

Introduction To Digital Photography

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Why Digital?

- Conventional photos can be scanned, but...
- Film cost
 - Digital “film” is expensive, but reusable
 - No processing required (easy to postprocess)
- Review & playback give immediate feedback
- Permanence of digital data can be excellent (e.g., color reference is preserved)
- In 2016, only photography classes use film

Storage Media (“Digital Film”)



Types: lots... SD, Micro SD most common now
Capacity: cost effective to ~256GB, max >1TB

General Digital Camera Types

- **Webcam**: no mechanical shutter; video oriented; usually low cost, resolution, & image quality
- **Compact**: fits in a pocket; may be high resolution, but lens and manual controls are usually limited
- **Super-Zoom**: built-in lens covers wide focal length range and many compensate for camera shake
- **Camcorder**: video-oriented compact
- **DSLR**: optically view through the lens using a mirror; manual controls; interchangeable lenses

Rising Camera Types

- **Cell Phone**: pretty much killing low-end compacts... somewhere between a webcam & compact
- **Rugged / Waterproof**: an indestructable compact
- **Mirrorless**: like a DSLR, but uses live view; can mount nearly any lens ever made with an adapter

... and everything is expected to do video.

While We're Discussing Video...

- **Resolution**: original VGA was 640x480...
8K: ~8000x?; **8K UHD TV** is 7680x4320
4K: 4096x?; **UHD** is 3840x2160
2K: 2048x?; **1080** is 1920x1080
720: 1280x720
- **Rolling** vs. **Global** shutter
- **Framerate**: 59.94Hz (NTSC fields), 24FPS (cinema), 25FPS (PAL)
- **Progressive** vs. **Interlaced** fields (every other line)

Exposure

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

Shutter Speed

- The time period during which light is sensed
- 2X time is 2X light energy
- Speeds from about 30 to 1/4000 second
- Things moving faster than the shutter blur
(that's everything if you move the camera ;-)
- Longer than 1/30, brace the camera
(use a tripod, lean on something, etc.)
- Image stabilization helps about 4X

Aperture or f /Stop

- How much light is admitted by the lens
(T/Stop is light transmitted by the lens)
- Larger aperture is smaller f /Stop number;
2X steps:

$f/0.71, f/1, f/1.4, f/2, f/2.8, f/4,$
 $f/5.6, f/8, f/11, f/16, f/22, f/32, \dots$

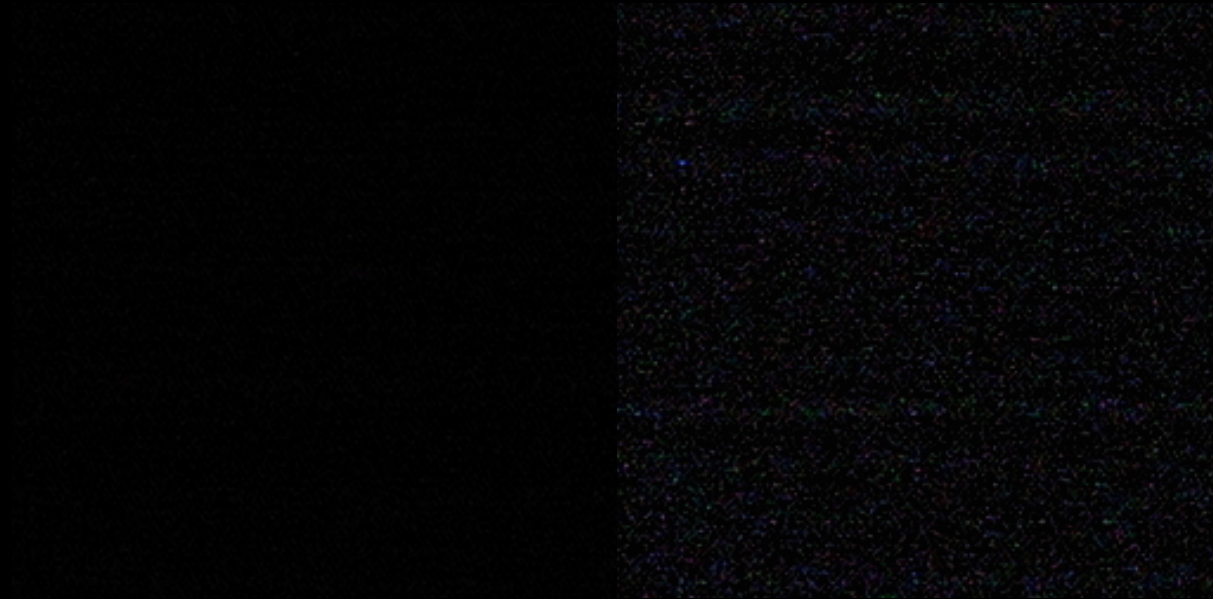
Film Speed EI, ISO, ASA

- Higher is more sensitive; 2X steps:

25, 50, 100, 200, 400, 800, 1600,
3200, 6400, 12800, 25600, ...

