Exposure Fusion

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Abstract

We propose a technique for fusing a bracketed exposure sequence into a high quality image, without converting to HDR first. Skipping the physically-based HDR assembly step simplifies the acquisition pipeline. This avoids camera response curve calibration and is computationally efficient. It also allows for including flash images in the sequence. Our technique blends multiple exposures, guided by simple quality measures like saturation and contrast. This is done in a multiresolution fashion to account for the brightness variation in the sequence. The resulting image quality is comparable to existing tone mapping operators.

(a) Exposure bracketed sequence

1. Introduction

Digital cameras have a limited dynamic range, which is lower than one encounters in the real world. In high dy-

LDR images → ~~HDR randiance map~~ → LDR tone mapped image

- Combining bracketed exposure images without converting to HDR first
- Avoids camera response curve calibration
- Can include flash images

Ideas

- Keeping only the “best” parts in multi-exposure images
  - Quality measures?
- A weight map characterizes the quality measures
  - Collapsing the input images using weighted blending
- Assume that the images are perfectly aligned

Quality Measures

- Contrast
  - Apply a Laplacian filter
  - Assign a high weight to edges and textures
- Saturation
  - Standard deviation within the R, G, B channels at each pixel
- Well-exposureness

$$\exp\left(-\frac{(i-0.5)^2}{2\sigma^2}\right)$$

Pixel Weight

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

pixel (i, j)
in the kth image

contrast

saturation

well-exposureness

$$(\omega_C = \omega_S = \omega_E = 1)$$

normalized

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

Naïve Fusion

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

(b) Naive

(c) Blurred

(d) Cross-Bilateral

(e) Multiresolution

Multi-exposure

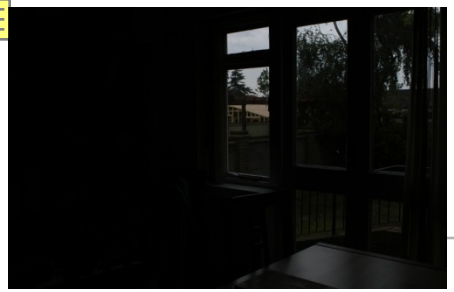
X

Weight

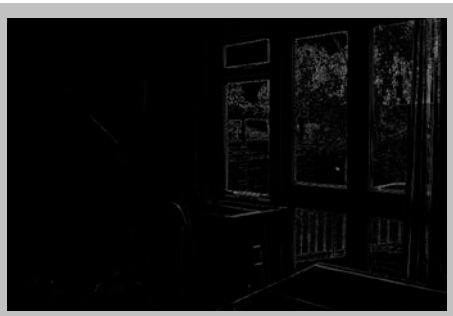
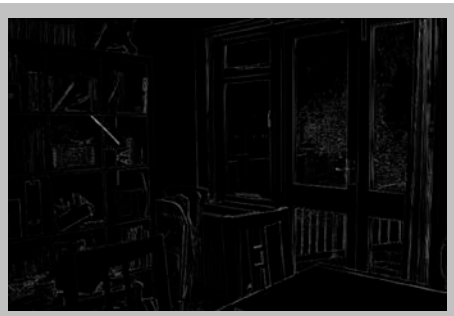
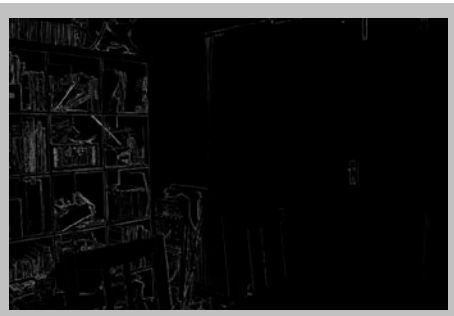
+

[Marten et al.]

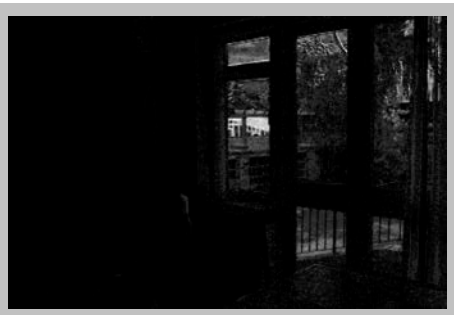
Challenges:
1. Good weights
2. Good blending



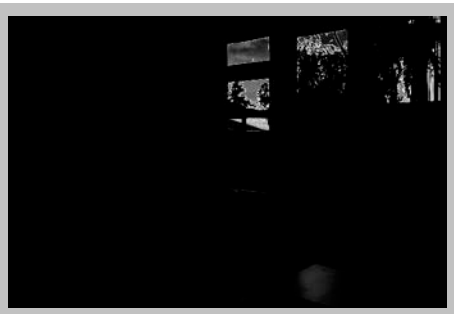

[Marten et al.]

