Visually Significant Edges

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MPI Informatik
Edge Detection

Zero crossings of the second derivative
Marr and Hildreth [1980]

Maxima of the first derivative
Canny [1986]

Multiscale Edge Detection
(see Pellegrino et al. [2004])
Edge Preserving Image Decompositions

**Bilateral Filter**
Durand and Dorsey [2002]

**Weighted Least Squares (WLS)**
Farbman et al. [2008]

**2nd Generation Wavelets**
Fattal [2009]
Applications

Image Editing in Contour Domain
Elder and Goldberg [2001]

Stylization
[Orzan et al. 2007]

Contrast Editing [Farbman et al. 2008]
Contrast Perception

**Contrast Sensitivity Function (CSF)**
[Daly 1993; Barten 1999]

**Visual Masking:**
- **Intra-channel**
  [Legge and Foley 1980; Wilson 1980; Mantiuk et al. 2006]
- **Inter-channel**
  [Watson and Solomon 1997; Zeng et al. 2000]
Summary of the "Lifting Scheme"
2nd Generation Wavelets

- Bases do not have to be translates and dilates of each other.
- Bases are expressed through a weighting function that depends on some neighborhood.
- In the Edge Avoiding Framework: the weight $w$ of the current pixel $m$ as a function of the intensity of some neighboring pixel $n$:

$$
\omega(m, n) = \frac{1}{(|\nu(m, n)|^\alpha + \epsilon)}
$$

$v$ is the **edge importance function**
Contrast in EAW Framework

Weber's Contrast:

\[ W = \frac{L - L_{bg}}{L_{bg}} \]

Lifting Scheme approximation:

\[ C = \frac{\text{Fine}}{\left(\frac{1}{K}\right) \sum_{K} \text{Coarse}_k} - 1 \]
2D Neighborhood

X-Y Splitting

Red/Black - Blue/Yellow Splitting
(Low anisotropy)
Contrast Sensitivity Function

Sensitivity depends on:
- Adaptation Luminance
- Spatial frequency of the contrast patch

\[ C' = C \cdot CSF(\rho, L_a) \]
The Contrast Effect

Input luminance profile

Gradient

Contrast
Smoothing with **luminance adaptation**
Visual Masking

- The decrease of sensitivity to a signal due to the presence of "similar" signals.
- JPEG 2000 Point-wise extended masking:

\[ R = \frac{\text{sign}(C')|C'|^{0.5}}{(1 + \sum_{K} |C'_k|^{0.2})} \]
The Visual Masking Effect

Input luminance profile

Gradient

Visual Significance
Smoothing with visual masking
Subjective Study

Experimental Procedure

threshold-level perceptual experiment
two adjacent grayscale patches
calibrated Barco Coronis MDCC 3120 DL (10b)
PEST procedure
random noise between stimuli
10 trials per subject (1.5 - 400 cd/m^2)
22 subjects
Model Calibration

Calibration procedure and results

measured thresholds --> 2nd order polynomial --> 100 calibration stimuli
model output should be $R=1$JND for stimulus at threshold

calibration by linear function:

$$R' = \frac{R}{0.0002 L_a + 0.2822}.$$
HDR Retargeting - Preserve scanlines containing strong edges
HDR Retargeting (2)

Original

Avidan and Shamir [2007]

EAW + visual significance
Avidan and Shamir [2007]

EAW + visual significance

EAW + Drago'03

HDR Retargeting (3)
Original

Avidan and Shamir [2007]

EAW + visual significance

EAW + Drago'03

HDR Retargeting (4)
**Tone Mapping** - Compress wavelet components by a factor of `b_scale`, s.t. low frequencies are compressed more aggressively.
EAW

EAW +
visual significance

Tone Mapping (2)
Hiding Seams in HDR Panoramas

Basic principle [Ward 2006]:
- Blend low frequencies
- Splice high frequencies near strong edges

Seams are "masked" by strong edges.

Our modification:
Compute visually significant edges $E$, then:

$$E = \max(E_{left} \cdot E_{right}, 0)$$
HDR Panorama Stitching

Ward [2006]

EAW +

visual significance
Thank You.