HDR Imaging

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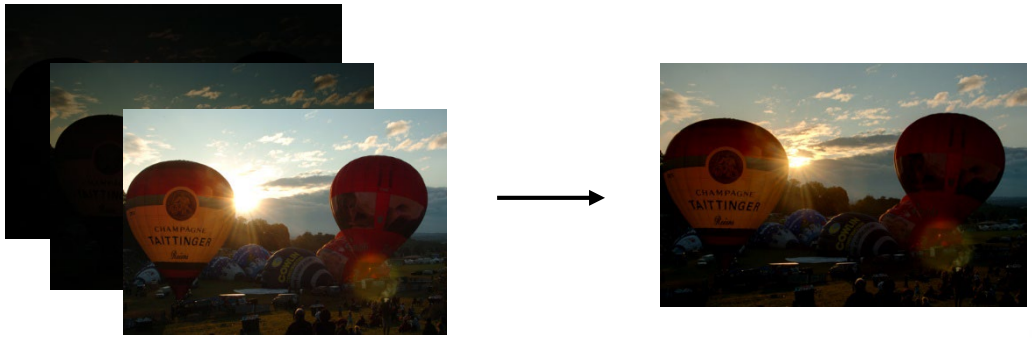
The HDR Problem

Short exposure:
Noise in shadows

Long exposure:
Clipping in highlights

- **Limited dynamic range of the camera: noise or clipping**
- **How to get HDR image from LDR input?**



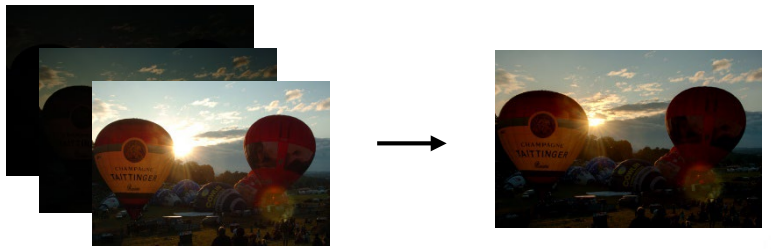
MultiFrame HDR

SingleFrame HDR

Two methods for Multiframe HDR

The Debevec Method

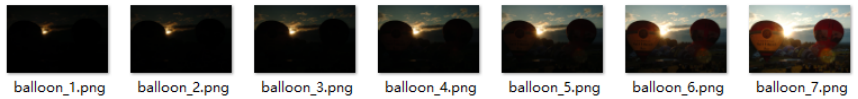
(Use Opencv Function)



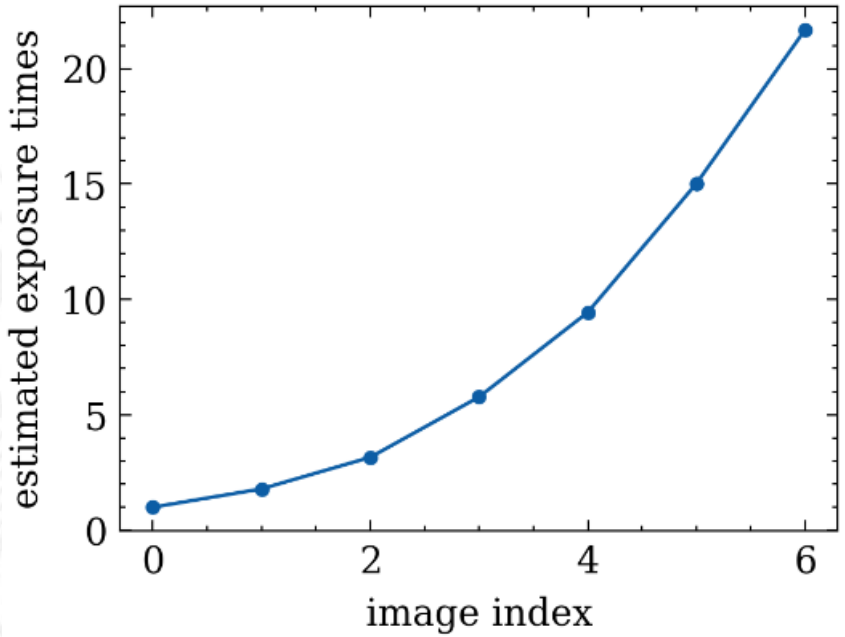
Exposure Fusion

(Implemented by ourselves)

