

# Computational Photography

Digital Visual Effects, Spring 2009

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## Computational photography

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wikipedia:

**Computational photography** refers broadly to computational imaging techniques that enhance or extend the capabilities of digital photography. The output of these techniques is an ordinary photograph, but one that could not have been taken by a traditional camera.

## What is computational photography

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- Convergence of image processing, computer vision, computer graphics and photography
- Digital photography:
  - Simply mimics traditional sensors and recording by digital technology
  - Involves only simple image processing
- Computational photography
  - More elaborate image manipulation, more computation
  - New types of media (panorama, 3D, etc.)
  - Camera design that take computation into account

## Computational photography

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- One of the most exciting fields.
- [Symposium on Computational Photography and Video](#), 2005
- Full-semester courses in MIT, CMU, Stanford, GaTech, University of Delaware
- A new book by Raskar and Tumblin in SIGGRAPH 2007.
- [IEEE International Conference on computational Photography](#), San Francisco, 2009.

## Siggraph 2006 Papers (16/86=18.6%)

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Hybrid Images  
 Drag-and-Drop Pasting  
 Two-scale Tone Management for Photographic Look  
 Interactive Local Adjustment of Tonal Values  
 Image-Based Material Editing  
 Flash Matting  
 Natural Video Matting using Camera Arrays  
 Removing Camera Shake From a Single Photograph  
 Coded Exposure Photography: Motion Deblurring  
 Photo Tourism: Exploring Photo Collections in 3D  
 AutoCollage  
 Photographing Long Scenes With Multi-Viewpoint Panoramas  
 Projection Defocus Analysis for Scene Capture and Image Display  
 Multiview Radial Catadioptric Imaging for Scene Capture  
 Light Field Microscopy  
 Fast Separation of Direct and Global Components of a Scene Using High Frequency Illumination

## Siggraph 2007 Papers (23/108=21.3%)

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Image Deblurring with Blurred/Noisy Image Pairs  
 Photo Clip Art  
 Scene Completion Using Millions of Photographs  
 Soft Scissors: An Interactive Tool for Realtime High Quality Matting  
 Seam Carving for Content-Aware Image Resizing  
 Detail-Preserving Shape Deformation in Image Editing  
 Veiling Glare in High Dynamic Range Imaging  
 Do HDR Displays Support LDR content? A Psychophysical Evaluation  
 Ldr2hdr: On-the-fly Reverse Tone Mapping of Legacy Video and Photographs  
 Rendering for an Interactive 360-Degree Light Field Display  
 Multiscale Shape and Detail Enhancement from Multi-light Image Collections  
 Post-Production Facial Performance Relighting Using Reflectance Transfer  
 Active Refocusing of Images and Videos  
 Multi-aperture Photography  
 Dappled Photography: Mask-Enhanced Cameras for Heterodyned Light Fields and Coded Aperture Refocusing  
 Image and Depth from a Conventional Camera with a Coded Aperture  
 Capturing and Viewing Gigapixel Images  
 Efficient Gradient-Domain Compositing Using Quadrees  
 Image Upsampling via Imposed Edges Statistics  
 Joint Bilateral Upsampling  
 Factored Time-Lapse Video  
 Computational Time-Lapse Video  
 Real-Time Edge-Aware Image Processing With the Bilateral Grid

## Siggraph 2009 Papers (17/78=21.8%)

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[Gaussian KD-Trees for Fast High-Dimensional Filtering](#)  
[Edge-Avoiding Wavelets and their Applications](#)  
[Multi-operator Media Retargeting](#)  
[PatchMatch: A Randomized Correspondence Algorithm for Structural Image Editing](#)  
[Modeling Human Color Perception under Extended Luminance Levels](#)  
[Moving Gradients: A Path-Based Method for Plausible Image Interpolation](#)  
[Optimizing Content-Preserving Projections for Wide-Angle Images](#)  
[Content-Preserving Warps for 3D Video Stabilization](#)  
[Visio-lization: Generating Novel Facial Images](#)  
[Coordinates for Instant Image Cloning](#)  
[SkyFinder: Attribute-based Sky Image Search](#)  
[Paint Selection](#)  
[Video SnapCut: Robust Video Object Cutout Using Localized Classifiers](#)  
[Invertible Motion Blur in Video](#)  
 Dark Flash Photography  
[4D Frequency Analysis of Computational Cameras for Depth of Field Extension](#)  
 Bokode: Imperceptible Visual Tags for Camera-based Interaction from a Distance