- “Auto” increases film speed as needed
- Sensor signal is amplified, then digitized; more amplification implies more noise
- Moderate underexposure increases noise
- Moderate overexposure clips highlights

Film Speed & Sensor Noise



EI 50 vs. EI 400

Lens Properties

- **Focal Length**
 - Shorter means wider viewing angle
 - For 135 film (beware “**35mm equivalent**”):
 - wide-angle is $<43\text{mm}$ (e.g., 35mm)
 - telephoto is $>43\text{mm}$ (e.g., 135mm)
- **Depth-of-field**
 - Distance range that is in sharp focus
 - Smaller focal length increases range
 - Higher F/Stop increases range

Depth-of-field



7.0mm (36mm) f8.0 vs. 20.3mm (104mm) f2.5

Flash

- A light pulse synchronized with the shutter
- Gives fast exposure without enough ambient lighting, but yields images of poor quality
- Limited useful range, images look flat
- **Red Eye** and **red-eye reduction** modes
- **Fill-in flash** & flash with slow shutter speeds
- **Bounce** or otherwise soften flash lighting

Fill-In Flash

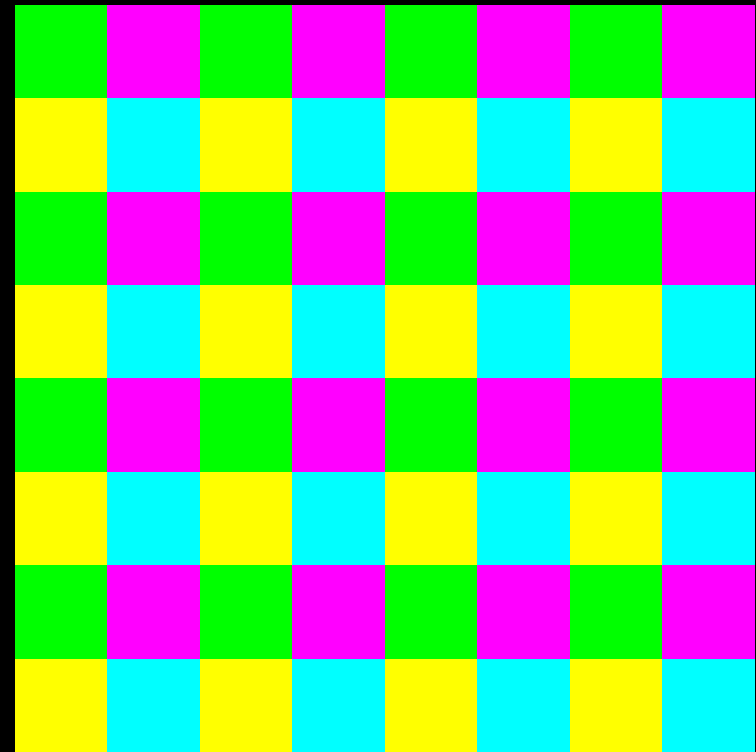
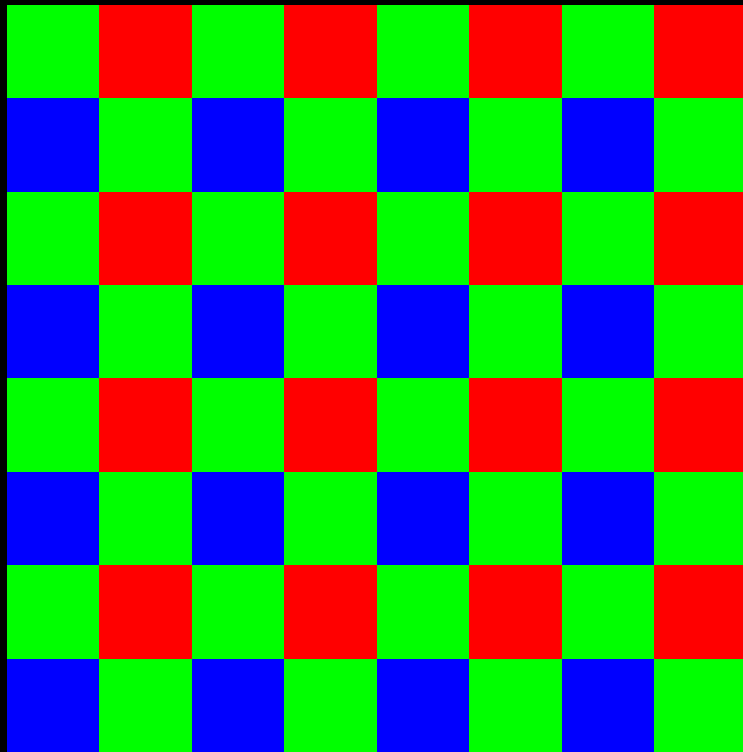