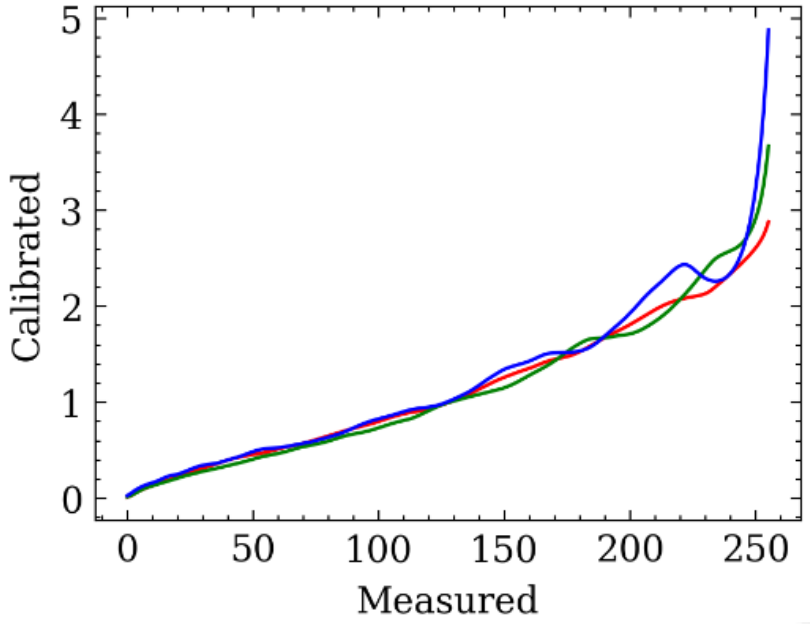
CRF estimation (Debevec)



Estimate ↓



$$\mathcal{O} = \sum_{i=1}^{N}\sum_{j=1}^{P}\{w(Z_{ij})\,[g(Z_{ij}) - \ln E_i - \ln \Delta t_j]\}^2 + \lambda \sum_{z=Z_{min}+1}^{Z_{max}-1} [w(z)g''(z)]^2$$



Input:

Pixel value Z and exposure time Δt

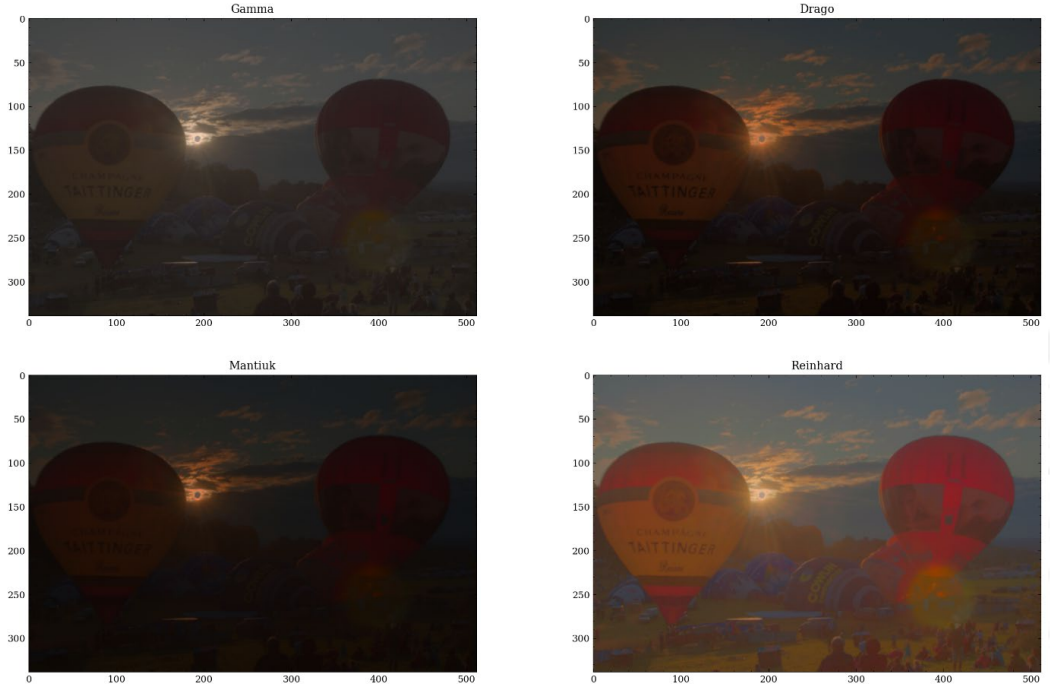
Estimate Camera response function

by optimizing the target function

Paul E Debevec and Jitendra Malik. Recovering high dynamic range radiance maps from photographs. In ACM SIGGRAPH 2008 classes, page 31. ACM, 2008

HDR recovery and tonemapping

$$\ln E_i = \frac{\sum_{j=1}^{P} w(Z_{ij})(g(Z_{ij}) - \ln \Delta t_j)}{\sum_{j=1}^{P} w(Z_{ij})}$$



HDR recovery:

weighted average of recovered HDR values in images with different exposures

Tonemapping:

