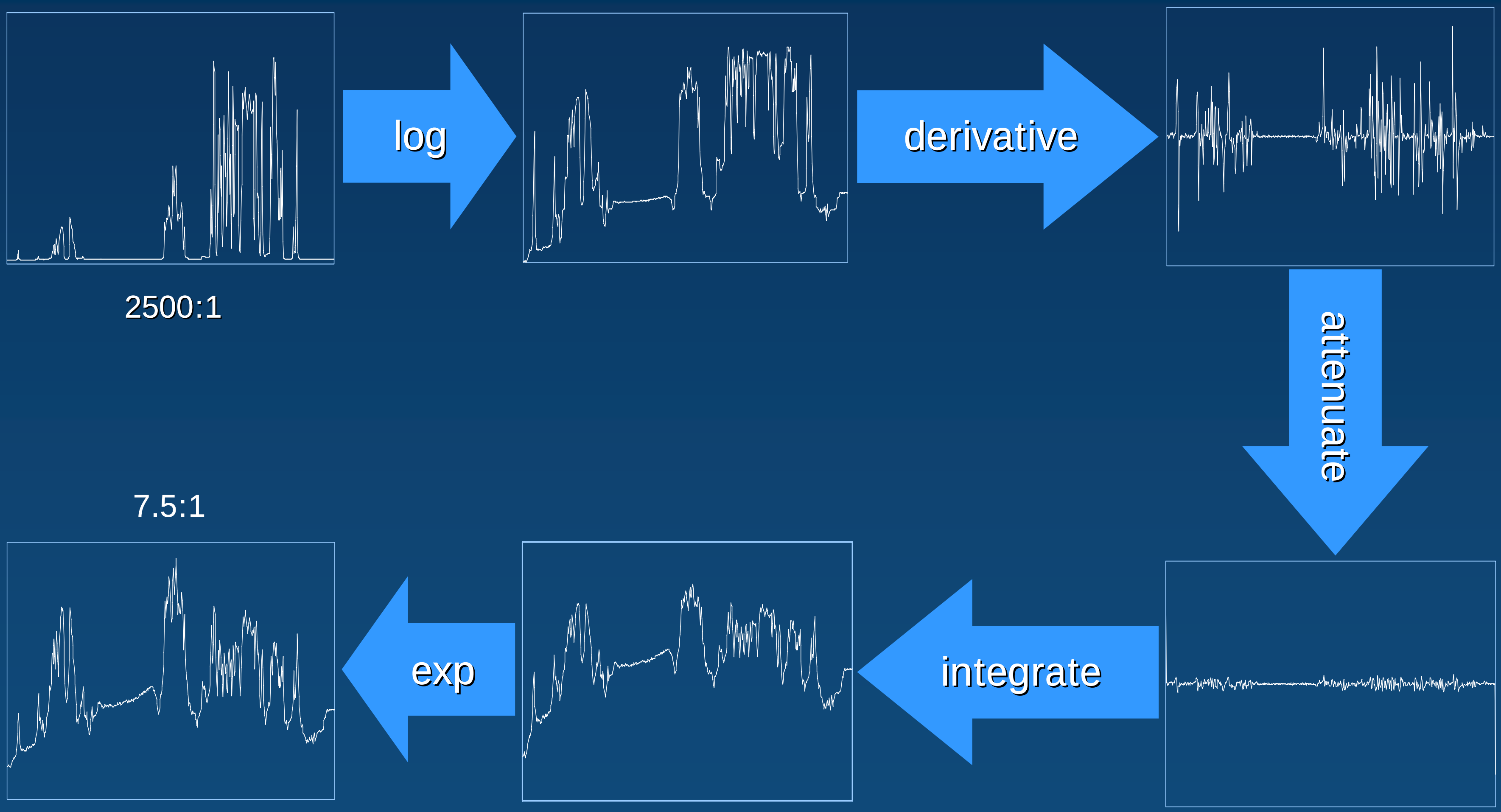
Gradient Domain High Dynamic Range Compression

Raanan Fattal Dani Lischinski
Michael Werman

The Hebrew University of Jerusalem

The Method in 1D



The Method in 2D

- Given: a log-luminance image $H(x,y)$
- Compute an *attenuation map* $\Phi\left(\|\nabla H\|\right)$
- Compute an attenuated gradient field G:

$$G\left(x,y\right) = \nabla H\left(x,y\right) \cdot \Phi\left(\|\nabla H\|\right)$$

- Problem: G is not integrable!