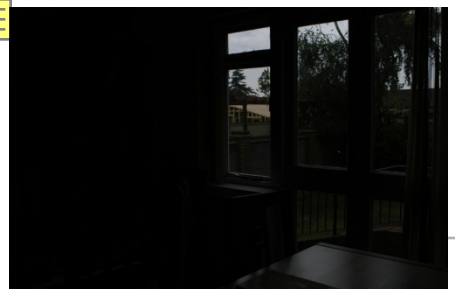
contrast



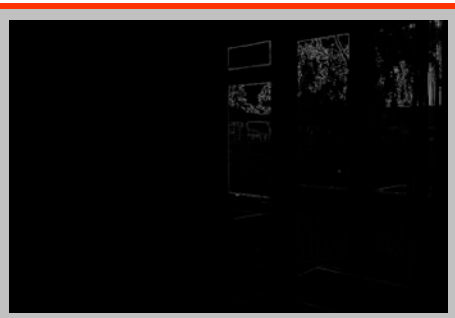
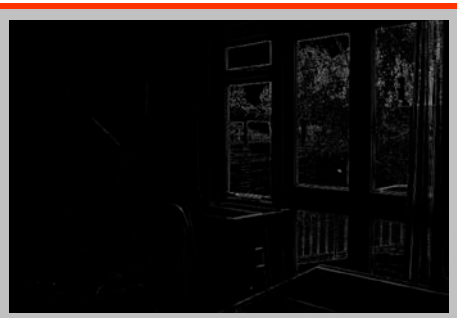

saturation

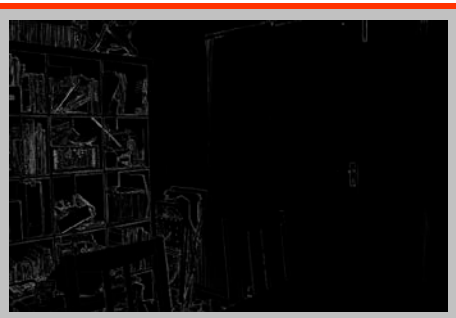



well-exposednes



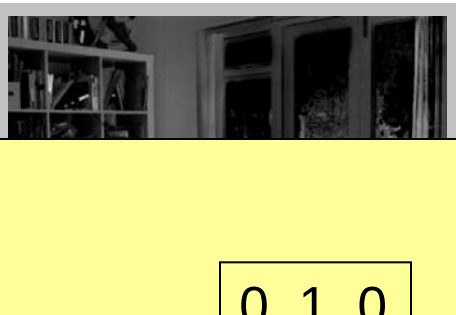
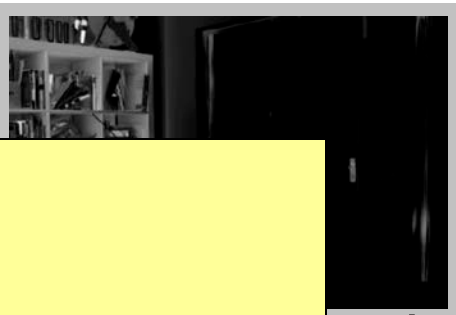

[Marten et al.]



contrast

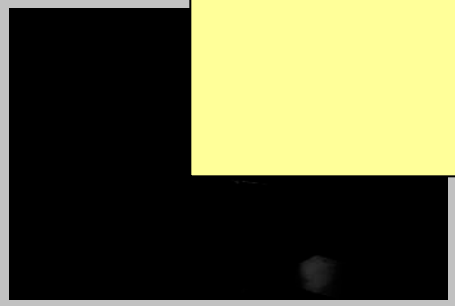
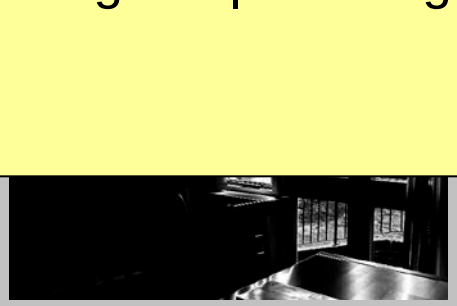
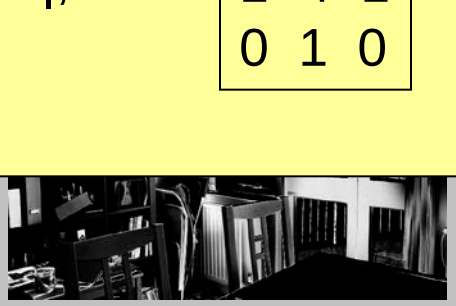
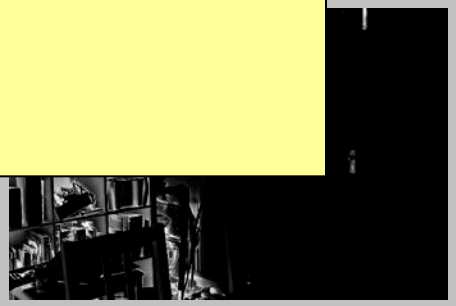