Map HDR image to LDR for display

Exposure Fusion

(a) Input images with corresponding weight maps

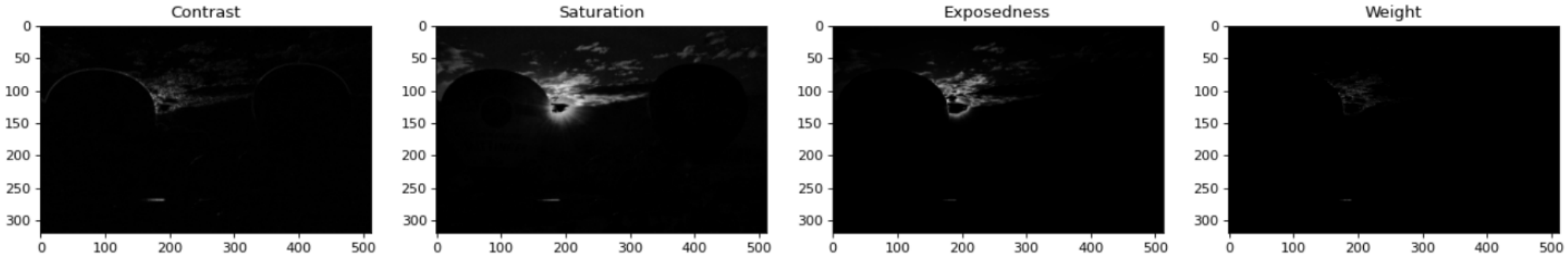
(b) Fused result

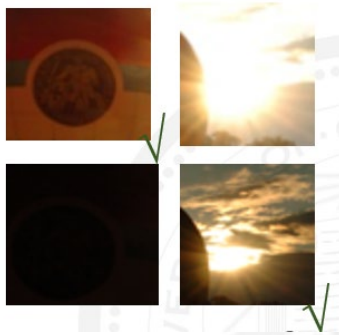
Directly **fuse** several LDR images

based on **the quality of a pixel** in different LDR images

Tom Mertens, Jan Kautz, and Frank Van Reeth. Exposure fusion. In Computer Graphics and Applications, 2007. PG'07. 15th Pacific Conference on, pages 382–390. IEEE, 2007

