What's wrong with video? – Frédo Durand, MIT CSAIL

Disclaimer

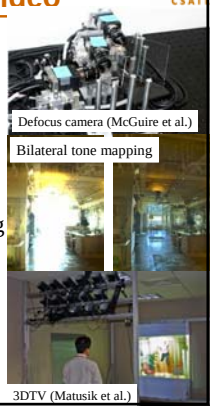
- **This is a non-technical talk**
- **I have no credential or authority to talk about the following subjects**
- **A lot of it is common-sense/well-known**
- **My goal is to point out research challenges to create compelling videos**
- **And chat about what makes it compelling**

Traditional Photo & Video

- **Scene preparation**
  - Make up, lighting, viewpoint
- **Capture**
  - Optics + film
- **Post production**
  - Dodge & burn, movie editing
  - some tedious, some creative
- **Viewing**
  - Flip through photos, passive in front of TV

Computational Photo & Video

- **Scene preparation**
  - Get rid of it!
- **Capture**
  - Data-rich, active
- **Post production**
  - Reconstruct image
  - Automate tedious post-processing
  - Facilitate creative choices
- **Viewing**
  - Additional dimensions (autostereoscopic, motion, HDR)
  - Interaction



Recipe for computational photography

- **If you think photorealistic graphics is difficult**
- **If you think vision is too hard**

Recipe for computational photography

- **If you think photorealistic graphics is difficult**
- **If you think vision is too hard**
- **Do computational photography:**
  - Do a bad job at solving an ill-posed vision problem
  - And cheat: record more information, have user in the loop
  - Modify things a little bit
  - Re-synthesize
  - And voila, a photorealistic picture

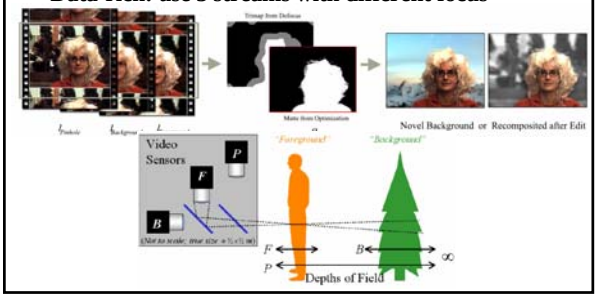
Image-based editing

- With B. Mok Oh, Max Chen and Julie Dorsey, [Siggraph 2001]
- See www.mok3.com
- 3D model from single photograph
- 3D not accurate, but looks great
- Lots of user input

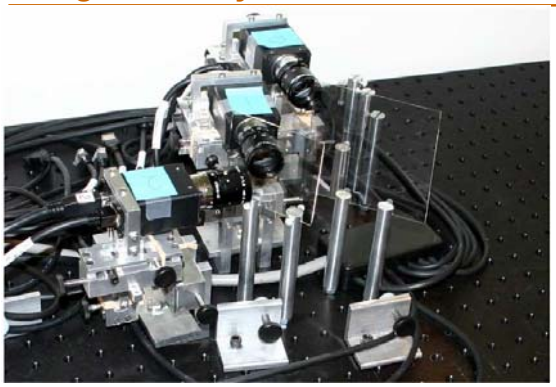
Input image | New viewpoint | Relighting

Defocus Matting

- With Morgan McGuire, Wojciech Matusik, Hanspeter Pfister, John "Spike" Hughes
- Data-rich: use 3 streams with different focus



Morgan's crazy camera

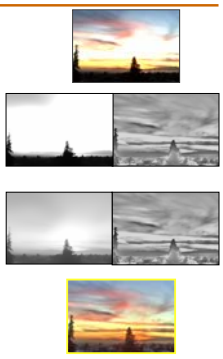


Tone mapping

With Julie Dorsey

Three wrongs make one right

- **Analyze image**
  - Intrinsic image: albedo & illumination
  - Simple bilateral filter
- **Modify**
  - In our case, reduce contrast of large-scale (illumination)
- **Recombine**
  - Get final image



Flash Photography

- Elmar Eisemann and Fredo Durand, [Siggraph 2004]
- Available light is too weak, image is blurry/noisy