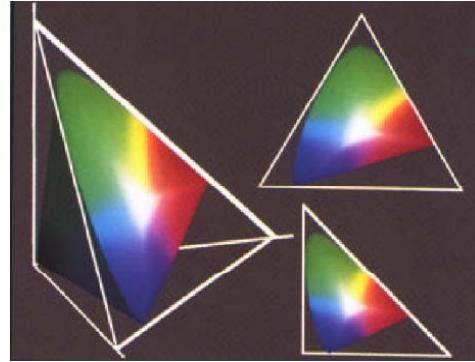
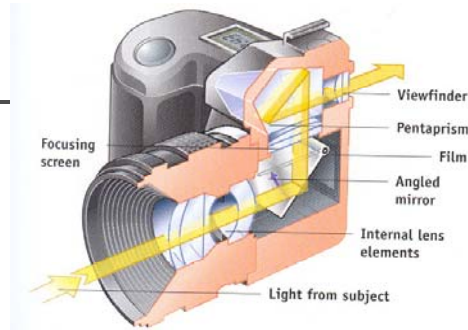
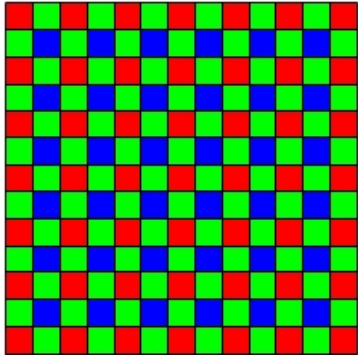
## Scope

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- We can't yet set its precise definition. The following are scopes of what researchers are exploring in this field.
  - Record a richer visual experience
  - Overcome long-standing limitations of conventional cameras
  - Enable new classes of visual signal
  - Enable synthesis impossible photos

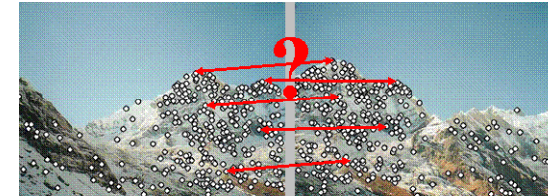
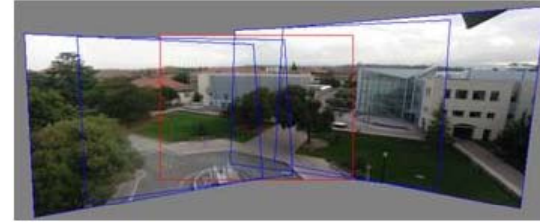
## Scope

- Image formation
- Color and color perception



## Scope

- Panoramic imaging
- Image and video registration
- Spatial warping operations

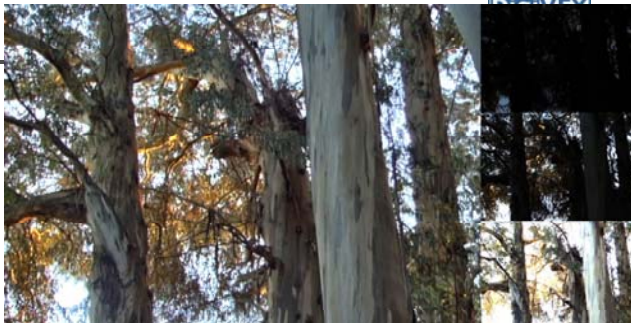


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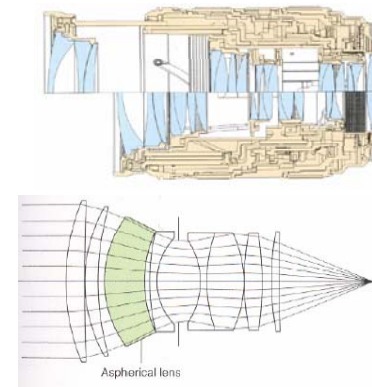
## Scope

- High Dynamic Range Imaging
- Bilateral filtering and HDR display
- Matting



## Scope

- Active flash methods
- Lens technology
- Depth and defocus

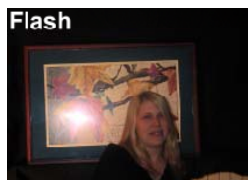
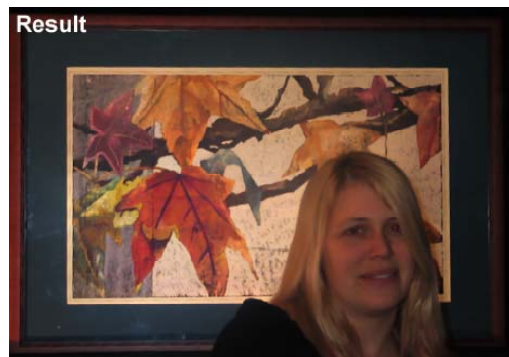
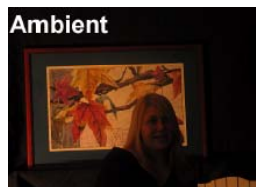