ration

contrast

weight = | h * image |, h = $\begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix}$

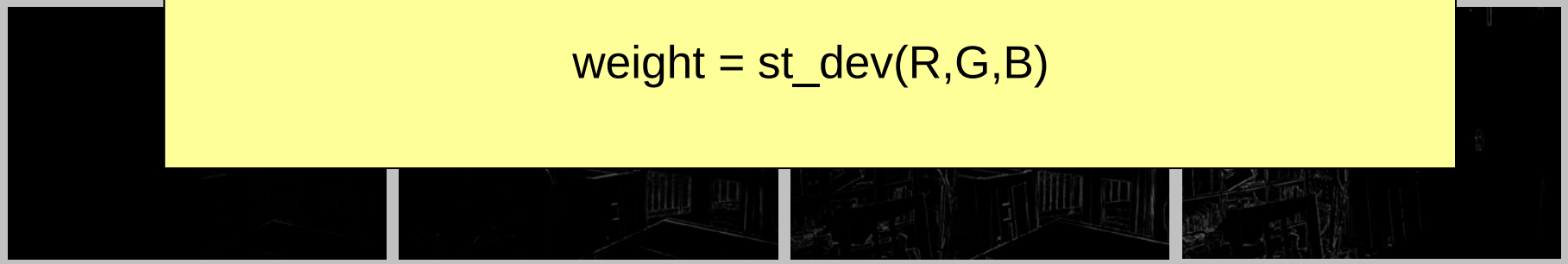





well-exposednes

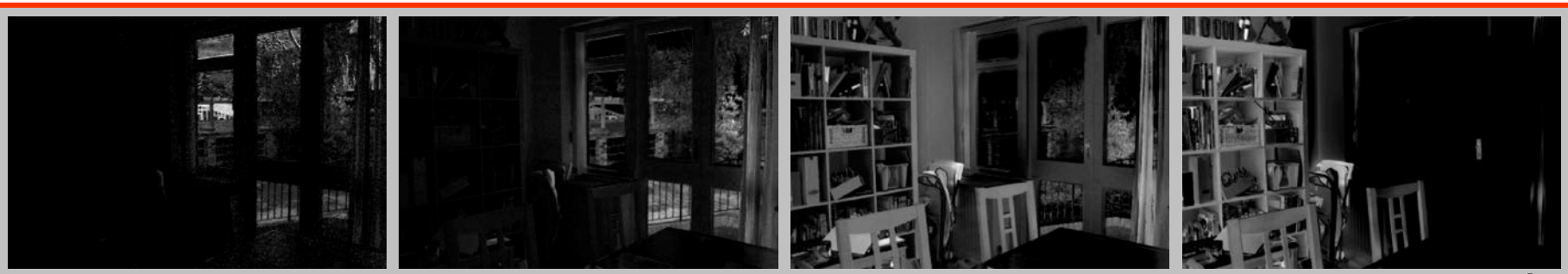
[Marten et al.]

saturation

weight = st_dev(R,G,B)