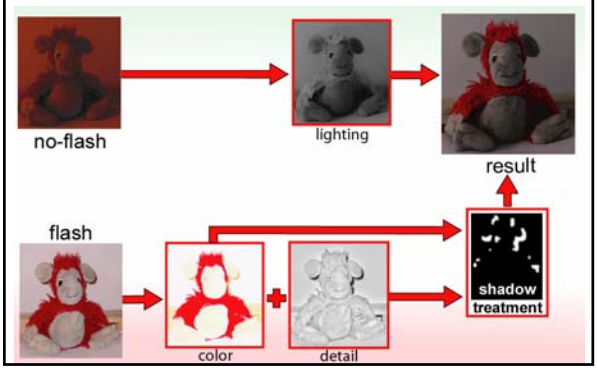
Flash Photography

- Available light is too weak, image is blurry/noisy
- Flash photos look harsh, ambiance is not nice

Flash Photography

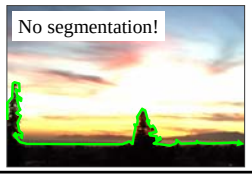
- **Available light is too weak, image is blurry/noisy**
- **Flash photos look harsh, ambiance is not nice**
- **Our work combines the two to get the best of both**

Flash photography relighting



Recipe for computational photography

- **Do a bad job at solving an ill-posed vision problem**
  - But be non-committal about it, no hard decision
- **Modify things a little bit**
  - But not too much, be conservative
- **Re-synthesize**
  - And voila, you get a photorealistic picture



Other example: colorization

- **Colorization Using Optimization**
  Anat Levin, Dani Lischinski, Yair Weiss [Siggraph 2004]
- **Optimization with similarity on pixel intensity**

Colorization using segmentation

With optimization and similarity

The "film look"

- **What makes Hollywood production different from a home video**
  - The story is better!
  - Hum, wait, there must be a better explanation!
- **It is not only the medium:**
  a film transferred to DVD still has the "film look"
- **What makes a still picture different from video?**

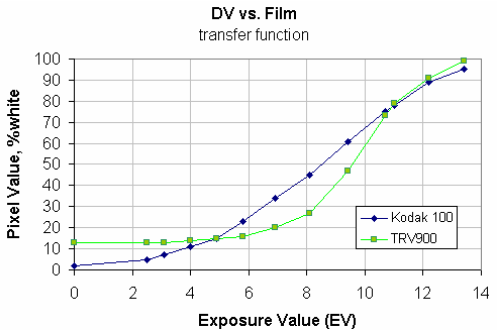
Why is home video usually bad?

People we should fire:

- **Director of Photography (image quality)**
- **Director, script author (story)**
- **Editor**

Response curve, dynamic range

- **Video sensors have poor dynamic range**



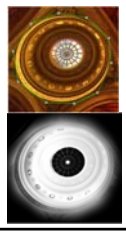
Traditional craft: dodging and burning

- ***Clearing Winter Storm*** **by Ansel Adams**

Straight print | After dodging and burning

Tone mapping in comp. photo

- **Much success**
- **No one question is control (work with Philip Guo)**
  - Use bilateral for selection
- **Open problem: dodging/burning for video**



Polygonal selection

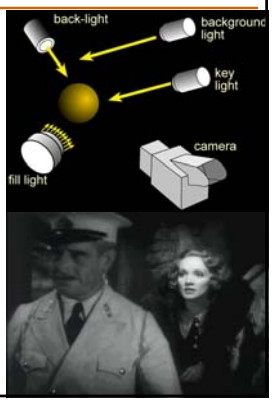
Bilateral selection

Low contrast is also an advantage

- **W. Eugene Smith photo of Albert Schweitzer**
- **5 days to print!**
- **Things can be related because the intensity is more similar**
- **Balance, composition**

Lighting

- **E.g. 3-point lighting**
  - Reduce dynamic range
  - Emphasize silhouettes → 3D cues
- **Goals of lighting:**
  - Manage dynamic range
  - Reveal shape, layout, material
  - Tell story



