SIGGRAPH2007

A Gentle Introduction to Bilateral Filtering and its Applications

SIGGRAPH2007

08/10: Applications: Advanced uses of Bilateral Filters

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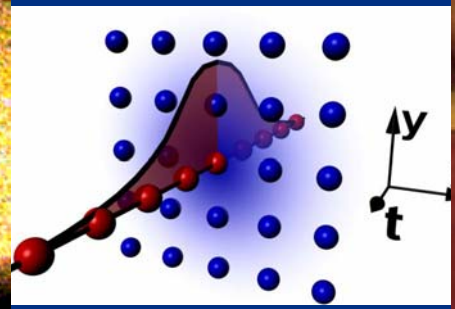
Advanced Uses of Bilateral Filters



Advanced Uses for Bilateral

A few clever, exemplary applications…

- Flash/No Flash Image Merge (Petschnigg2004,Eisenman2004)
- Tone Management (Bae 2006)
- Exposure Correction (Bennett2006)

  (See also: Bennett 2007
  Multispectral Bilateral Video Fusion, IEEE Trans. On Img Proc)

Many more, many new ones…

– 6 new SIGGRAPH 2007 papers!

Flash / No-Flash Photo Improvement (Petschnigg04) (Eisemann04)

Merge best features: warm, cozy candle light (no-flash)
low-noise, detailed flash image

‘Joint Bilateral’ or ‘Cross Bilateral’ (2004)

Bilateral → *two kinds* of weights,

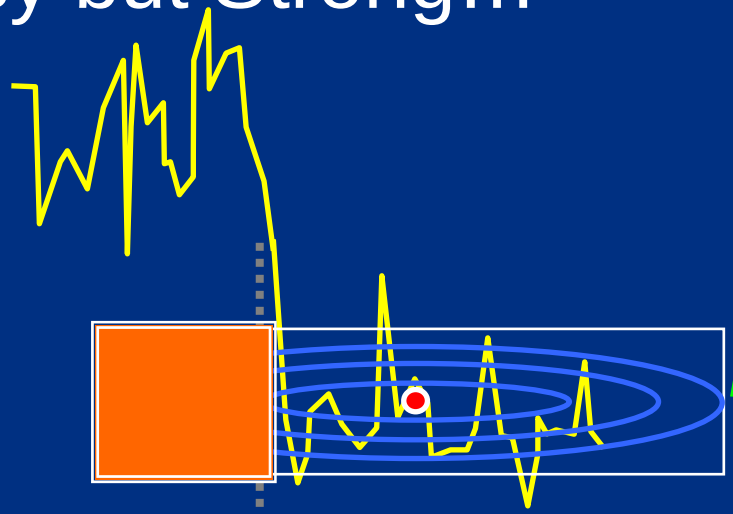
Cross Bilateral Filter (CBF):

→ get them from *two kinds* of images.

- Spatial smoothing of pixels in image A, with
- WEIGHTED by intensity similarities in image B:

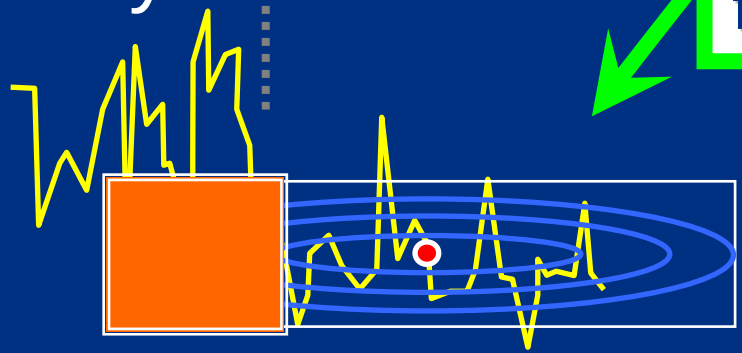
‘Cross’ or ‘Joint’ Bilateral Idea:

Noisy but Strong…

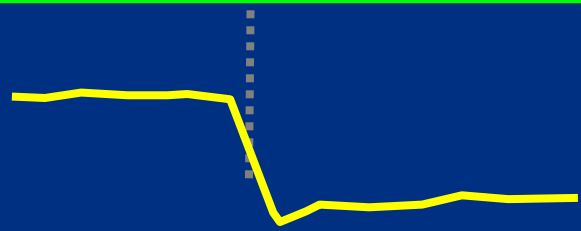


Range filter preserves signal

Noisy and Weak…



Use stronger signal’s range filter weights…



‘Joint’ or ‘Cross’ Bilateral Filter (CBF)

- Enhanced ability to find weak details in noise
  (B’s weights preserve similar edges in A)

- Useful Residues for ‘Detail Transfer’
  - CBF(A,B) to remove A’s noisy details
  - CBF(B,A) to remove B’s less-noisy details;
  - add to CBF(A,B) for clean, detailed, sharp image

  (See the papers for details)

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Overview

Basic approach of both flash/noflash papers

Remove noise + details from image A,

Keep as image A Lighting

Obtain noise-free details from image B,

Discard Image B Lighting

Petschnigg: Detail Transfer Results

- Lamp made of hay:

No Flash

Flash

Detail Transfer

Petschnigg:

- Flash

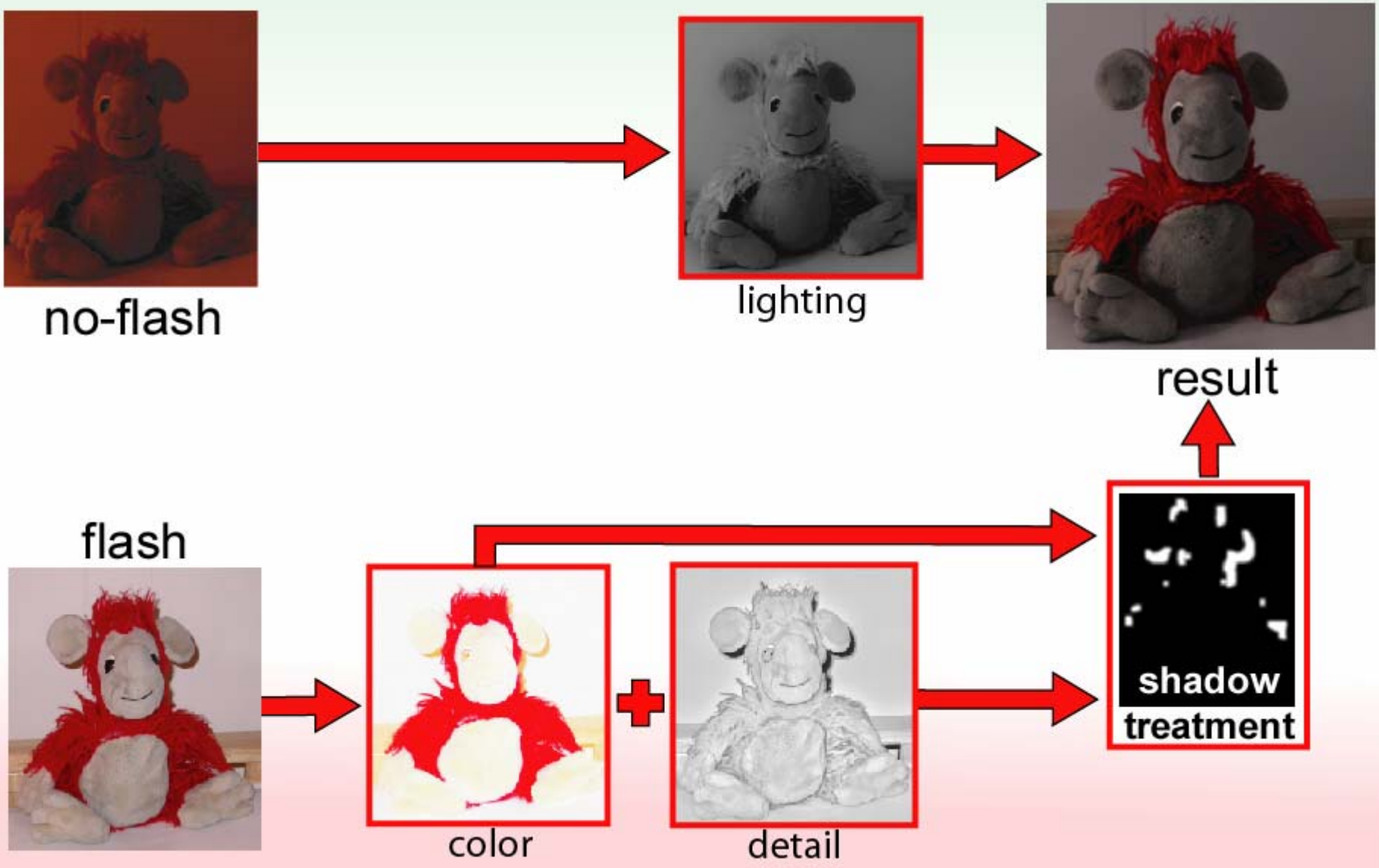
Petschnigg:

- No Flash,

Petschnigg:

- Result

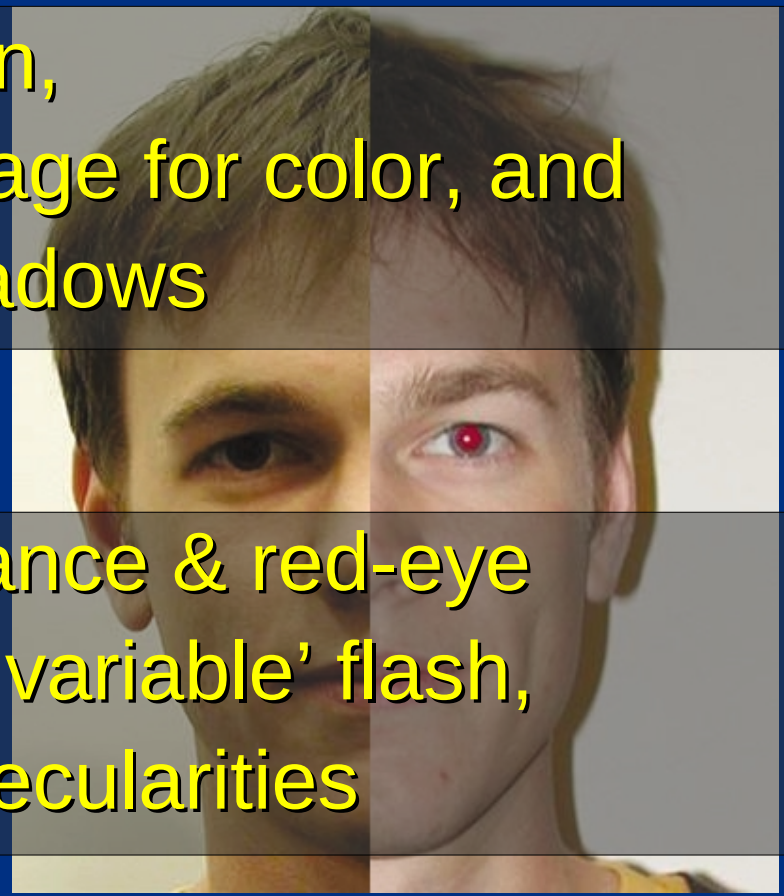
Approaches - Main Idea



Petschnigg04, Eisemann04 Features

Eisemann 2004:

--included image registration,
--used lower-noise flash image for color, and
--compensates for flash shadows



Petschnigg 2004:

--included explicit color-balance & red-eye
--interpolated ‘continuously variable’ flash,
--Compensates for flash specularities

Tonal Management (Bae et al., SIGGRAPH 2006)

Cross bilateral, residues →
visually compelling
image decompositions.