Fusion weights





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

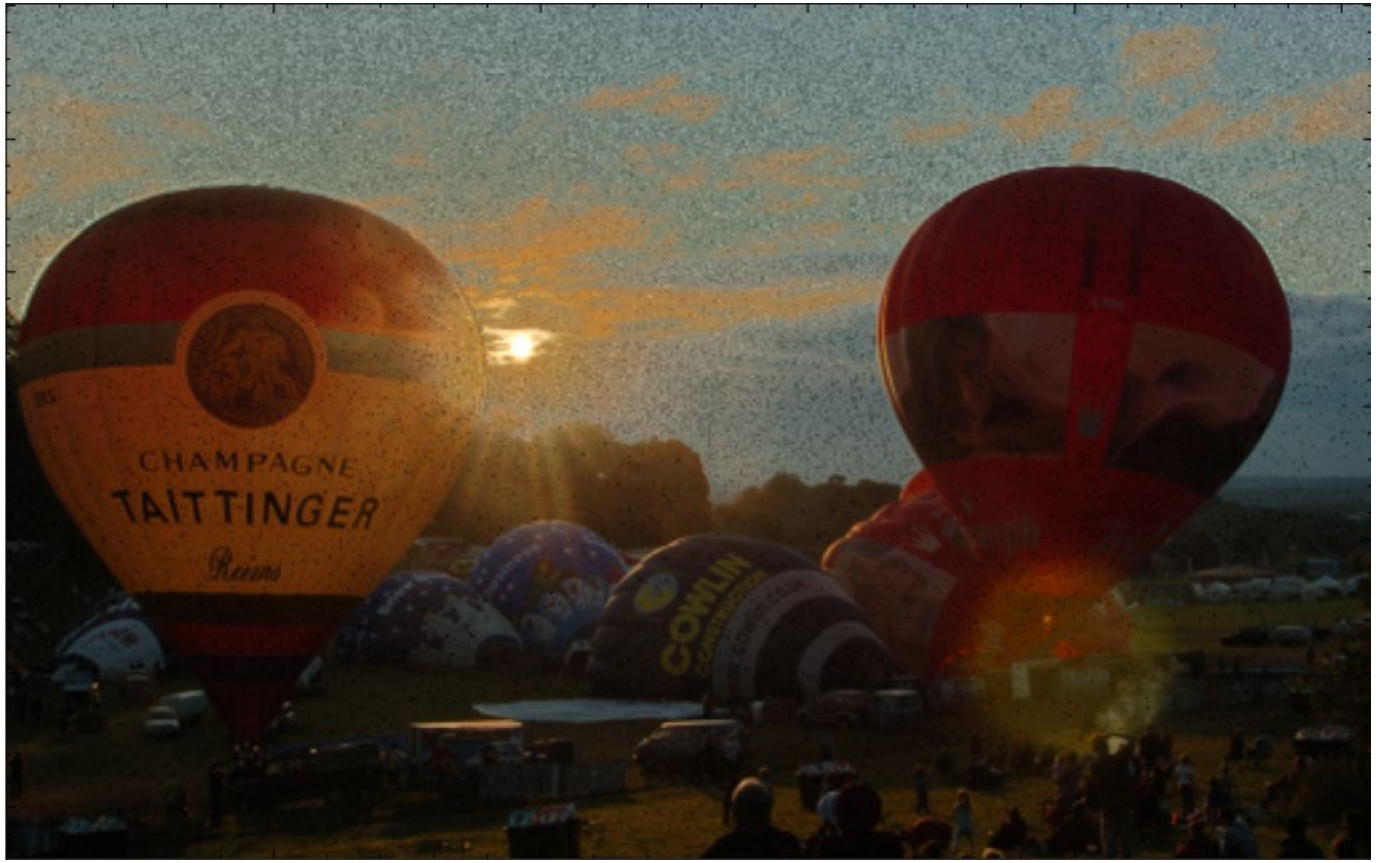
Compute fusion weights

from the **contrast, saturation and exposedness** of an image

Naïve Fusion

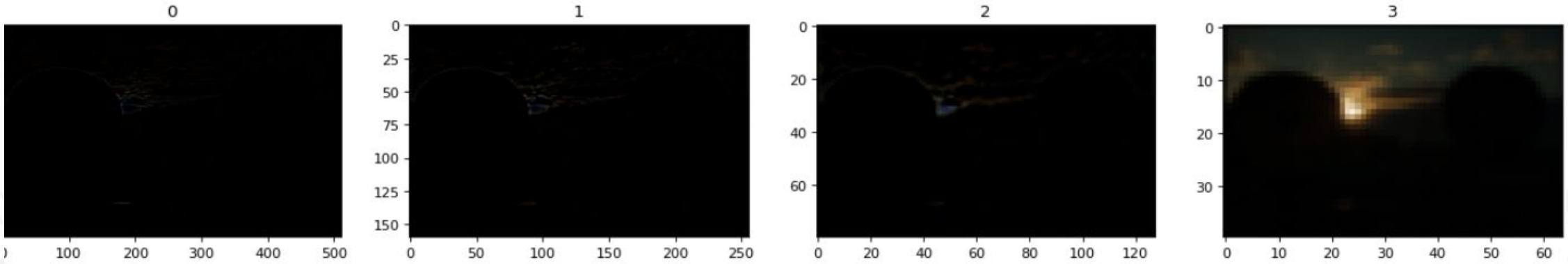
If we directly fuse the images by multiplying images with the weights,

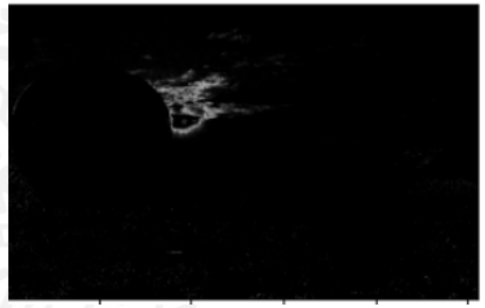
We get corrupted result:



