Gradient Domain High Dynamic Range Compression

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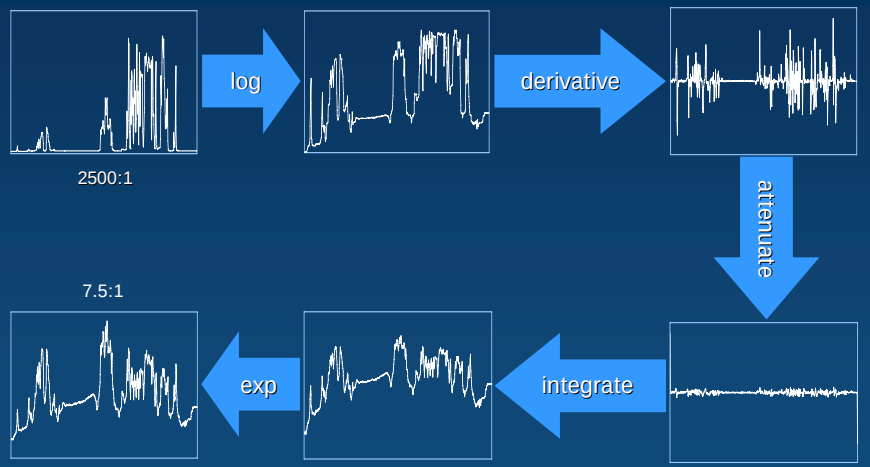
The Method in 1D



The Method in 2D

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

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

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

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

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

$$\begin{bmatrix} \cdots & 1 & \cdots \\ 1 & -4 & 1 \\ \cdots & 1 & \cdots \end{bmatrix} \begin{bmatrix} \\ \\ \\ \end{bmatrix} = \begin{bmatrix} \\ \\ \\ \end{bmatrix}$$

Attenuation

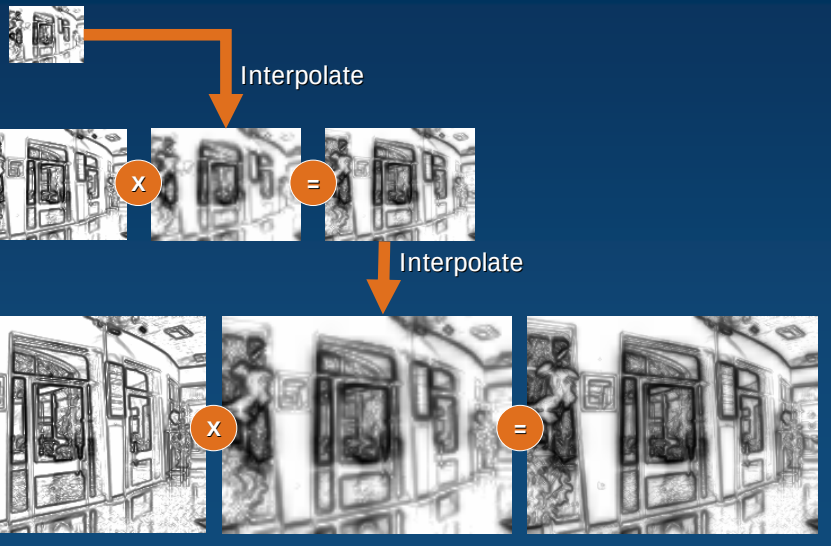
$$\varphi_k(x,y)=\frac{\alpha}{\|\nabla H_k(x,y)\|}\left(\frac{\|\nabla H_k(x,y)\|}{\alpha}\right)^{\beta}$$

log(Luminance)

Gradient magnitude

Attenuation map

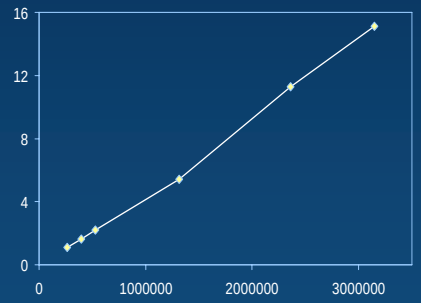
Multiscale Gradient Attenuation



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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Formal validation