Cross-fertilization with other fields

Bill Freeman,
Fredo Durand
Martial Herbert
Aaron Hertzmann
Dimitri Metaxas

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Cross-fertilization with other fields  2:30 - 3:45

- Bill Freeman:  Computer Science, Computational Photography
- Fredo Durand:  Computer Graphics 1
- Aaron Hertzmann:  Computer Graphics 2
- Martial Herbert:  Robotics
- Dimitri Metaxas:  Medicine
Computational Photography

Frédo Durand
MIT CSAIL
sub for Bill Freeman
who will conveniently be back for beers
Computational Photography

- Computation is an inherent part of image formation
- ...or anything where computation helps with imaging
  - quantitatively
  - qualitatively
  - automatically
  - user-assistedly
Multiple-exposure & multiplexing

• Expand capabilities by combining multiple images
• Multiplex through time, assorted pixels, beam splitters, camera array
• e.g.
  - Panorama stitching
  - HDR imaging
  - Focus stacks
  - Photomontage
  - Super-resolution
Coded Imaging

- motion-invariant
- coded aperture
- flutter shutter
- wavefront coding
- compressive sensing
- heterodyning
- warp-unwarp
Natural signal prior

- Statistics that distinguish images of the world from random signals
- Use to “bias” algorithms to output more likely results or to disambiguate ill-posed problems
- Extension of regularization
- e.g.
  - Denoising
  - Deconvolution
  - Compressive sensing
  - Light field prior

Random  “Natural” image
Edges matter but are not binary

- Sparse derivative image prior
- Gradient domain (seamless cloning, tone mapping, convert2gray)
- Bilateral filter for decomposition
- Non-homogenous regularization for scribble propagation
Leverage millions of images

• The ultimate prior?
• Reconstruct the world

Hays & Efros 07

Photo Tourism
Exploring photo collections in 3D

(a) (b) (c)
The raw data is high dimensional

- Light field: 4D (space-angle)
- Time space: 3D
- +Fourier
Active imaging

- Modulate light to facilitate information gathering
  - e.g.
    - Flash/no flash
    - Light stages
    - Dual imaging
    - Structured-light scanning
Recap: Big ideas in comp. photo.

- Multiplexing: quality through quantity
- Coded imaging
- Natural signal prior
- Edges matter but should not be detected
- Leverage millions of images
- Raw data is high-dimensional (ligh field, space-time)
- Active Imaging
Current successes

- Panorama stitching

- High-Dynamic-Range Imaging & tone mapping
Current successes

- Face detection (+smile +blink)

- Photo bios
Current successes

- Poisson image editing / healing brush

- Patch match (content-aware fill)

(a) original                  (b) hole+constraints                  (c) hole filled
Current successes

• Video stabilization

• match move

• Tracking
Current successes

• Photo tourism / Photosynth

Photo Tourism
Exploring photo collections in 3D

Noah Snavely    Steven M. Seitz    Richard Szeliski
University of Washington    Microsoft Research

SIGGRAPH 2006
Current successes

- Calibrate & remove blur
- e.g. DXO, Adobe, Panasonic, Mamyia
Current successes

• Light field cameras
Open Challenges

• Upper bounds on acquisition/reconstruction
• Natural image priors
• Light field, space time priors/reconstruction
• Computational illumination
• New modalities (coherent, femtosecond)
• Video mid-level representation

• Link to other fields
  - Astronomy, microscopy, medical, radar, science