Fusion with Laplacian Pyramid

High Freq — **Laplacian pyramid of the image** — **Low Freq**





High Freq weight

High Freq artifacts

Naïve approach: $I_{hf} \times W_{hf} + I_{lf} \times W_{hf}$

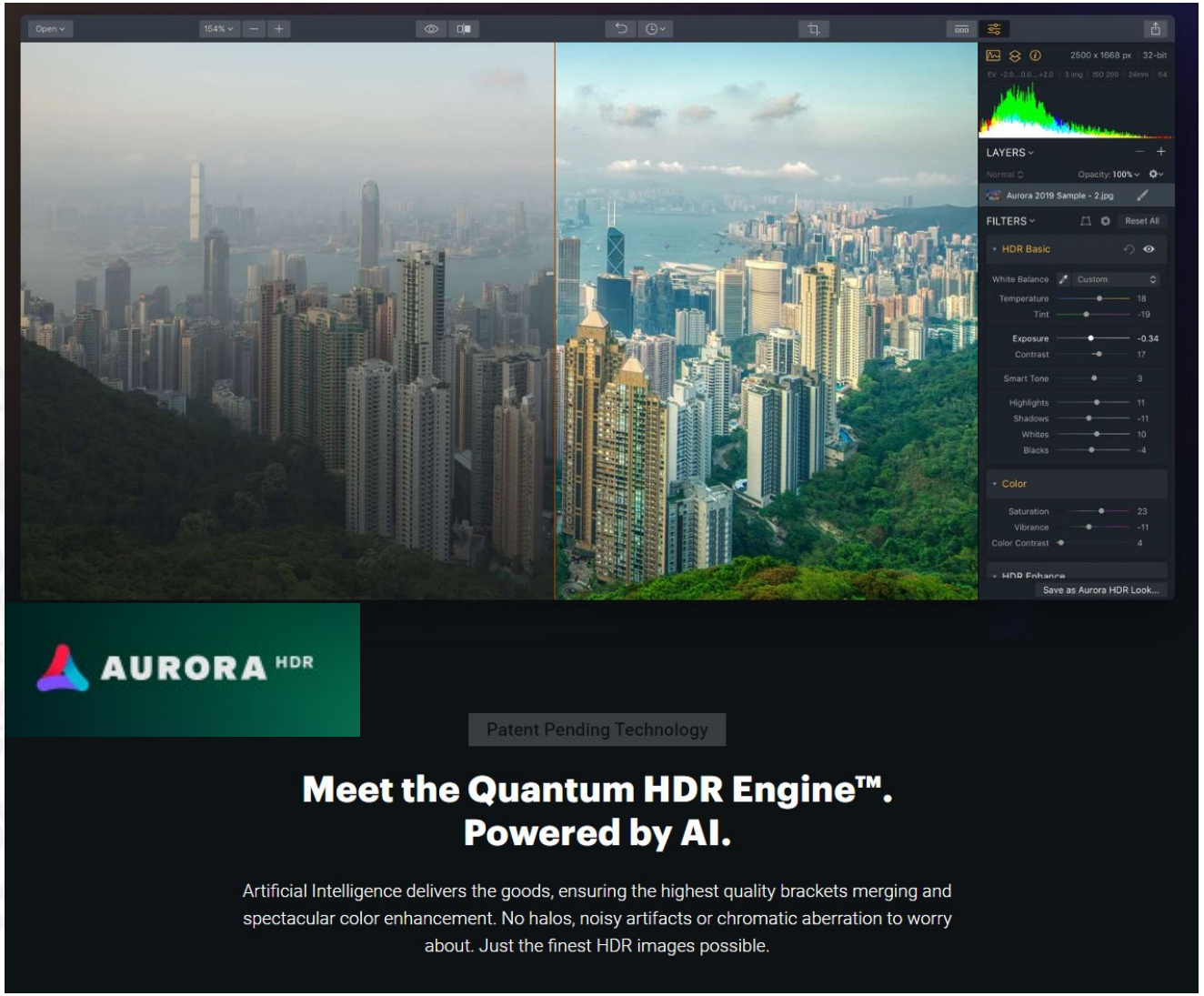
Fusion with Laplacian Pyramid

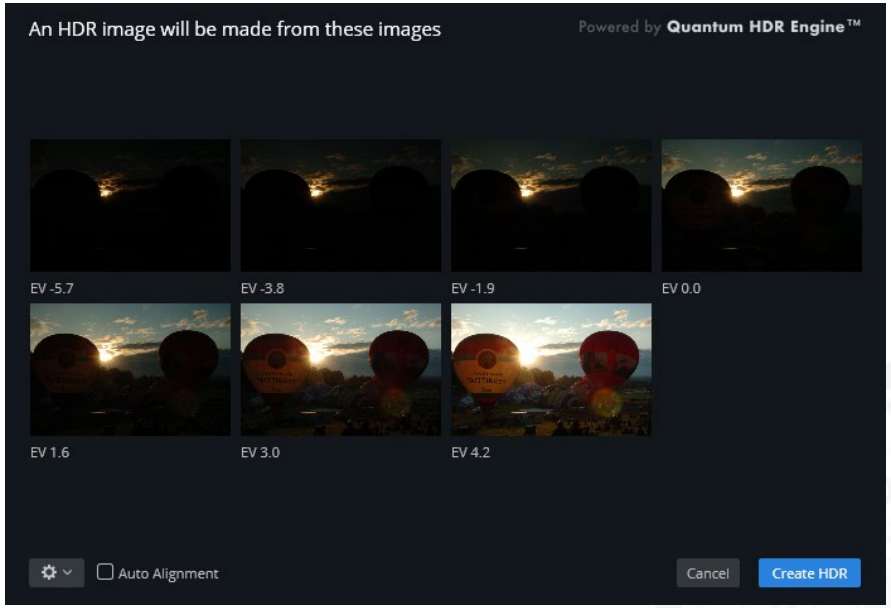
High Freq — **Laplacian pyramid of the image** — **Low Freq**