Used to flatten harsh shadows, backlighting

Image Capture

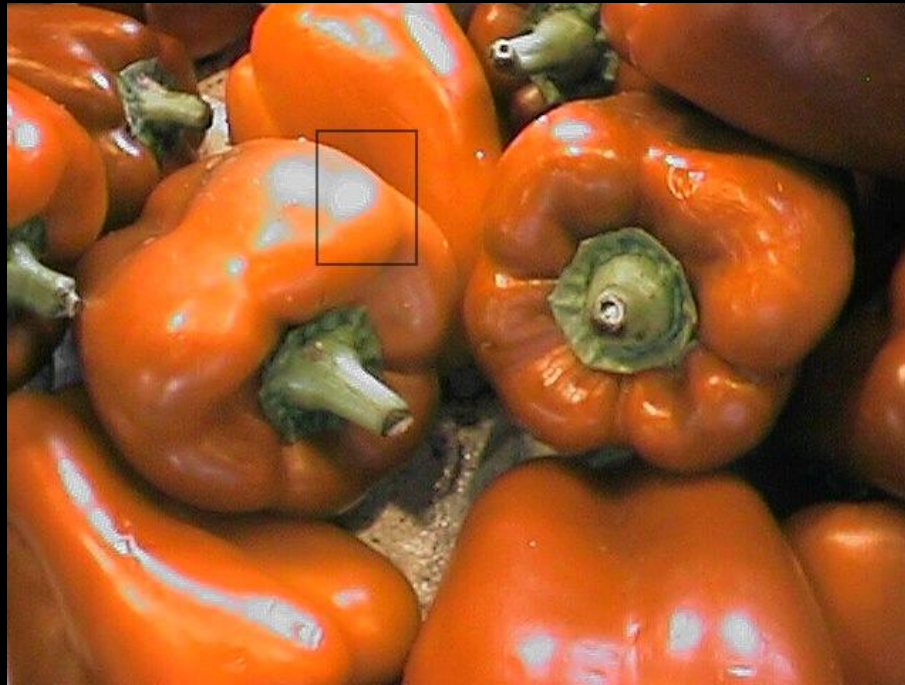
- **CCD** or **CMOS** sensel arrays with a color filter array or **Foveon** “stacked” sensors
- Analog converted to 8-14 bit digital values
- Each light-sensitive position is called a **pixel** (1.5-6MP is *comparable* to 135 film)
- **Grain** is mostly noise, also sensor pixel count
- Sensor noise is generally less for: **bigger pixels, colder temperatures, & faster shutter**

Sensor Filter Patterns



EOS-1D, GRBG vs. G1, GMYC

Overexposure



Lost highlight detail, local distortion of color

Shutter Speed & Noise



Conventional film has reciprocity failure;
digital has “Christmas tree lights”

Resolution & Image Quality

- Resolution (of the sensor):
 - Some pixels used as “black reference”
 - Can interpolate to any image resolution
- Image Quality (Compression) settings:
 - JPEG is interpolated & compressed
 - TIFF is interpolated 8 bit/color/pixel
 - Raw formats save digitized sensor data

