Introduction To Digital Photography

EDay 2003 ECE Short Course
Saturday, February 22, 2003

Hank Dietz
Professor and James F. Hardymon Chair in Networking
Electrical and Computer Engineering Department
University of Kentucky
Lexington, KY 40506-0046

http://aggregate.org/hankd/
Why Digital?

- Conventional photos can be scanned, but...
- Film cost
  1. Digital "film" is expensive but reusable
  2. No processing required
- Review & playback give immediate feedback
- Permanence of digital data can be excellent (e.g., color reference is preserved)
Exposure

- How much light energy does the sensor process?
- A function of 4 things:
  1. Available light... which is hard to control
  2. Shutter Speed
  3. Aperture or F/Stop
  4. "Film" Speed (sensor gain)
- Generally, if available light is constant, other parameters trade-off
Exposure: Shutter Speed

- The time period during which light is sensed
- 2X time is 2X light energy
- Speeds usually range from about 1 second to 1/1000s
- Things moving faster than shutter are blurred (and that’s everything if you move the camera ;-)
- Under 1/30s, brace the camera (e.g., use a tripod)
Exposure: Aperture, F/Stop, or T/Stop

• How much light is admitted (transmitted) by the lens
• Larger aperture is smaller F/Stop number; 2X steps F2, 2.8, 4, 5.6, 8, 11, 16
Exposure: Film Speed EI, ISO, ASA

- Light measured by electric charge, amplified, & digitized
- Higher is more sensitive; 2X steps 50, 100, 200, 400
- Higher implies more amplification, hence more noise
- Moderate underexposure correctable with higher noise; Moderate overexposure clips (looses detail in) highlights
- Example equivalent exposures:
  EI 50, 1/250s @ F2.8
  EI 50, 1/15s @ F11
  EI 200, 1/60s @ F11
Exposure: Film Speed & Sensor Noise

EI 400  

EI 50

Introduction To Digital Photography
Photographic Effects

• Focal Length
  • Shorter means wider viewing angle
  • Sensor size varies, so quote 35mm equivalents; *wide-angle* is $< 43\text{mm}$ (e.g., 35mm) *telephoto* is $> 43\text{mm}$ (e.g., 135mm)

• Depth-of-field
  • Depth-of-field is distance range that is sharp
  • Smaller focal length increases range
  • Higher F/Stop (smaller aperture) increases range
Photographic Effects: Depth-of-field

G1, 7.0mm (36mm) f/8.0  G1, 20.3mm (104mm) f2.5

Introduction To Digital Photography
Photographic Effects: Flash

- A pulsed light source synchronized with the shutter
- Gives fast exposure without enough ambient lighting, but easily yields images of poor quality
- Flash has a limited useful range, images look flat
- *Red Eye* and red-eye reduction flash modes
- Fill-in flash and flash with slow shutter speeds
- Bounce or otherwise soften flash lighting
Photographic Effects: Fill-In Flash

Flattens harsh lighting, especially backlighting
Image Capture: Sensors

- CCD or CMOS arrays with RGB or CMYG filters; Foveon R-G-B sensor stacks
- Analog readings converted to 8, 10, or 12 bit digital
- Each light-sensitive position is called a pixel (1.5-3M pixels is roughly comparable to 35mm film)
- Grain is mostly noise, but also sensor pixel count
- Sensor noise is less when cold
- Sensor noise is less for fast shutter speeds
Image Capture: Sensor Filters

EOS-1D, GRBG

G1, GMYC
Image Capture: Overexposure

Loss of highlight detail; possible local distortion of color
Image Capture: Speed & Sensor Noise

Conventional film has *reciprocity failure* problems; for digital, very long times increase sensor noise

16s  16s - 16s  1/60s
Image Capture: Storage Media

- Types: CF, SmartMedia, MemoryStick, XD, etc.
- Capacity from 4MB to 1GB, with 50KB to 2MB per image
Image Capture: Resolution & Image Quality

- Resolution (of the sensor):
  - Some sensor pixels are used as a "black reference"
  - Can *interpolate* sensor data to any image resolution

- Image Quality (Compression) Settings:
  - JPEG images are interpolated and compressed
    - JPEG works better with higher resolutions
    - Even "100% quality" JPEGs are imperfect
  - TIFF images are interpolated, saved 24 bits/pixel RGB
  - Raw formats save sensor data to process later
    (e.g., 10-12 bits/pixel one color)
Image Capture: Resolution & Image Quality

JPEG compression is effective for photos
Image Capture: Resolution & Image Quality

jpeg is more effective at higher resolutions
Both 100% and 50% 256x256 better than 100% 128x128!
Image Capture: 100% JPEG Isn’t Perfect

Master 32x24

100% JPEG
50% JPEG
25% JPEG
5% JPEG

Introduction To Digital Photography
Image Capture: Color Balance

- Color reproduction and perception is tricky stuff
- Use manual white balance where possible
- Can fix later (best using raw format)
Digital Darkroom Techniques

- Done with the lights on, no nasty chemicals!
- Can do some on-site using in-camera preview, options
- Corrections:
  - Fixing underexposure increases noise; Overexposure clips highlights, information is lost
  - Adjust color, contrast, dodge/burn
  - Can fix RedEye, remove unwanted objects, etc.
- Cropping: sensors are 4:3 or 3:2, not 7:5, 10:8, 14:11, etc.
Digital Darkroom Techniques: Printing

- Various printing technologies:
  - Dye Sublimation: highest quality, expensive and slow
  - Inkjet: good quality (with the right paper)
  - Laser: fast & cheap per print
- Does the monitor match the printer?
- Want more than 100 pixels per inch for printed image
Advanced/Specialized Darkroom Techniques

- Remove/replace backgrounds
- Panorama stitching:
  Create larger, higher-resolution image from multiple lower-resolution images
- Correction of lens/perspective distortions:
  Can undo barrel/pincushion distortion, logically tilt the lens, etc.
- Various special effects (to use sparingly):
  Page curl, tiling/mosaics, "old photo" effects, etc.
Advanced/Specialized Darkroom Techniques

Panorama of the KAOS Lab, Summer 2002...
13700x1920 pixels, i.e., about 25MPixels
Non-Traditional Uses (of images)

- Images for the WWW
  - Download time matters; keep image file size small (generally, 640x480 or lower resolution)
  - Use JPEG, GIF, or PNG compression
- Image archiving:
  - CD or DVD as "archival" storage... (many DVD players can show JPEGs from a CD)
  - Can easily make slideshows on videotape, etc.
Non-Traditional Uses (of the camera)

- The camera is a (NTSC/PAL) presentation device:
  - Can do slide shows of photos taken
  - Upload and then show any images
    (often, cameras are picky about image format)
- Visual note-taking:
  Photograph where you parked, notes on a chalkboard, etc.
My Most Important Disneyworld Photo

Where did you park? ;-)

Introduction To Digital Photography
References

- Other tutorials:
  
  http://www.webphotoschool.com/ir/
  http://www.shortcourses.com/

- Digital photography equipment reviews, etc.:
  
  http://www.dpreview.com/
  http://www.imaging-resource.com/
  http://www.dcresource.com/
  http://www.steves-digicams.com/
The Quiz
Hands-On Period

- Digital cameras here (somewhat old):
  - Olympus D320R: 1M pixel, SmartMedia, ...
  - Nikon CoolPix 950: 2M pixel, CF, ...
- Printers here (cheap ones):
  - Lexmark Z35
  - HP 3820