SIGGRAPH2008

A Gentle Introduction to Bilateral Filtering and its Applications

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10/10: Conclusions

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The Bilateral Filter

- As Simple as
  Weights from *two* Gaussian Functions;

- Has deep connections to PDE formalisms,
  shock-forming, heat flow, and diffusion

- Speed? several *very fast* versions

Bilateral Filter

GOALS are Ambitious & Subjective, but

- Noise Removal
- “Edge-Preserving Smoothing”
- Locally Weighted Averaging with Outlier Rejection
- Visual Separation of ‘fine details’ and ‘large features’

METHODS are Simple & Practical

- Bilateral Filter: doubly-weighted local average,
  High weights only for ‘nearby’, ‘similar’ values
- **YOU** decide parameters of what is **“nearby”**,
  of what is **“similar”**

VERY Broad Range of Applications:

- any task where **‘edges’** and **‘similarities’** carry useful information

- data of arbitrary dimensions;
  M to N, time, color,
  image vector-spaces, etc,

- even on manifolds →3D meshes, etc.

Explosive Growth: at SIGGRAPH, EUROGRAPHCIS, CVPR, ICCV, ECCV…

- *Image Deblurring with Blurred/Noisy Image Pairs* — L. Yuan, et al.
- *Multiscale Shape and Detail Enhancement from Multi-Light Image Collections* — R. Fattal et al.
- *Joint Bilateral Upsampling* — J. Kopf et al.
- *LDR2HDR: On-the-fly Reverse Tone Mapping of Legacy Video and Photographs* — A. G. Rempel et al.
- *Factored Time-Lapse Video* — K. Sunkavalli et al.
- Computational Time-Lapse Video — E. Bennett et al.
- *Real-Time Edge-Aware Image Processing With the Bilateral Grid* — J. Chen et al.
- *Constant Time O(1) Bilateral Filtering* — Fatih Porikli
- *A Hybrid Camera for Motion Deblurring and Depth Map Super-Resolution* — Feng Li, et al.
- *Geo-spatial Aerial Video Processing for Scene Understanding and Object Tracking* — Jiangjian Xiao, et al.
- *Illumination and Camera Invariant Stereo Matching* — Yong Seok Heo, et al.
- *Enhancing Photographs with Near Infrared Images* — Xiaopeng Zhang,et al.
- *FuzzyMatte: A Computationally Efficient Scheme for Interactive Matting* — Yuanjie Zheng, et al.
- *Accurate Multi-View Reconstruction Using Robust Binocular Stereo and Surface Meshing* — Derek Bradley, et al.
- *Demosaicing by Smoothing along 1D Features* — Boris Ajdin, et al.

AND MANY MORE

Is All the Work Finished?

- Nothing left to explore?

No, No, No!

Bilateral filters raise deep, basic questions;
Answers still vague and tentative..

For example …

What Is ‘Noise’? What is ‘Texture’?

Wet Sand (Jay Sekora)

What Is ‘Noise’? What is ‘Texture’?

