Gradient Domain High Dynamic Range Compression

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The Method in 1D

2500:1

log

derivative

attenuate

7.5:1

exp

integrate
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: $\int \int F(\nabla I, G) \, dx \, dy$

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

\[
\frac{\partial^2 I}{\partial x^2} + \frac{\partial^2 I}{\partial y^2} = \frac{\partial G}{\partial x} + \frac{\partial G}{\partial y} \quad \text{Poisson equation}
\]
Solve
\[
\frac{\partial^2 I}{\partial x^2} + \frac{\partial^2 I}{\partial y^2} = \frac{\partial G_x}{\partial x} + \frac{\partial G_y}{\partial y}
\]

\[
G_x (x, y) - G_x (x - 1, y) + G_y (x, y) - G_y (x, y - 1)
\]

\[
I(x + 1, y) + I(x - 1, y) + I(x, y + 1) + I(x, y - 1) - 4I(x, y)
\]
**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

Interpolate

Interpolate

Interpolate
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.]
Informal comparison

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