- Explore: adjust component contrast, find visually pleasing transfer functions, etc.
- Stylize: finds transfer functions that match histograms of preferred artists,
- 'Textureness'; local measure of textural richness; can use this to guide local mods to match artist's

Tone Mgmt. Examples:

Original

Tone Mgmt. Examples:

‘Bright and Sharp’

Tone Mgmt. Examples:

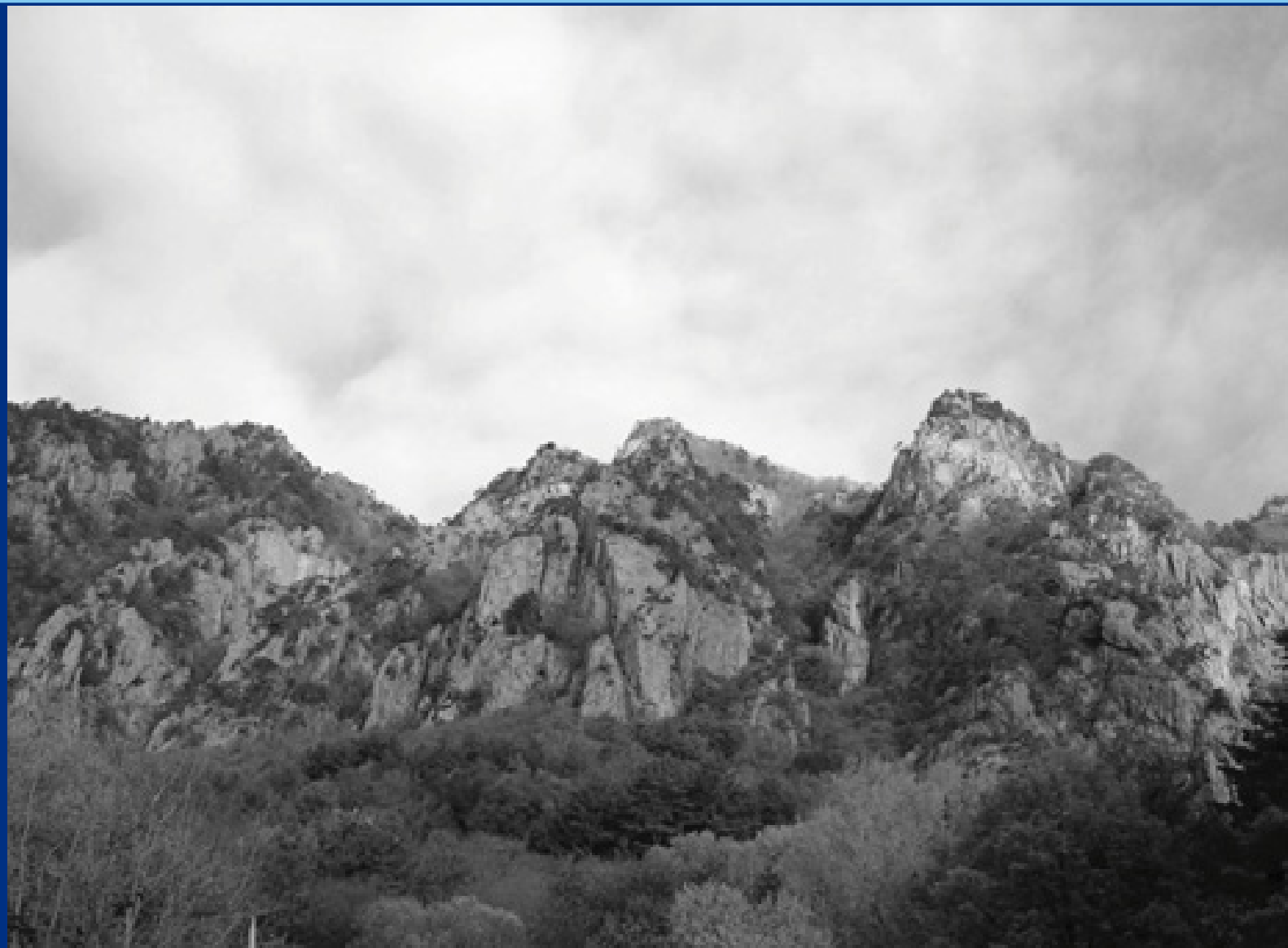
Gray and detailed

Tone Mgmt. Examples:

Smooth and grainy

Tone Management Examples

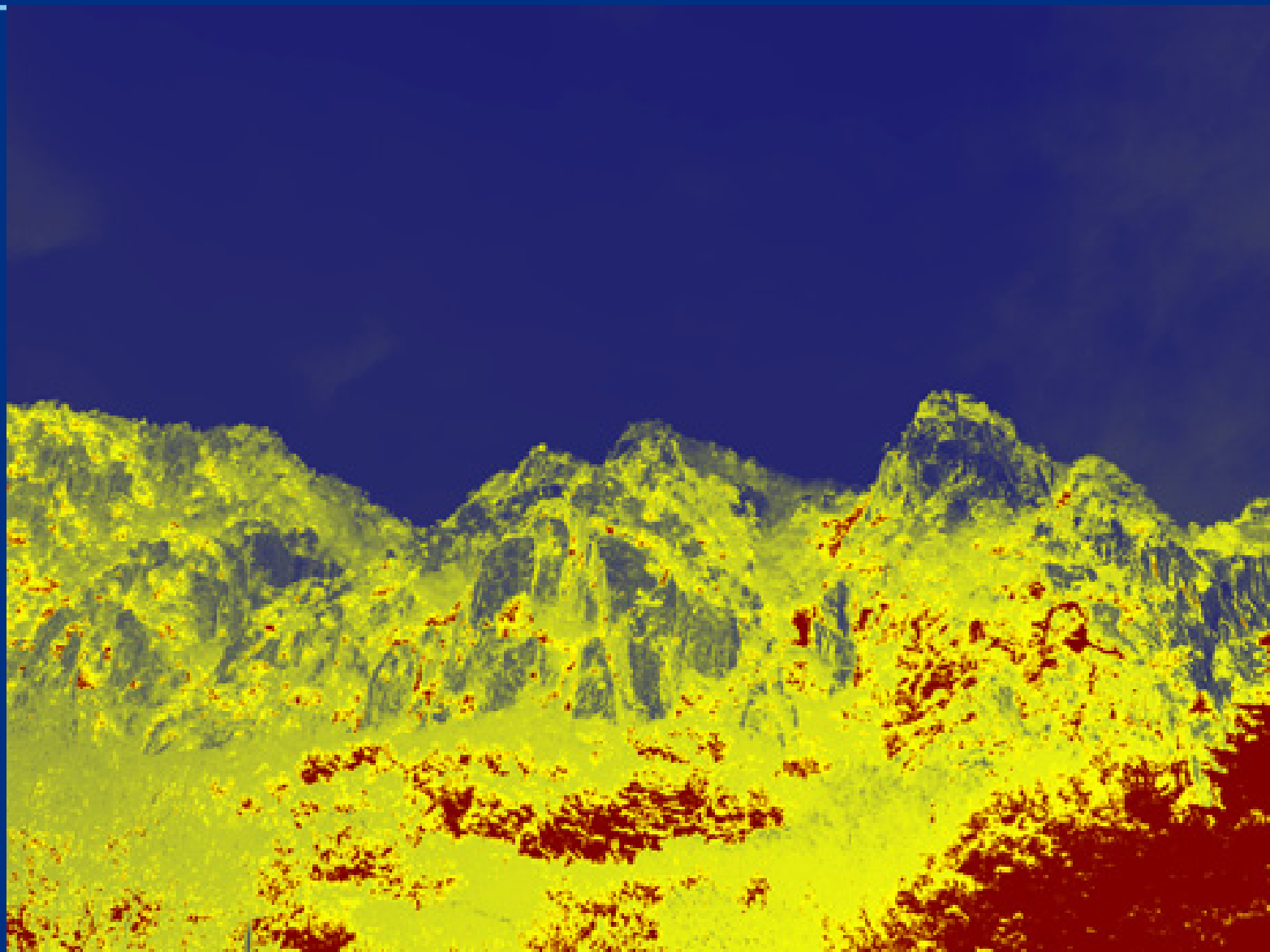
Source



Tone Management (Bae06)

‘Textured-ness’ Metric:

(shows highest Contrast-adjusted texture)