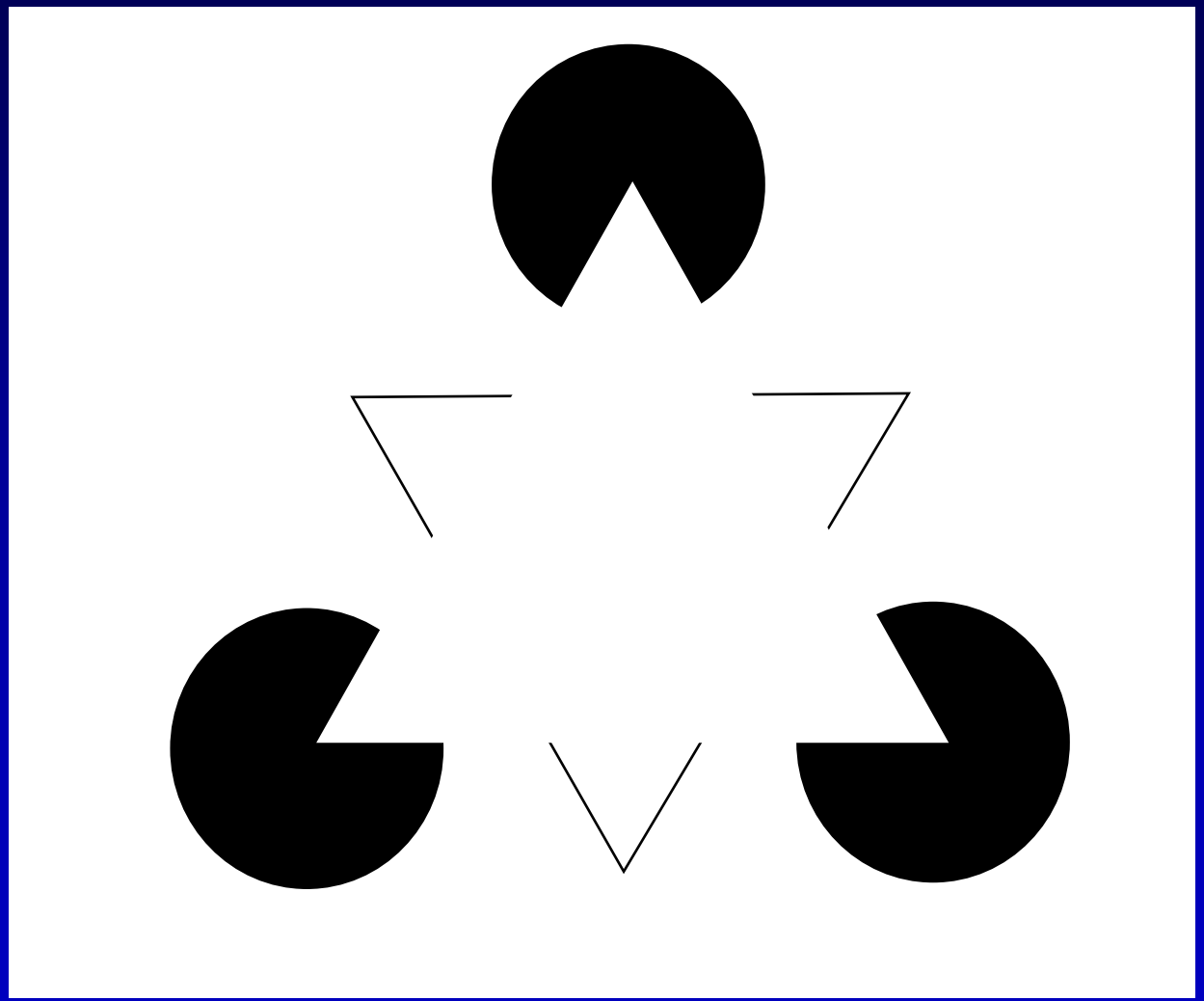
Human Skin (Ken Perlin)

What Is ‘texture’? What is an ‘Edge’?

Fine details don’t always match large structures

Wireframe VW Beetle [The Cellar: Image of the Day]