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## Removing Photography Artifacts using Gradient Projection and Flash-Exposure Sampling

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## Continuous flash

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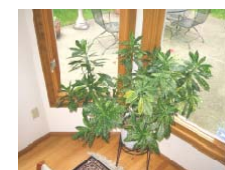
Flash = 0.0



Flash = 1.0



Flash = 0.3



Flash = 0.7



Flash = 1.4

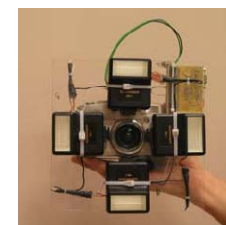
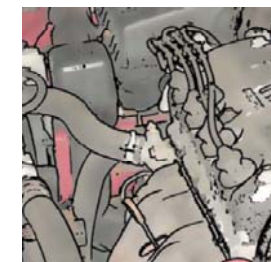
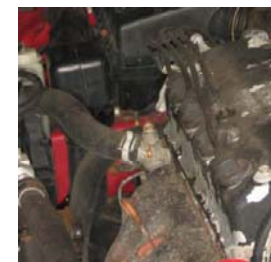
## Flash matting

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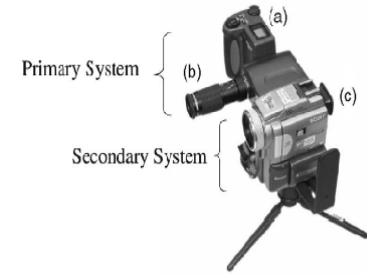


## Depth Edge Detection and Stylized Rendering Using a Multi-Flash Camera

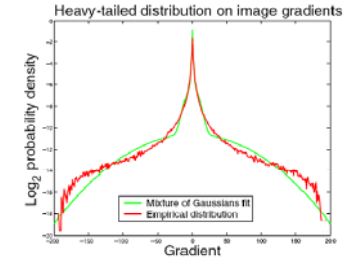
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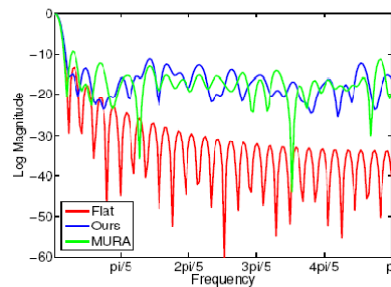
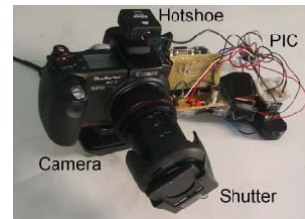
# Motion-Based Motion Deblurring



# Removing Camera Shake from a Single Photograph



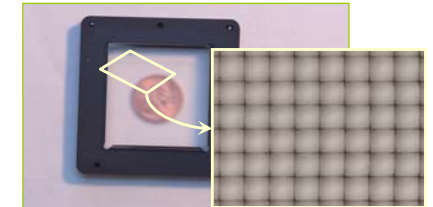
# Motion Deblurring using Fluttered Shutter