contrast



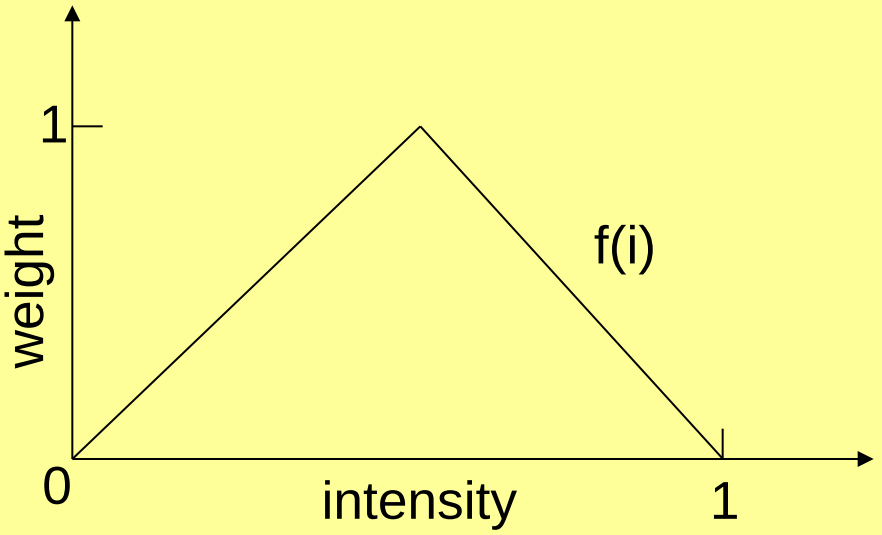
saturation

well-exposednes

[Marten et al.]

well-exposedness

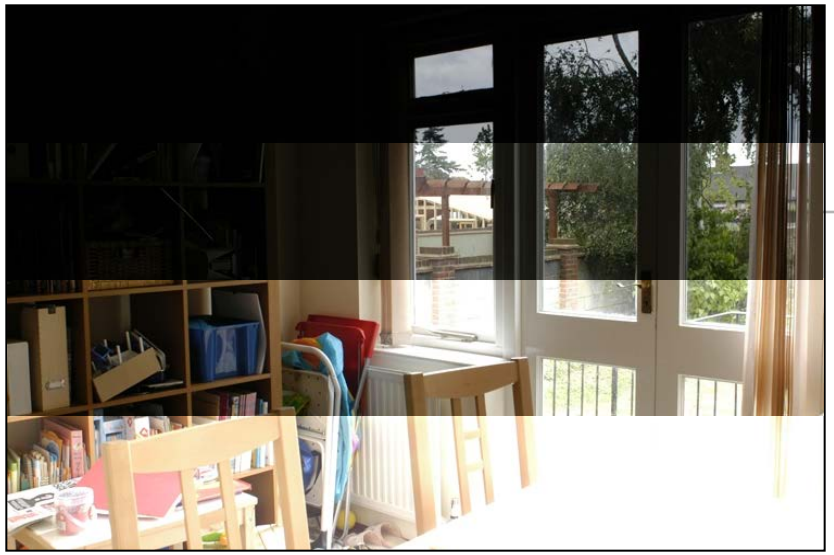
weight = f(intensity)



ntrast

saturation

well-exposedne



Exposures

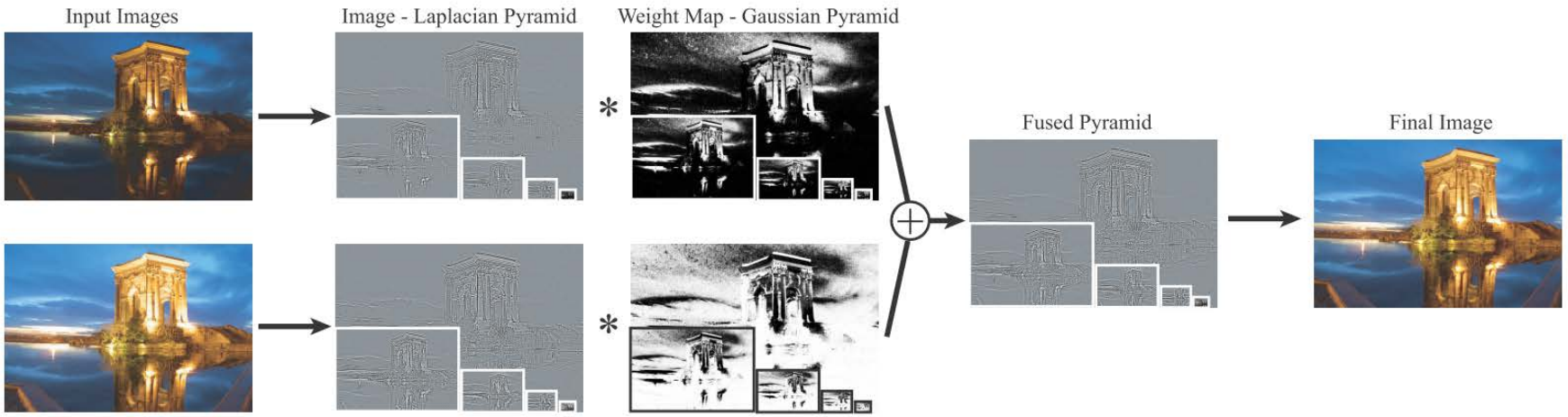
[Marten et al.]