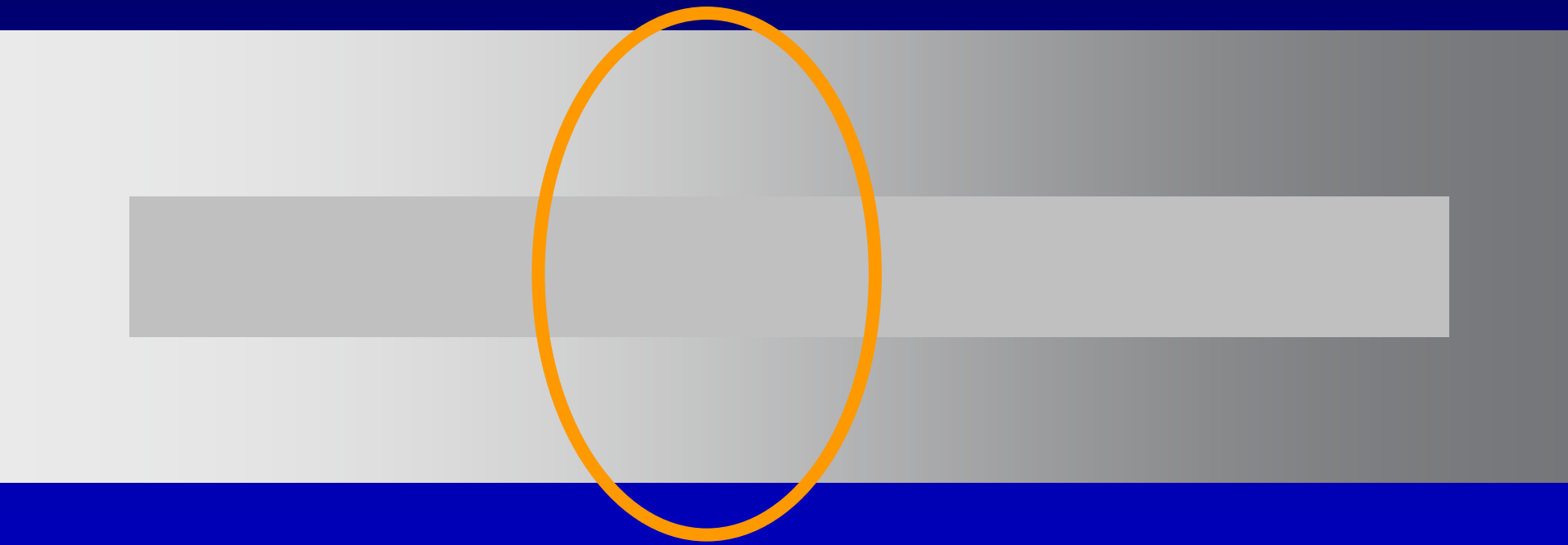
What Is an ‘Edge’ in Human Vision?



Illusory Contours (G. Kanizsa, 1955)

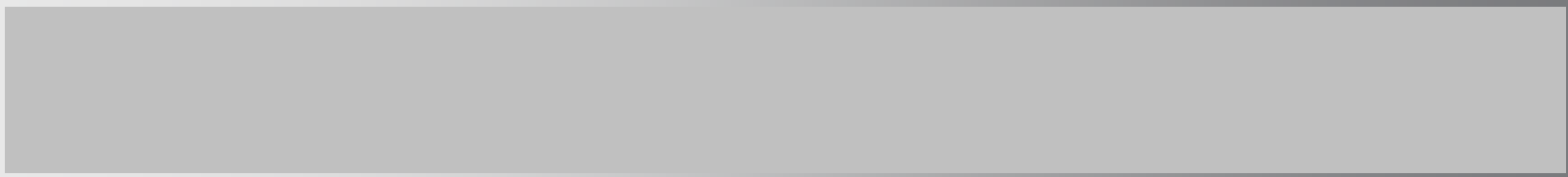
What Is an ‘Edge’ in Human Vision?

Do edges exist here?



Does *absolute* intensity matter?

Often, Perceived Intensities ≠ Pixel Values:



Example: 'Simultaneous Contrast'
Center strip has <u>CONSTANT</u> intensity…

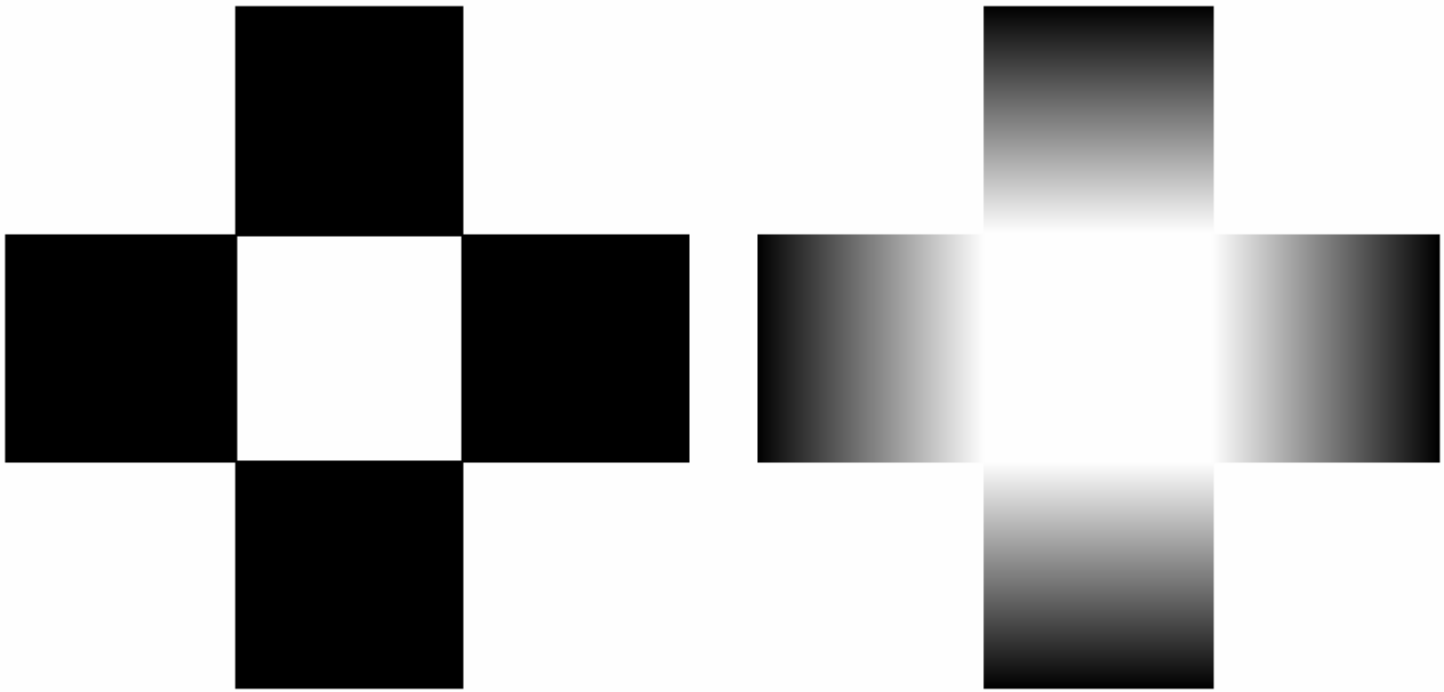
Does *absolute* intensity matter?

Often, Perceived Intensities ≠ Pixel Values:

Example: 'Simultaneous Contrast'
Center strip has <u>CONSTANT</u> intensity…

What Is an ‘Illumination Edge’?