# Scope



- Future cameras
- Plenoptic function and light fields



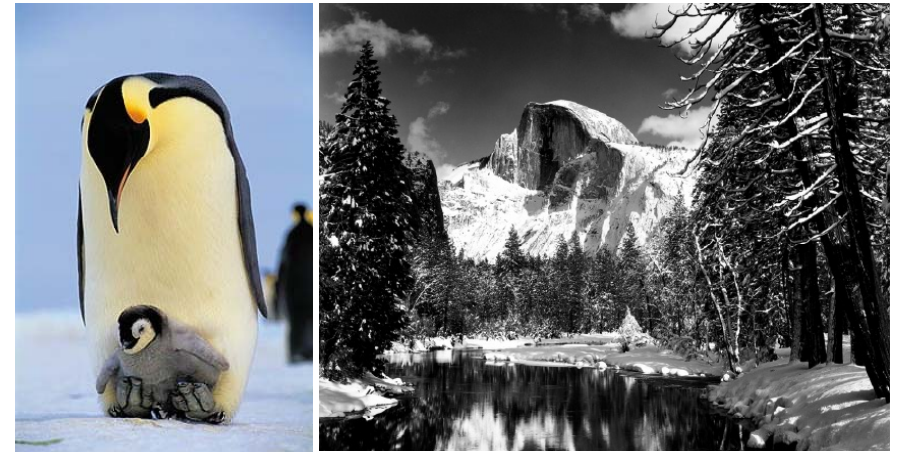
# Scope

- Gradient image manipulation



# Scope

- Taking great pictures



Art Wolfe

Ansel Adams

# Scope

- Non-parametric image synthesis, inpainting, analogies

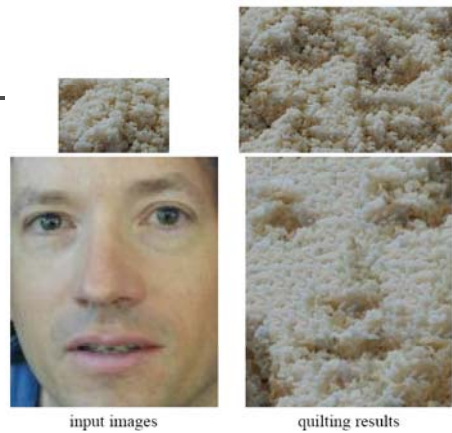


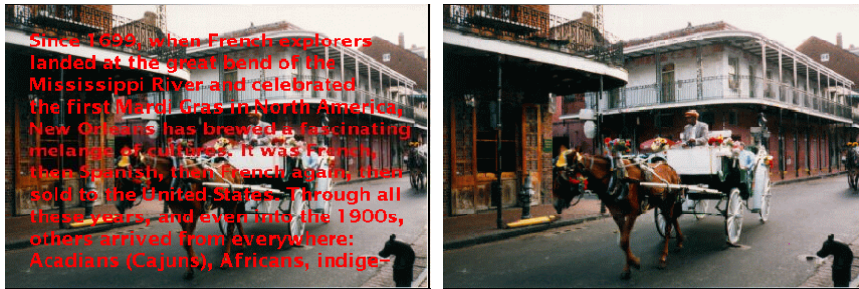
Figure 1 An image analogy. Our problem is to compute a new "analogous" image  $B'$  that relates to  $B$  in "the same way" as  $A'$  relates to  $A$ . Here,  $A$ ,  $A'$ , and  $B$  are inputs to our algorithm, and  $B'$  is the output. The full-size images are shown in Figures 10 and 11.

# Scope

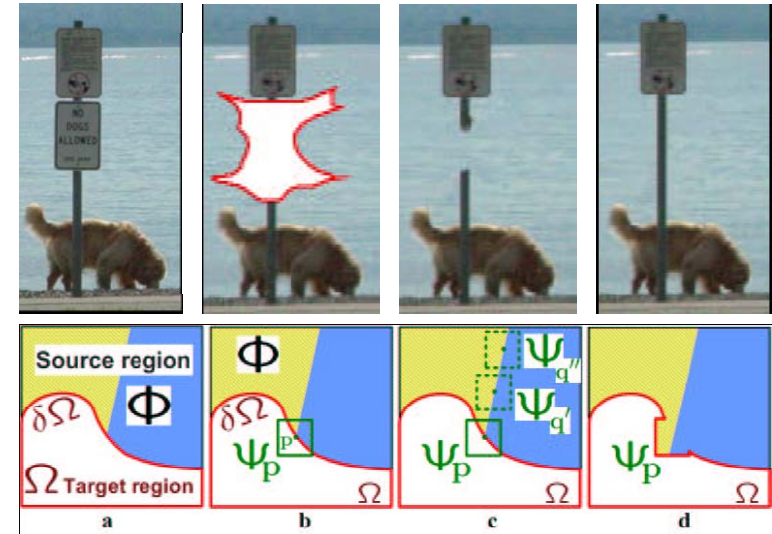
- Motion analysis



# Image Inpainting



# Object Removal by Exemplar-Based Inpainting



# Image Completion with Structure Propagation

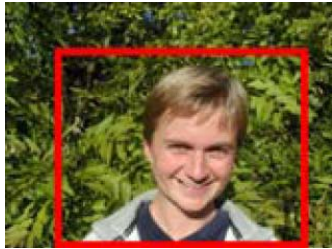


# Lazy snapping



## Grab Cut - Interactive Foreground Extraction using Iterated Graph Cuts

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## Tools

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- Graph cuts,
  - Segmentation and mosaicing
- Gradient domain operations,
  - Tone mapping, fusion and matting
- Bilateral filters,
  - Denoising, image enhancement