Lighting research challenges

- **Get rid of scene preparation: Lighting as a post-process**
- **Dynamic range can be handled by tone mapping**
- **Reveal shape, layout, material**
- **Tell story**
- **Note that cinematic lighting is often "non-realistic"**
  - → relighting does not need to be physical

See e.g. Flash/No-Flash, Ted's face relighting

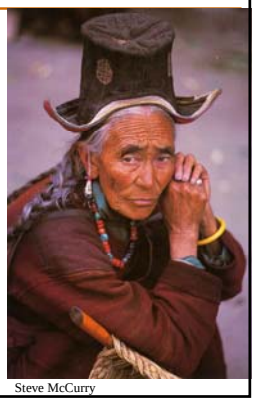
Make Up

- **Can we do post-processing make up?**
  - Color response, wrinkle removal
  - Face tracking, template-based processing

Depth of field

- **Two types of photographers**
  - Hate/love depth of field
- **Computational imaging**
  - Reduce dof (George)
  - Increase it (Berthold)

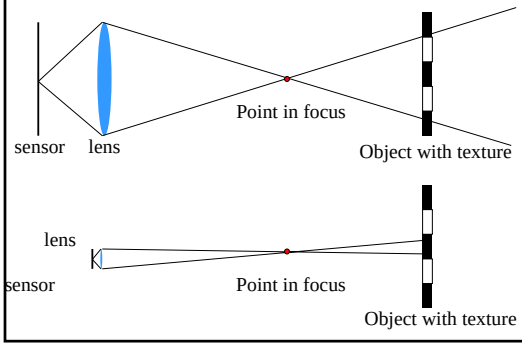
Michael Reichman



Steve McCurry

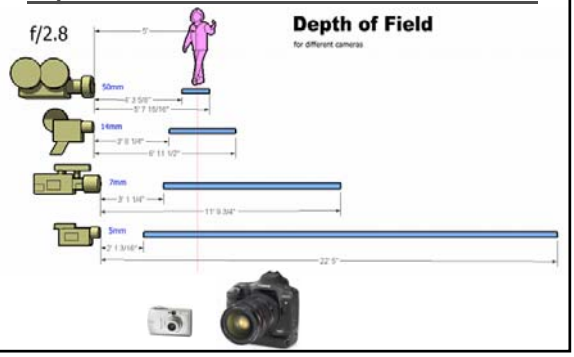
Depth of field

- **It's all about the size of the lens aperture**



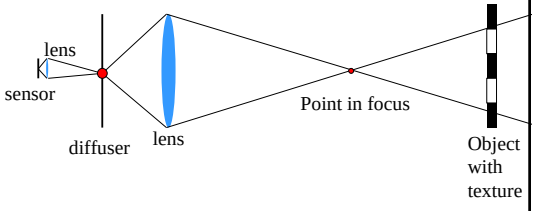
Sensor size

- http://www.mediachance.com/dvdlab/dof/index.htm



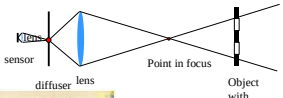
The coolest depth of field solution

- http://www.mediachance.com/dvdlab/dof/index.htm
- **Use two optical systems**



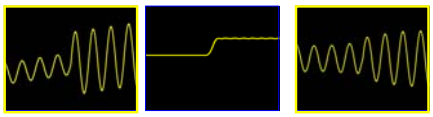
The coolest depth of field solution

- http://www.mediachance.com/dvdlab/dof/index.htm



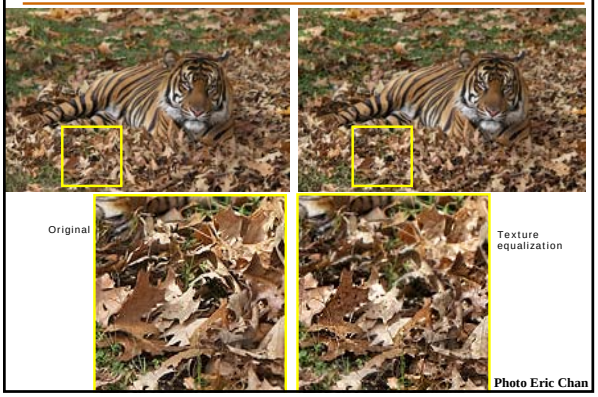
General issue: (de)-emphasis

- **Crucial pictorial tools**
  - E.g. Lighting, depth of field, Gaussian blur
- **New tool: Emphasis and texture variation (with Sara Su & Maneesh Agrawala)**
  - Modify texture variation to "hide" distracting background