Solution

- Look for image I with gradient closest to G in the least squares sense.
- I minimizes the integral: $\iint F(\nabla I, G)\, dx\, dy$

$$F(\nabla I, G) = \|\nabla I - G\|^2 = \left(\frac{\partial I}{\partial x} - G_x\right)^2 + \left(\frac{\partial I}{\partial y} - G_y\right)^2$$

$$\Rightarrow \quad \frac{\partial^2 I}{\partial x^2} + \frac{\partial^2 I}{\partial y^2} = \frac{\partial G_x}{\partial x} + \frac{\partial G_y}{\partial y}$$

Poisson equation

Solve $$\frac{\partial^2 I}{\partial x^2} + \frac{\partial^2 I}{\partial y^2} = \frac{\partial G_x}{\partial x} + \frac{\partial G_y}{\partial y}$$

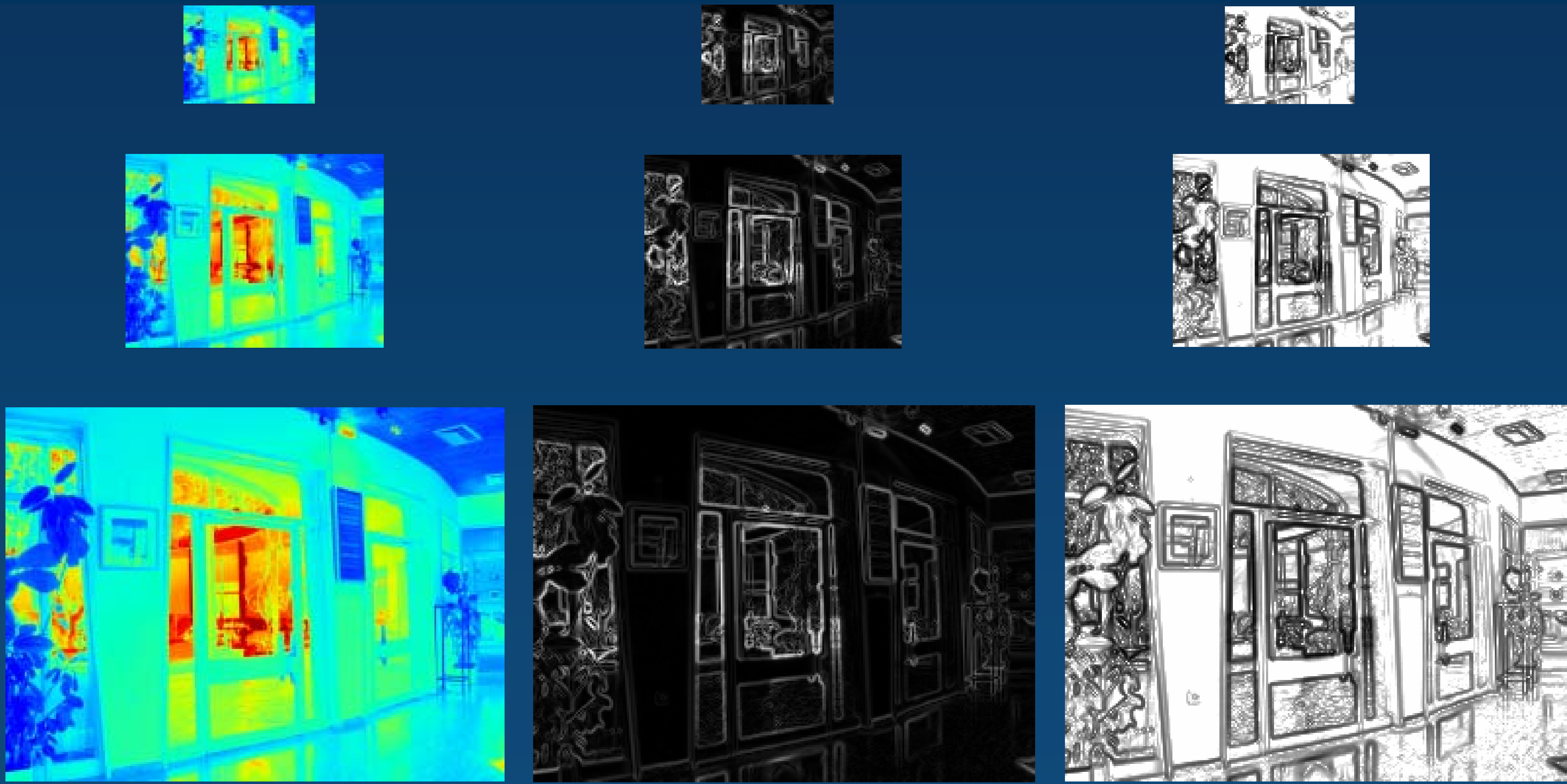
$$G_x(x,y) - G_x(x-1,y) + G_y(x,y) - G_y(x,y-1)$$