High Freq — **Guassian pyramid of the weight** — **Low Freq**

Pyramid approach: $I_{hf} \times W_{hf} + I_{lf} \times W_{lf}$

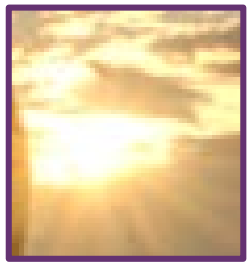
Compared App: Aurora

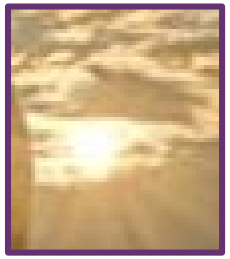


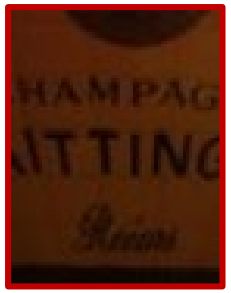


- **Claims to be the best HDR app**
- **Quantum AI engine**

Results



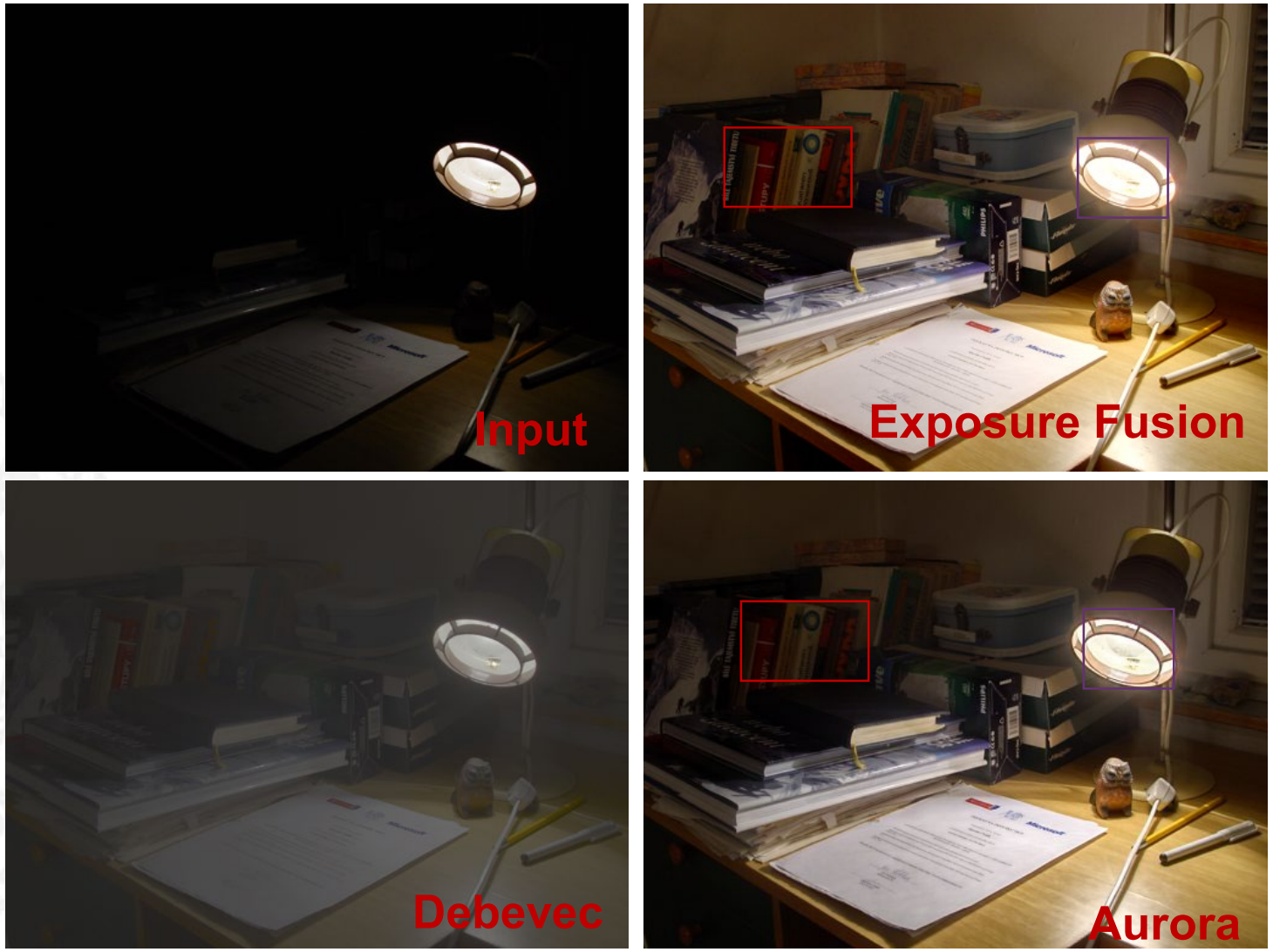




Fusion:
Less noise
In shadows

Aurora:
More details
in highlights

Results

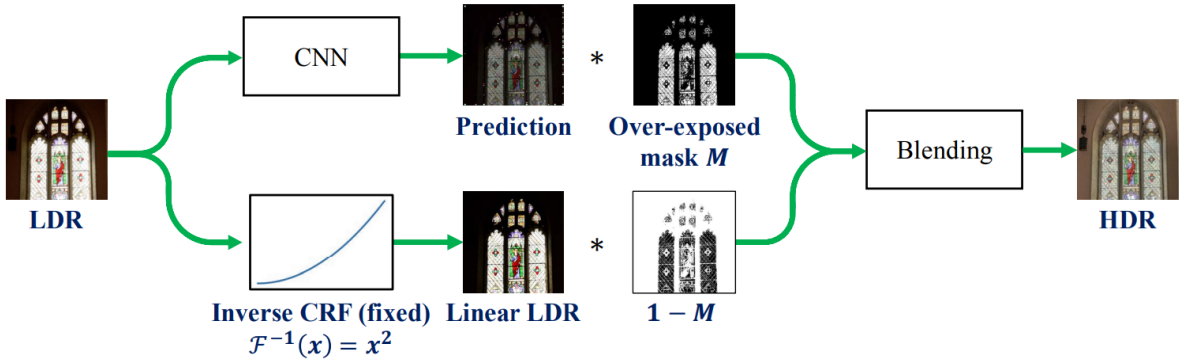


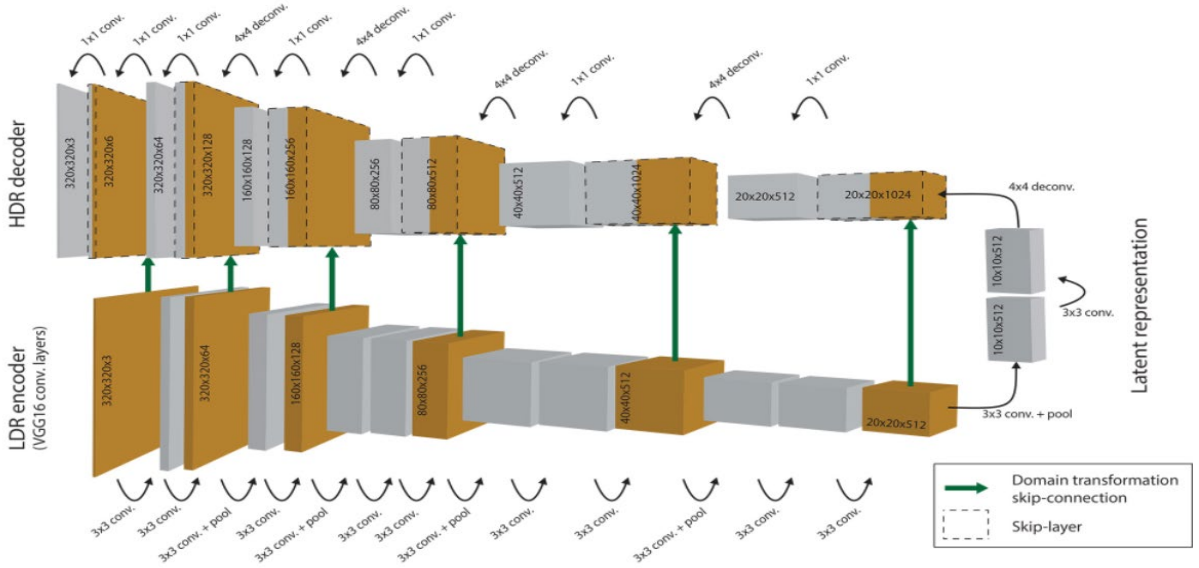
- Fusion: Less noise In shadows