Reference Model

Model: Ansel Adams

Input with auto-levels

Results

Results

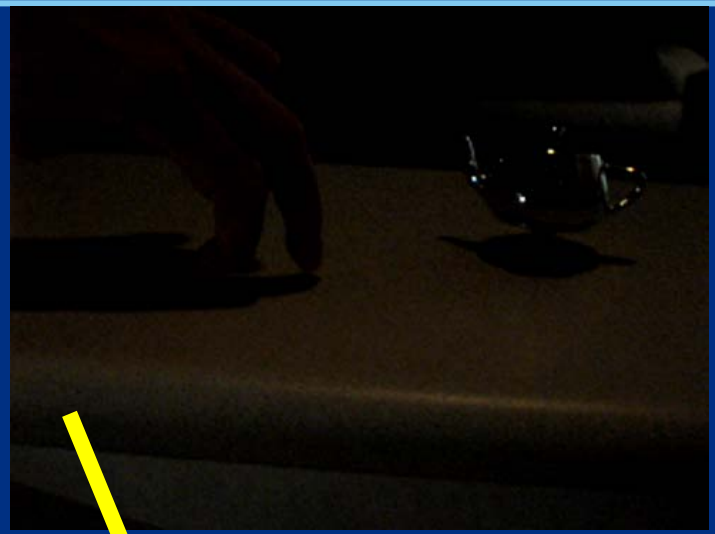
- Direct Histogram Transfer (dull)

Results

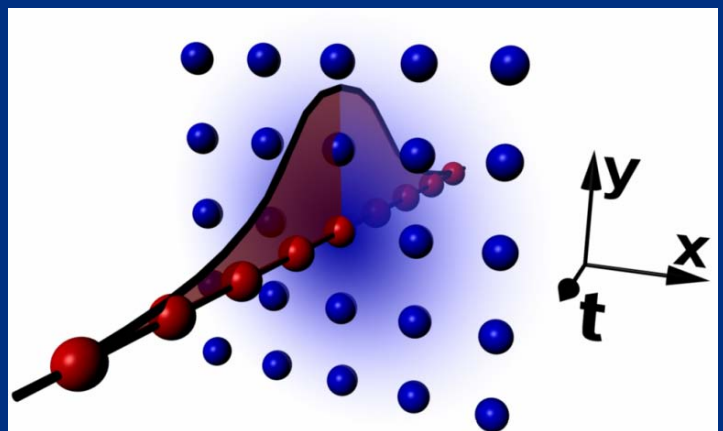
- Best…

Video Enhancement Using Per Pixel Exposures (Bennett, 06)

From this video:



ASTA: ***A*daptive**
***S*patio-**
***T*emporal**
***A*ccumulation** Filter



VIDEO

The Process for One Frame

- Raw Video Frame: (from FIFO center)
- Histogram stretching; (estimate gain for each pixel)
- *'Mostly Temporal'* Bilateral Filter:
  - Average recent similar values,
  - Reject outliers (avoids 'ghosting'), spatial avg as needed
  - Tone Mapping