$$I(x+1,y) + I(x-1,y) + I(x,y+1) + I(x,y-1) - 4I(x,y)$$

$$\begin{bmatrix} \\ ..\ 1\ \ldots\quad 1\ \text{-}4\ 1\ \ldots\quad 1\ .. \\ \\ \end{bmatrix} \begin{bmatrix} \\ \\ \\ \end{bmatrix} = \begin{bmatrix} \\ \\ \\ \end{bmatrix}$$

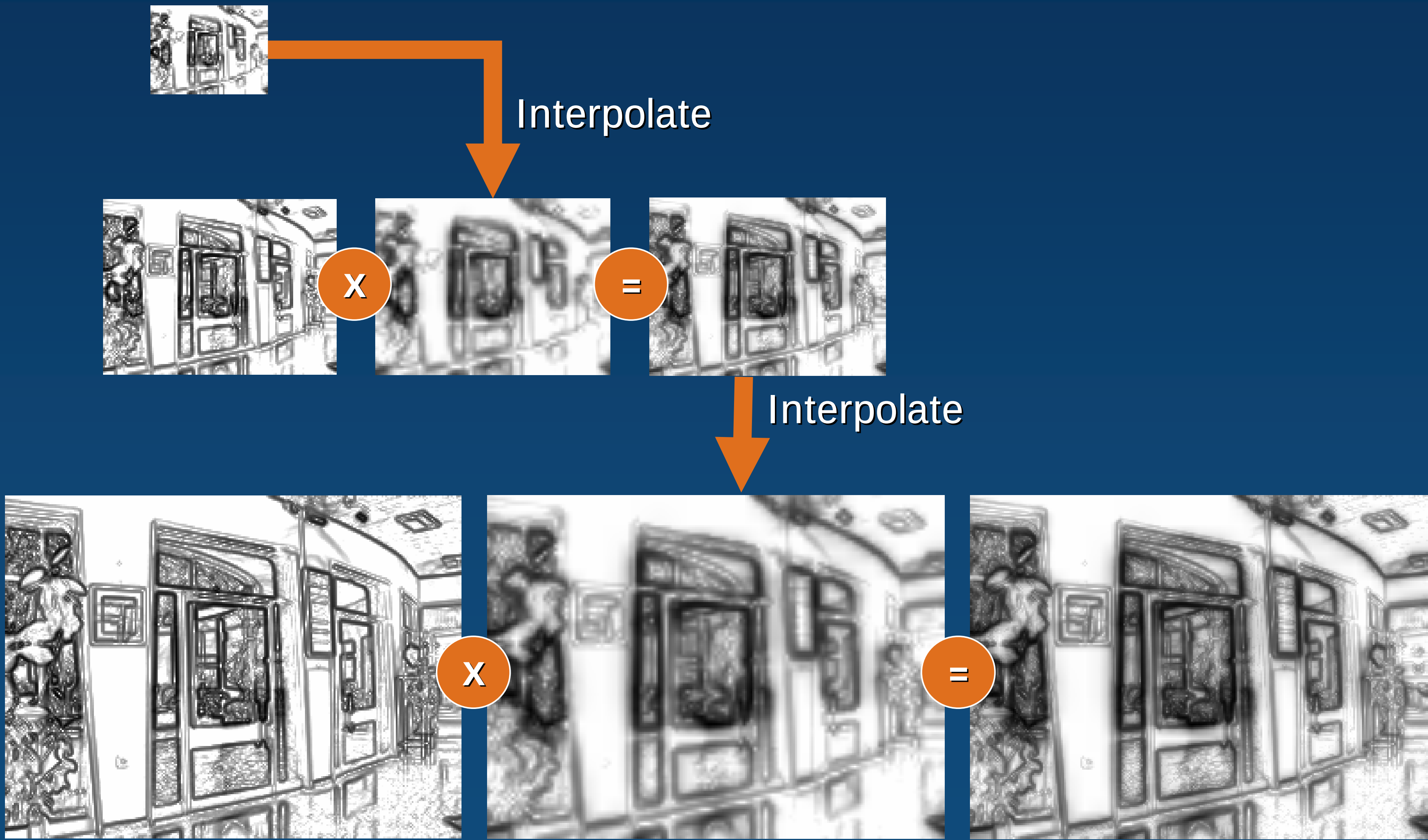
Attenuation

$$\varphi_k(x,y) = \frac{\alpha}{\|\nabla H_k(x,y)\|}\left(\frac{\|\nabla H_k(x,y)\|}{\alpha}\right)^{\beta}$$



