Extreme photography

CS 178, Spring 2012

Marc Levoy
Computer Science Department
Stanford University
Extremes

- high resolution
  - high speed
  - low speed
  - small aperture
  - large aperture
  - narrow field of view
  - wide field of view
  - high dynamic range
  - low dynamic range

Sinar view camera
10,000 × 8,000 pixels

Nokia 808
41 megapixels
111-megapixel wafer-scale sensor

- 95mm × 95mm CCD sensor
- 10,580 × 10,560 pixels
- low yield, very expensive

5” (aperture) telescope at the U.S. naval observatory, Flagstaff, AZ
Graham Flint’s gigapxl.org

- custom camera and lens
- 18” negative → drum scanner → printer
- 40,000 pixels × 25,000 pixels
Balboa Park, San Diego

(full-resolution print in Gates Hall, 3rd floor, entrance to graphics wing)
San Diego Skyline
xrez.com  (also gigapixel resolution)
xrez.com  (also gigapixel resolution)
Extremes

- high resolution
- high speed
- low speed
- small aperture
- large aperture
- narrow field of view
- wide field of view
- high dynamic range
- low dynamic range
Harold Edgerton: “father” of high-speed photography

- no shutter
- electronic strobe
- microphone near gun

from Stopping Time, 1964
Ultra-high speed photography

- atomic explosion
- 1/100,000,000 second
- camera was 7 miles away
- telescopc lens
High-speed video with a still camera: the Casio EX-F1

- 640 × 480 pixels
- 300 frames per second
- border collie
- 320 × 480 pixels
- 600 frames per second
- 160 × 480 pixels
- 1200 frames per second
Extremes

- high resolution
- high speed
- low speed
- small aperture
- large aperture
- narrow field of view
- wide field of view
- high dynamic range
- low dynamic range
Low-light photography

- composite of two exposures
- cityscape was 30 seconds

Lee Frost, Santorini, Greece
Time exposures in astronomy

- 30-minute exposure
- Telescopes can rotate to avoid smearing stars
- What is the unmoving star in the middle?

Lee Frost, star trails

(Palomar 200-inch)
Painting with light

• 30-second exposure
• multiple flashes
• Don’t stand between the flash-lit part of the scene and the camera!

Lee Frost, railroad yard
Extremes

- high resolution
- high speed
- low speed
- small aperture
- large aperture
- narrow field of view
- wide field of view
- high dynamic range
- low dynamic range
Small aperture  (large depth of field)

Ansel Adams, Mission San Xavier del Bac, Tucson

- the f/64 club
Extremes

- high resolution
- high speed
- low speed
- small aperture
- large aperture
- narrow field of view
- wide field of view
- high dynamic range
- low dynamic range
Large aperture  (shallow depth of field)

Lewis Hine, Girl Worker in Cotton Mill, 1908
Synthetic aperture photography
Example using 45 cameras
[Vaish CVPR 2004]
Light field photography

• we’ll have a lecture on this later in the course
SynthCam is an app for the iPhone 4, 3GS, iPod Touch 4G, and iPad2 (requires iOS 4.2 or higher)

Price: Free  
Current version: 2.0
single frame  
synthetic aperture photograph
Tilt-shift of Stanford quadrangle as seen from Hoover Tower
Extremes

- high resolution
- high speed
- low speed
- small aperture
- large aperture
- narrow field of view
- wide field of view
- high dynamic range
- low dynamic range
Narrow field of view: telephoto lens

- 300mm lens

Bryan Peterson, Golden Gate Bridge
Extreme telephoto

- Nikon 1540mm Cassegrain reflector
Other extreme telephoto lenses

Canon 1200mm

Zeiss 1700mm

Nikon 2000mm
Really extreme

Hale telescope on Mt. Palomar, CA

\[ A = 200'' \text{ (16')} \]
\[ f = 650'' \text{ (50')} \]
\[ N = f/3.3 \]
Extremes

- high resolution
- high speed
- low speed
- small aperture
- large aperture
- narrow field of view
- wide field of view
- high dynamic range
- low dynamic range
Wide field of view: stitched panoramas
Wide field of view: stitched panoramas

• 4 photos, total = 90° field of view
• Canon point-and-shoot camera, handheld
• stitched using Photoshop CS3

Crater Lake, Oregon
Games with stitched panoramas

- 5 shots, with camera aimed slightly downwards and rolled clockwise around its optical axis between shots left to right, producing a curved world effect when stitched using Photoshop with cylindrical projection
Nikon 6mm fisheye lens

- 220° field of view measured diagonally
- 11.4 pounds

NOW ONLY $34,000 ON EBAY!!

(DigitalFreak.net)
Stanford CityBlock Project (now Google StreetView)

- capture video while driving
- extract middle column from each frame
- stack them to create a panorama
Stanford CityBlock Project
Stanford CityBlock Project
Extremes

• high resolution
• high speed
• low speed
• small aperture
• large aperture
• narrow field of view
• wide field of view

✦ high dynamic range
• low dynamic range
High dynamic range (HDR)

- one of photography’s key limitations
  - negative film = 250:1 (8 stops)
  - paper prints = 50:1
  - example below = 250,000:1 (18 stops)
DIY HDR

- 2 shots
- Photoshop CS4

Early morning in Zurich
Extremes

- high resolution
- high speed
- low speed
- small aperture
- large aperture
- narrow field of view
- wide field of view
- high dynamic range
- low dynamic range
Sinar P3 view camera with 54H digital back

- 2¼ x 2¼ sensor, actively cooled, 14 real bits
single frame
in dark room
using iPhone 4
average of ~30 frames using SynthCam

SNR increases as $\sqrt{\text{# of frames}}$
Slide credits
(in addition to individually credited images)

- http://gigapixl.org
- http://xrez.com