- Aurora: More details in highlights
- Besides, results of Fusion and Aurora are quite samiliar
- Both looks more visually appearling than debevec (related to the tonemapping function)

Single-shot HDR Reconstruction

- **HDR CNN**
- **HDR by Learning to Reverse the Camera Pipeline**
- **Deep Optics for HDR Imaging**

HDR-CNN

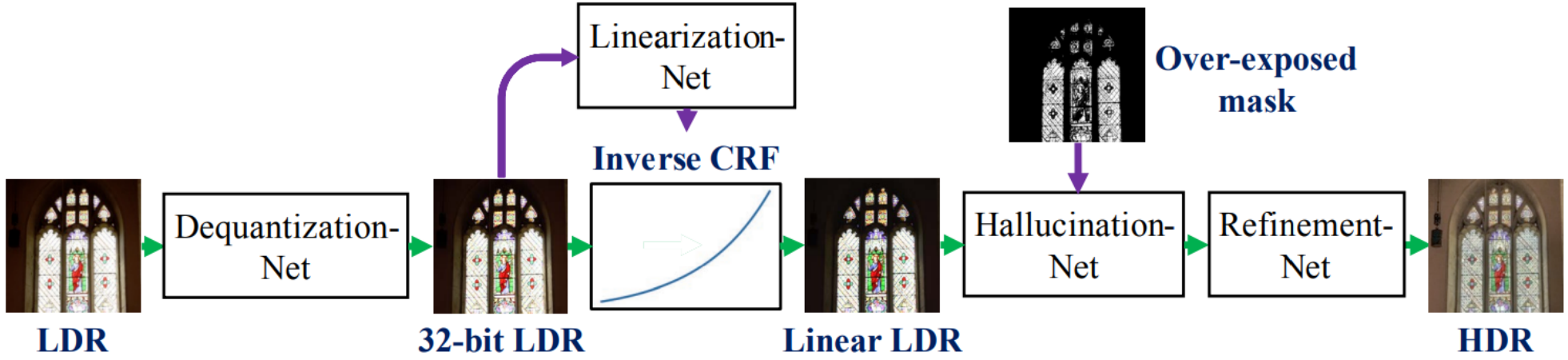




Fully CNN design in the form of a hybrid dynamic range auto-encoder

- Predicts details in over-exposed regions
- The encoder converts an LDR input to a latent feature representation
- The decoder reconstructs it into HDR image in the log domain