log(Luminance) Gradient magnitude Attenuation map

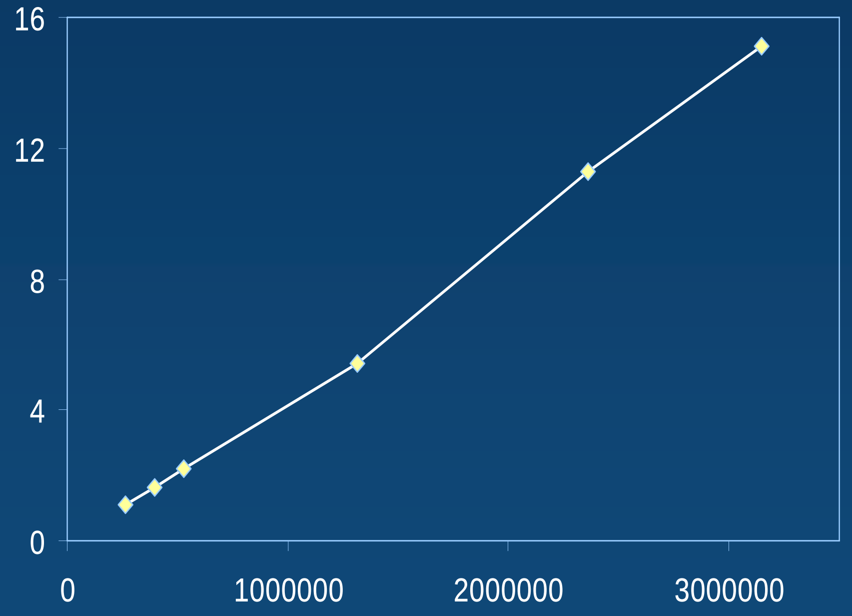
Multiscale Gradient Attenuation



Final Gradient Attenuation Map

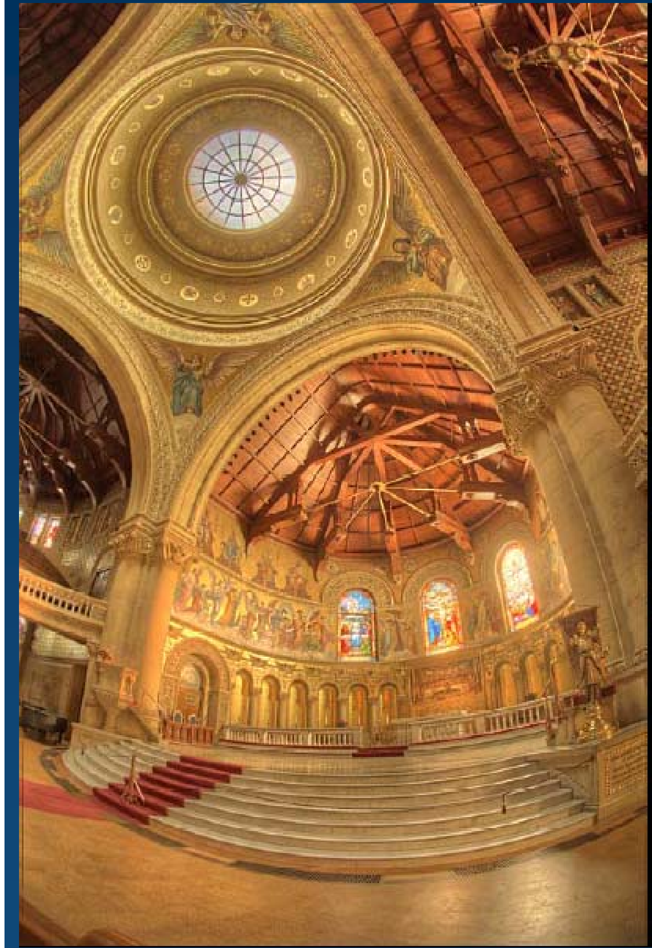
Performance

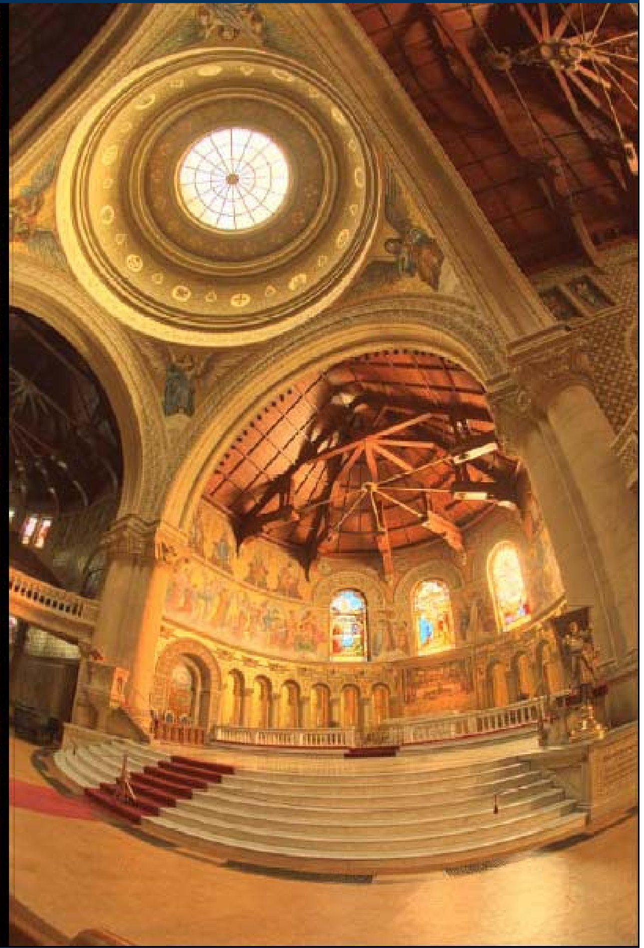
- Measured on 1.8 GHz Pentium 4:
  - 512 x 384: 1.1 sec
  - 1024 x 768: 4.5 sec



- Can be accelerated using processor-optimized libraries.

Informal comparison





Gradient domain
[Fattal et al.]

Bilateral
[Durand et al.]

Photographic
[Reinhard et al.]

