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MATHÉMATIQUES VISION APPRENTISSAGE

Exposure Fusion

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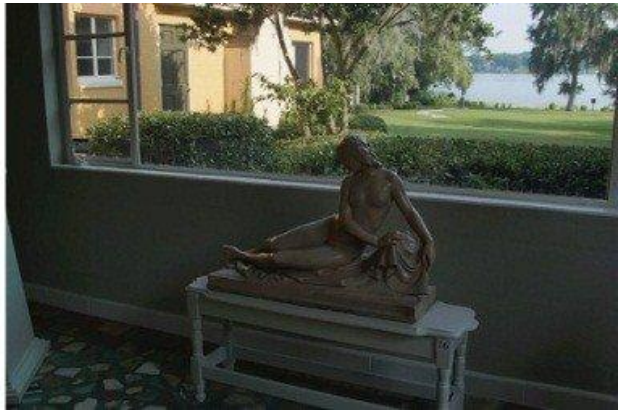
Background

LDR image (direct output of camera sensor)



HDR Image of the same scene

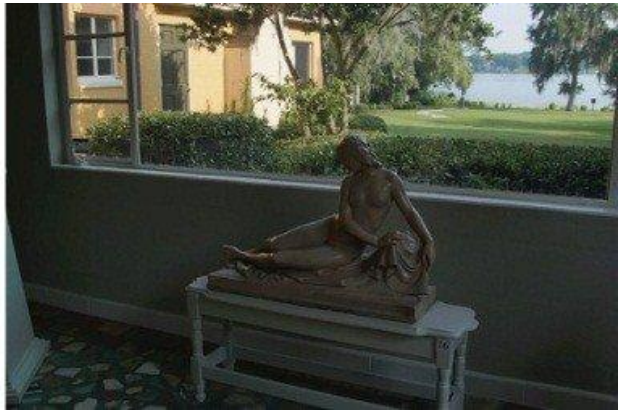
HDR : A technique for capturing and representing images with a wider range of luminance values than in traditional photography.

- + details in highlights and shadows
- Enhanced color representation
- Improved overall quality and more Creative control

Background

HDR photography is a long standing challenge !

LDR image (direct output of camera sensor)



HDR Image of the same scene

Cameras have lower dynamic range than real world scenes.

Existing techniques can be computationally heavy

Need to account for each camera's physical properties

Existing Methods

- **Global Tone Mapping**: spatially uniform remapping of intensity
  - + speed
  - - often fail to yield pleasing results
- **Local Tone Mapping**: spatially varying remapping of intensity
  - + pleasing result
  - - heavy computation

The promise of the paper

Fuse a bracketed exposure sequence into an HDR without converting to HDR first

Result

The promise of the paper

Fuse a bracketed exposure sequence into an HDR without converting to HDR first

- simplifies the acquisition pipeline by skipping HDR assembly
- avoid camera response curve calibration

Computational efficiency

- straightforward and generic

The Quality Measures and Weight Maps

- **Contrast (C) :** Absolute value of the Laplacian filter response of the grayscale version of each image in the sequence.

- **Saturation (S) :** The standard deviation within the Red, Green, and Blue channels

- **Well-Exposedness (E) :** A Gaussian curve to weight each intensity based on its proximity to 0.5.

$$W_{ij,k} = (C_{ij,k})^{\omega_C} \times (S_{ij,k})^{\omega_S} \times (E_{ij,k})^{\omega_E}$$

$$\hat{W}_{ij,k} = \left[\sum_{k'=1}^{N} W_{ij,k'}\right]^{-1} W_{ij,k}$$

The Quality Measures and Weight Maps

-4 stops

-2 stops

+2 stops

+4 stops

W1

W2

W3

W4

Naive Fusion

Simple weighted blending of input images

$$R_{ij} = \sum_{k=1}^{N} \hat{W}_{ij,k} I_{ij,k}$$

Appearance of seams in the resulting image due to sharp variations in weights

Gaussian smoothing of weight maps

Idea : Use a Gaussian Blur to smooth the weight maps and avoid sharp transitions

+ The seams disappear

- The resulting image is cartoonish and contains a lot of halos around edges

Cross-Bilateral smoothing of the weigh maps

An event better idea : Use a cross-bilateral filter to smooth weight maps

$$W_k(p) = \sum_{q \in p} \underbrace{G_{\sigma_s}(\|q-p\|)}_{\text{Spatially-aware term}} \underbrace{G_{\sigma_r}(|I(q)-I(p)|)}_{\text{intensity-aware term}} W_k(q)$$

+ elimination of halos and information spilling (the ghosting effects present on the statue is due to a slight misalignment of the images)

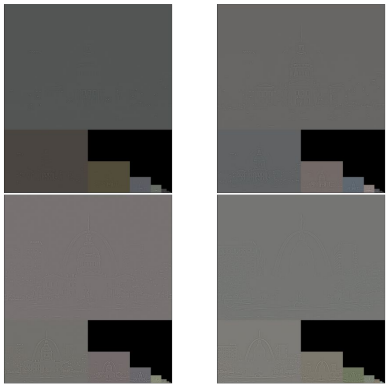
- The result is still unnatural
- Hard to tunes

Multi-resolution exposure fusion

Proposed Algorithm : Use a Multi-resolution Fusion approach

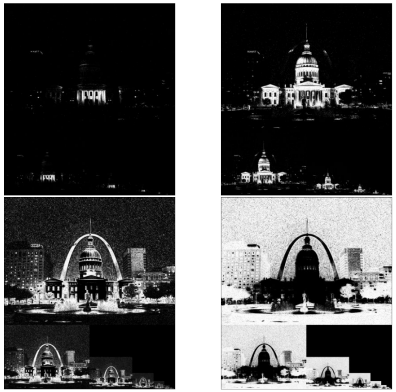
$$L\{R\}_{ij}^{l} = \sum_{k=1}^{N} \underbrace{G\{\hat{W}\}_{ij,k}^{l}}_{\text{Gaussian pyramid level of weight map}} \underbrace{L\{I\}_{ij,k}^{l}}_{\text{Laplacian Pyramid level of input image}}$$

Image Laplacian pyramid



*

Weight maps Gaussian pyramid



Final result

Quantitative Results

$w \times h \times N$	total time (s)
$580 \times 870 \times 3$	0.384
$558 \times 870 \times 3$	0.405
$960 \times 1280 \times 4$	1.45
$653 \times 870 \times 4$	0.591
$580 \times 870 \times 5$	0.624
$535 \times 870 \times 11$	1.240
$960 \times 1280 \times 13$	4.505

Time needed to complete the computation of the HDR image from a sequence of N images of shape w x h

More results

Overexposed (+3EV)

auto (0EV)

Underexposed (-2EV)

Underexposed (-3EV)

Result

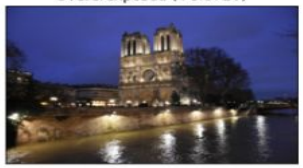
More results

Underexposed (-1.33EV)

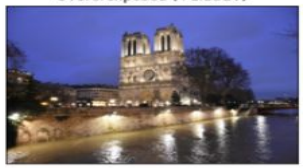
Underexposed (-0.67EV)

auto (0EV)

Overexposed (+0.67EV)



Overexposed (+1.33EV)



Result

More results

Thank You !