- Necessity of tone mapping in HDR image
  - Display HDR image on standard LDR display
    - Compressing dynamic range of HDR image
Previous method of tone mapping

- Reinhard et al.
  - Proposed method
    - Applying Zone system and dodging-and-burning
  - Drawback of Reinhard’s method
    - Limitation of representing textures contrast
      » Not enough textures of bright and dark regions in HDR image

- Fattal et al.
  - Proposed method
    - Focus on change of gradient
    - Representing detailed textures of HDR image
      » Compressing higher part more than lower contrast parts
  - Drawback of Fattal’s method
    - Limitation of dynamic range to generating LDR image
    - Restriction to keep magnitude relationship
      » between luminance value pixels in image
Yee et al, Chen et al, and Krawczyk et al

- Based on local adaptation mechanism in human visual perception
- Proposed method
  - Dividing HDR image into regions
    » Based on luminance distribution
  - Applying tone mapping
    » Computing local adaptation luminance
- Drawback of this method
  - Limitation of representing real scene
    » Amount of change of luminance values
Proposed method

- Tone mapping method for HDR image
  - Considering dimidiate luminance
  - Considering spatial distribution of bright and dark region
- Example image
  - Capturing image in scene where both outdoor and indoor conditions exist.

Fig. 1. An example of image with dimidiate luminance and spatial distributions of bright and dark regions.
– Proposing tone mapping curve
  • Representing relationship of luminance value between HDR and LDR images

Fig. 2. Tone mapping curves
Tone mapping applied to dimidiate bright and dark regions independently

- Outline of proposed tone mapping method
  - Aim to proposed method
    - Applying different tone mapping with dark and bright region
  - Process of proposed method
    - Segmentation of HDR image into bright and dark regions
    - Conversion of luminance values in bright and dark region
Segmentation of HDR image into bright and dark regions
- Dividing images dark and bright region
  - Considering regions interactively and boundaries of regions
- Using GrabCut algorithm for segmentation
  - Using iterative graph cut
  - Requiring user's interactions

Fig. 3. An example of segmenting Figure 1 by GrabCut
Conversion of luminance values in bright and dark regions
- Applying different tone mapping with dark and bright regions
  - Using Reinhard method
    - Log-average luminance value
      \[
      \bar{L}_w = \frac{1}{N} \exp \left( \sum_{x,y} \log \left( \delta + L_w(x, y) \right) \right)
      \] (1)
      where \( L_w(x, y) \) is input luminance value for pixel \((x, y)\),
      \( N \) is total number of pixels in image
      \( \delta \) is small value to avoid singularity that occurs if black pixel
      exist in image
  - Scale of whole image
    \[
    L(x, y) = \frac{a}{\bar{L}_w} L_w(x, y)
    \] (2)
    where \( L_w(x, y) \) is scaled luminance value and \( a \) is parameter
• Compressing luminance value

\[ L_d(x, y) = \frac{L(x, y)}{1 + L(x, y)} \]  \hspace{1cm} (3)

where \( L_d(x, y) \) is the luminance value after scaling

\[ L_d(x, y) = \frac{L(x, y)\left(1 + \frac{L(x, y)}{L_{white}^2}\right)}{1 + L(x, y)} \]  \hspace{1cm} (4)

where \( L_{white} \) represent smallest luminance value
Experiments results

- Result image of proposed method
  - Comparison with previous methods

Fig. 5. Result of tone mapping with the image supposed to be suitable for the proposed method: lab.
Comparison with previous methods

Fig. 6. Result of tone mapping with the image supposed to be suitable for the proposed method: room.
- Comparison with previous methods

Fig.7. Result of tone mapping with the image supposed to be suitable for the proposed method: memorial.

(a) Reinhard  
(b) Fattal  
(c) Proposed method
- Degree of satisfaction in subjective evaluation
  - Using suitable HDR image

**Fig. 8.** The degree of satisfaction in subjective evaluation with HDR images suitable for the proposed method
• Using suitable HDR image

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• Using suitable HDR image

**Fig. 8.** The degree of satisfaction in subjective evaluation with HDR images suitable for the proposed method
- Degree of satisfaction in subjective evaluation
  - Using suitable or unsuitable HDR image

**Fig. 9.** The degree of satisfaction in subjective evaluation with HDR images suitable or unsuitable for the proposed method
• Using suitable or unsuitable HDR image

**Fig. 9.** The degree of satisfaction in subjective evaluation with HDR images suitable or unsuitable for the proposed method
Using suitable or unsuitable HDR image

**Fig. 9.** The degree of satisfaction in subjective evaluation with HDR images suitable or unsuitable for the proposed method.
• Using suitable or unsuitable HDR image

**Fig. 9.** The degree of satisfaction in subjective evaluation with HDR images suitable or unsuitable for the proposed method

**Reinhard** | **Fattal** | **Proposed method**
---|---|---
- Degree of satisfaction in subjective evaluation
  - Using unsuitable HDR image

**Fig. 10.** The degree of satisfaction in subjective evaluation with HDR images suitable or unsuitable for the proposed method
• Using unsuitable HDR image

**Fig. 10.** The degree of satisfaction in subjective evaluation with HDR images suitable or unsuitable for the proposed method.
• Using unsuitable HDR image

**Fig. 10.** The degree of satisfaction in subjective evaluation with HDR images suitable or unsuitable for the proposed method
– Using unsuitable HDR image

**Fig.10.** The degree of satisfaction in subjective evaluation with HDR images suitable or unsuitable for the proposed method
Conclusions

- Proposed method
  - Novel tone mapping method
    ● Considering characteristics of human visual perception for HDR image
      - Dimidiated luminance
      - Spatial distribution of bright and dark region
  - Proposed method
    ● Dividing HDR image into bright and dark regions
    ● Applying different tone mapping function to each region