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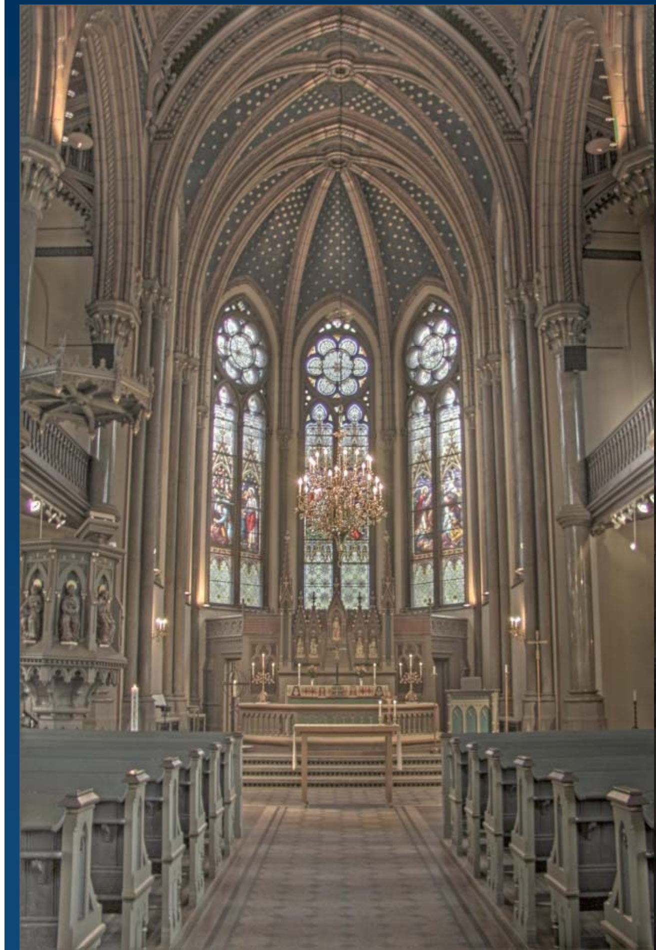

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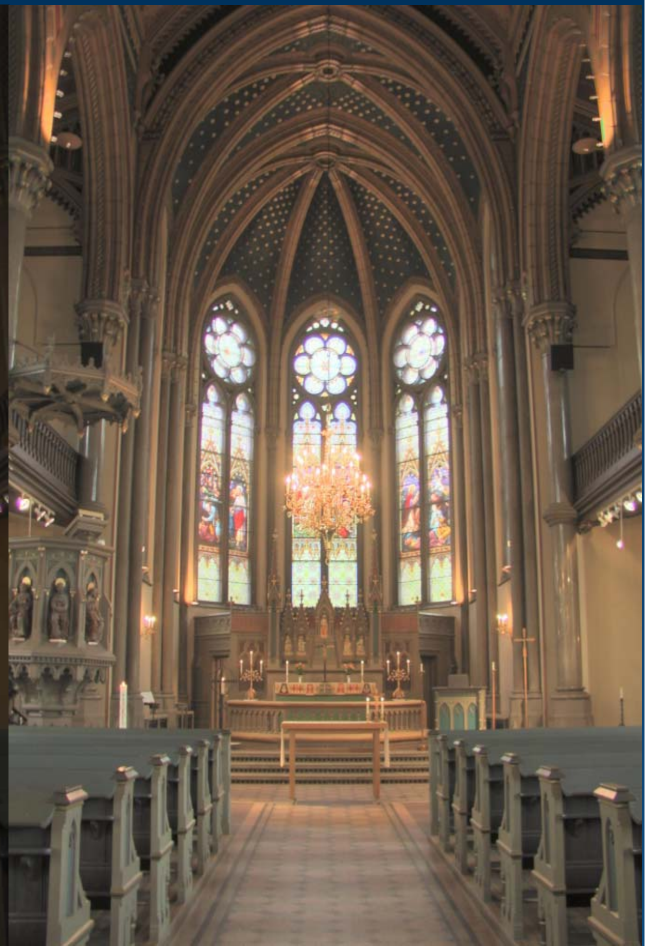

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Formal validation