Input | Power map | Scaled response

Results



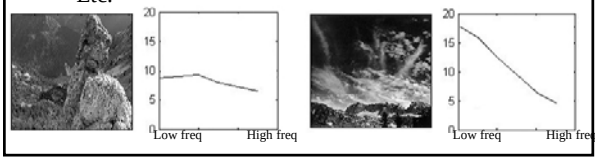
General pictorial issues & techniques

- **Lighting, dodge/burn, filtering, make up, touch up can be used for the same effects**
- **They solve the same *depiction challenge***
- **What are the general (medium-independent) depiction challenges**
- **What are the general pictorial techniques**

Holistic notion of "look"

With Soonmin Bae & Sylvain Paris

- **Can we characterize "look"?**
- **Can we transfer look?**
- **Coarse-grain characterization**
  - Intensity & color histogram
  - Frequency content
  - Etc.



Before

After transfer of Adams "look"

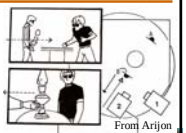
Evil fluctuations in video

- **Zoom**
- **Auto-exposure**
- **Idea for the zoom issue:**
  - Zooming is like cropping
  - Why not capture gigapixel video and post-crop?
    - Well, maybe file size and processing time
  - Do only when user zooms
    - And as a post-process, go directly to final framing
  - Or use superresolution

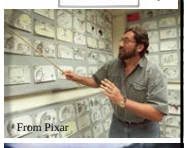
From Arijon's grammar of film language

Story & story telling in video

- **Hard to improvise, anticipate**
  - Go back in time!
  - At least have a buffer.
- **Editing is usually missing**
  - Discrete, pre-digested editing helps
  - Virtual cinematographer?
- **Pictorial techniques are needed for selection & (de)emphasis**
- **And often there is just no story, just a sense of place/moment**
  - Free exploration



From Arijon

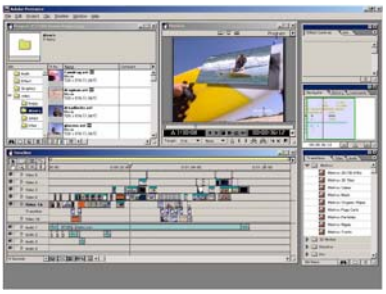


From Pixar

Steve McCurry

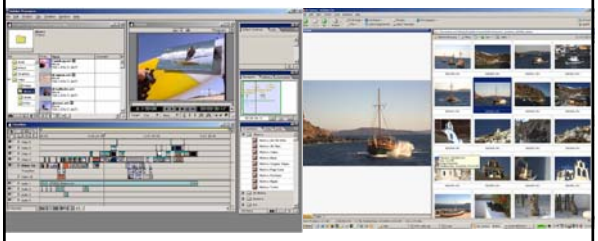
UI

- **Current video editing requires much decision**
- **Deal with continuous variable (time)**



Video equivalent of photo broswer?

- **Discrete interface is key:**
  - Keep or delete
- **Sort vs. search**



Video sorting/editing Photo sorting/editing

Less is more

- **Suspension of disbelief**
  - The more realistic, the more you notice the flaws
- **Beholder's imagination**
- **Free exploration vs. guided medium**

- **Computational imaging often reveals more**
- **My suggestion: use it to hide more**

System & performance issues

- **Video & computational imaging raise system challenges**
  - Large-data management
  - High computation cost
- **It is important to appreciate & tackle these issues**
- **See the example of other fields**
  - Real-time rendering
  - Out of core mesh processing
- **Side note: writing a good system paper is hard**
  - To learn how to write a bad one, see my web page

Summary: How can we help?

People whose job we should make easier:

- **Director of Photography (image quality)**
- **Editor**

Use automation to replace tedious component and complexe scene preparation

Provide creative or expressive knobs

Data-rich imaging, mid-level vision