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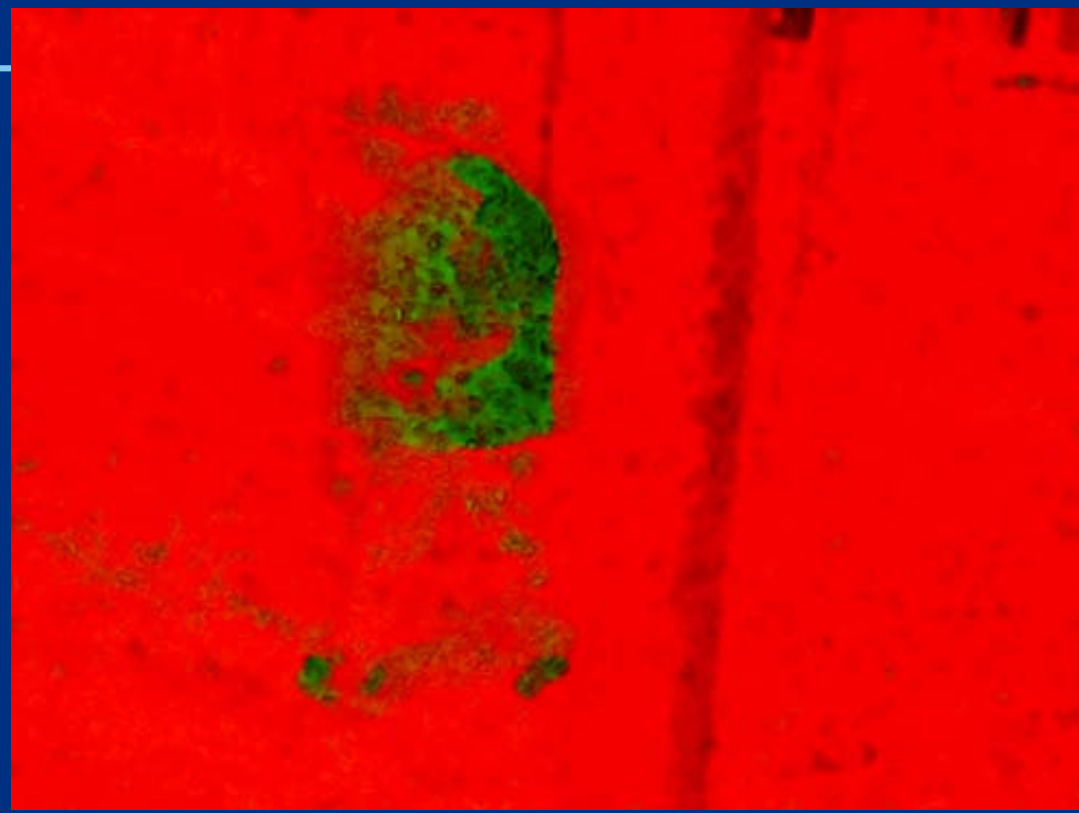

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(color: # avg' pixels)

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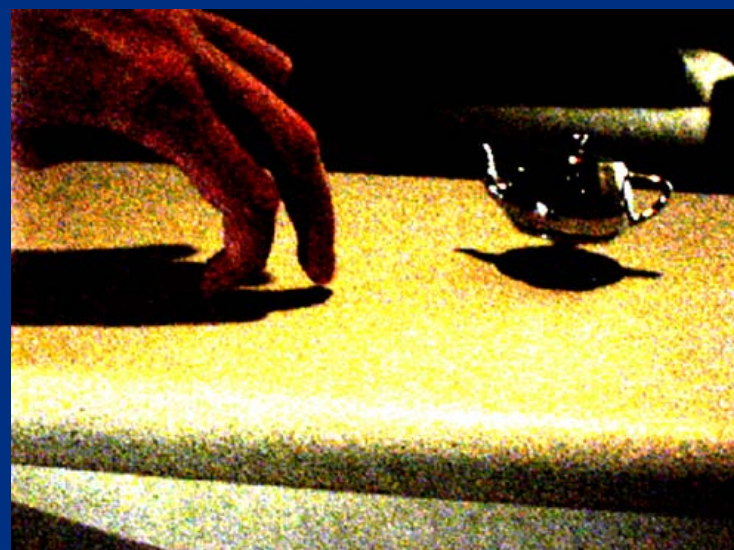
Bilateral Filter Variant: Mostly Temporal

- FIFO for Histogram-stretched video
  - Carry gain estimate for each pixel;
  - Use *future* as well as previous values;
- Expanded Bilateral Filter Methods:
  - Static scene? Temporal-only avg. works well
  - Motion? Bilateral rejects outliers: no ghosts!
- Generalize: ‘Dissimilarity’ (not just $|| I_p - I_q ||^2$)
- Voting: spatial filter de-noises motion

Multispectral Bilateral Video Fusion (Bennett,07)

- Result:
  - Produces watchable result from unwatchable input
  - ***VERY*** robust; accepts almost any dark video;
  - Exploits temporal coherence to emulate Low-light HDR video, without special equipment



Conclusions

- Bilateral Filter easily adapted, customized to broad class of problems
- One tool among many for complex problems
- Useful in for any task that needs Robust, reliable smoothing with outlier rejection

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