Weights

Naïve blending

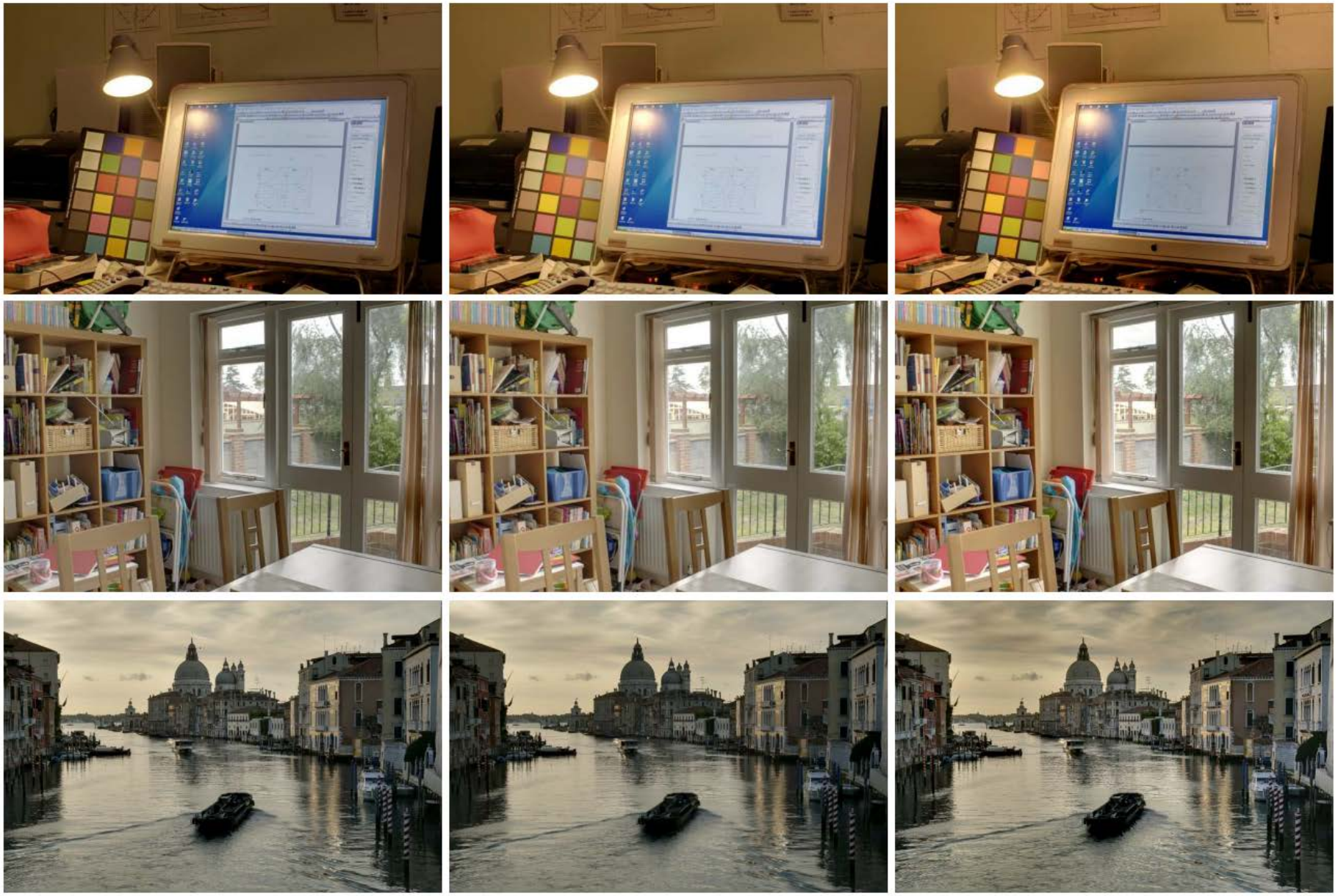
Multi-resolution blending

Laplacian Pyramid



$$\mathbf{L}\{R\}_{ij}^{l} = \sum_{k=1}^{N} \mathbf{G}\{\hat{W}\}_{ij,k}^{l} \mathbf{L}\{I\}_{ij,k}^{l}$$

blending each color channel separately



(a) Contrast (b) Saturation (c) Well-exposedness