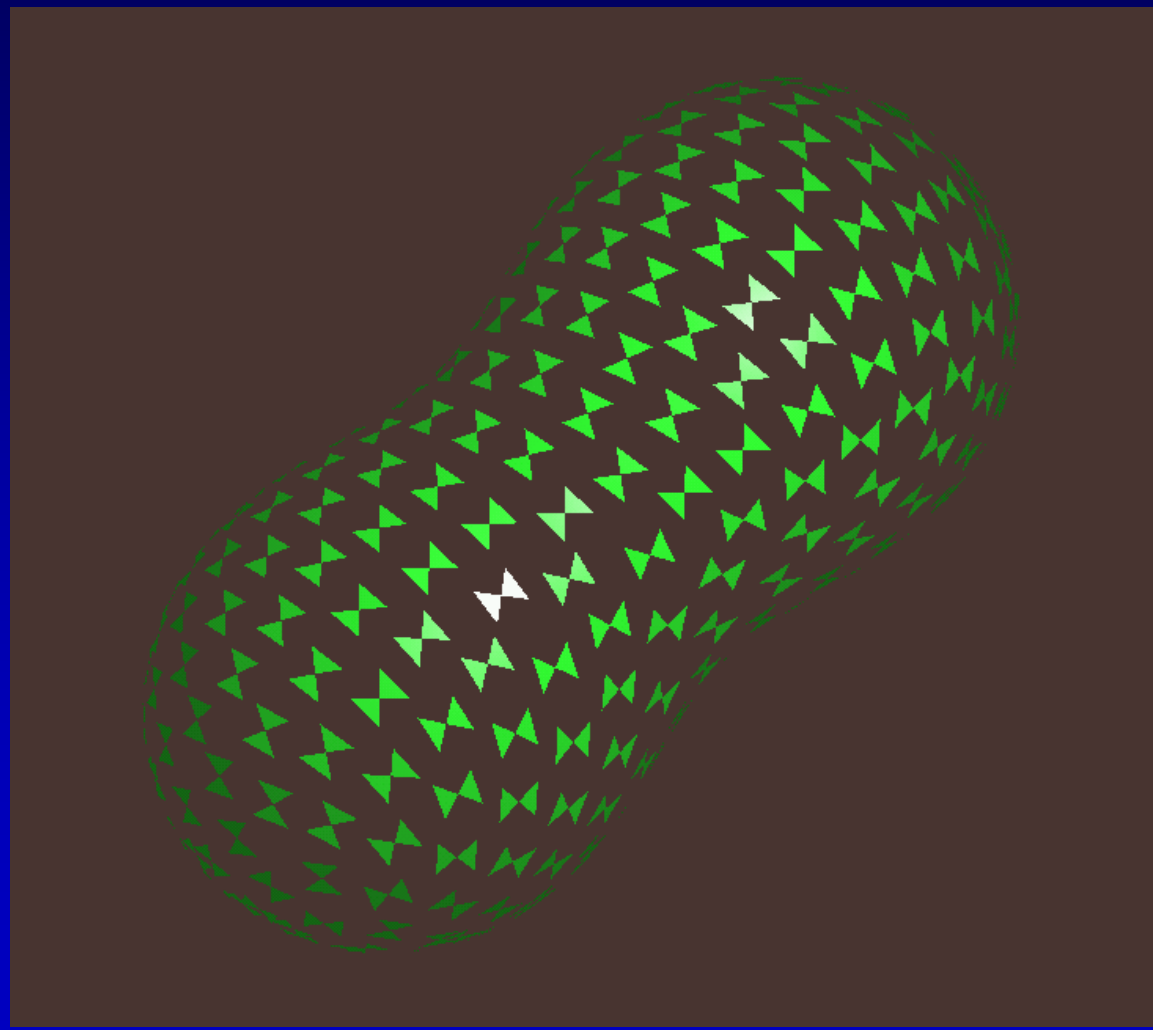
Sometimes it isn’t a large *intensity* change…



What Is a ‘Geometric Edge’ in Images?

3D ‘Peanut’ shape

Some silhouettes are **SUGGESTED** by shape cues



What Is an ‘Edge’ at The Finest Scales?

Scale Problems:

Can’t resolve every hair and fiber in fur…

Long Black Whiskers:

- Visible on Bkgnd, but
- Visible against fur?

Albrecht Durer (1502)
“Young Hare”

For any perceivable image?

Hmm.

Edge?
Noise?
Regions?
Texture?
Silhouette?
…

http://mfrost.typepad.com/cute_overload/2007/02/backlit_extrava.html

Thank You For Attending!

- For more in-depth info: links, and all docs:

http://people.csail.mit.edu/sparis/bf_course

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Conclusions

- 10 Minutes
- <14 slides