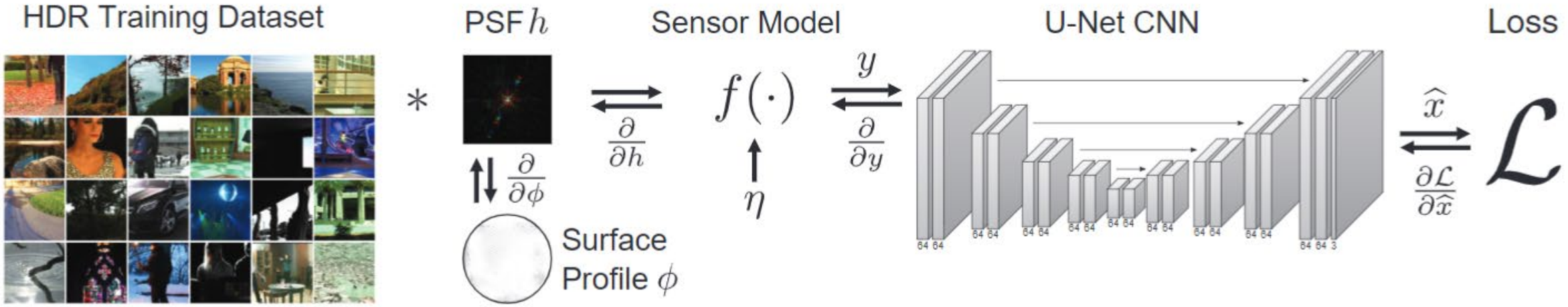
HDR by Reversing Camera Pipeline



Reversing image formation pipeline

- Dequantization-Net restores the missing details
- Linearization-Net estimates an inverse CRF and converts non-linear LDR to linear image
- Hallucination-Net predicts the missing content in over-exposed regions

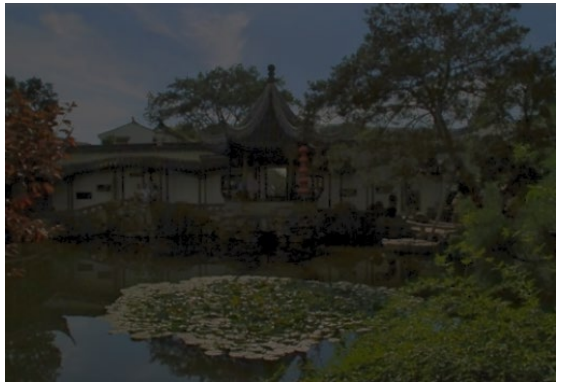
Deep Optics for HDR Imaging

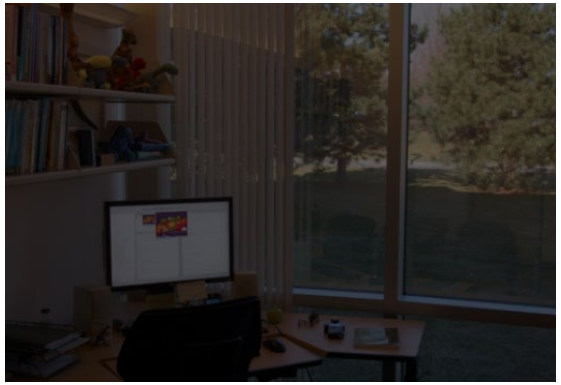
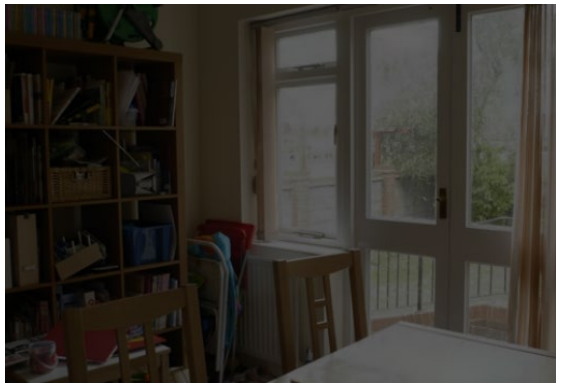
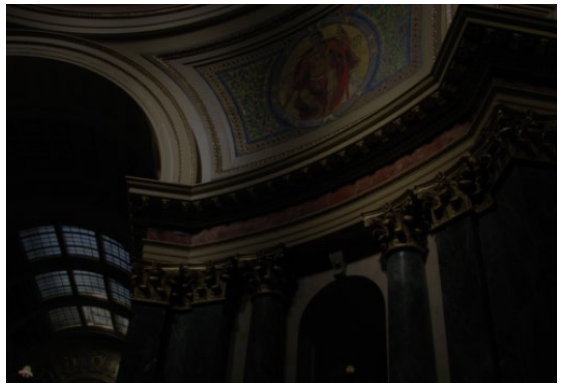


end-to-end optimization of optics and image processing

- Optical encoder and CNN-based decoder pipeline
- Learned grating-like diffractive optical element(DOE)
- Fabricate the optimized diffractive optical element and validate the proposed system experimentally

HDR-CNN Results




SingleHDR Results






SingleHDR Results on Different Inputs

Inputs:

Outputs:

Thanks for Listening!