Resolution & Image Quality



196932 vs. 13687 vs. 5735 Bytes

JPEG compression is effective for photos

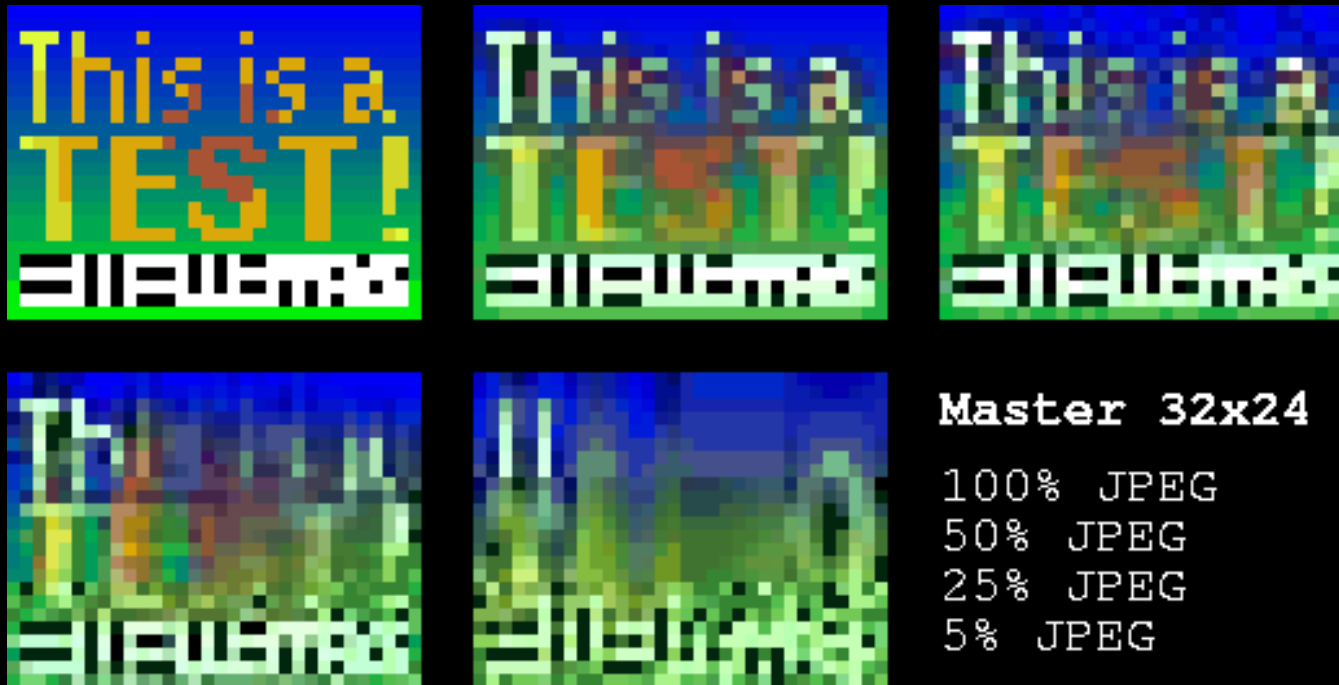
Resolution & Image Quality



61002 vs. 9025 vs. 16309 Bytes

50% at 256x256 better than 100% at 128x128

Resolution & Image Quality



Even 100% JPEG is far from perfect...

Color Balance



- Color reproduction & 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!**
- Do some in-camera using **preview, options**
- Corrections:
 - Fixing **underexposure** increases noise;
Overexposure clips, loses information
 - Adjust color, contrast, dodge/burn
 - Can fix **Red Eye**, remove objects, etc.
- Cropping: 4:3 or 3:2 becomes 7:5, 10:8, etc.

Printing

- Various printing technologies:
 - **Dye Sublimation**: high quality, slow, pricey
 - **Inkjet**: good quality, high ink+paper costs
 - **Laser**: faster, cheaper, lower quality
- Many cameras can print directly (e.g., DPOF)
- Does print match image on the monitor? **No!**
- Want >100 pixels per inch for printed image

Advanced & Specialized Darkroom Techniques

- Remove/replace backgrounds
- **Panorama stitching, superresolution**, etc.:
make one image by combining many
- Correction of lens/perspective distortions:
undo **barrel/pincushion, lens tilt**, etc.
- Various special effects (use sparingly!):
page curl, tiling/mosaics, “old photo,” etc.

Advanced & Specialized Darkroom Techniques



Panorama of the KAOS Lab, Summer 2002...
13,700x1,920 pixel, i.e., about **25MP**...
shot using a **3MP** camera!

Non-Traditional Uses (of images)

- Images for the WWW:
 - Download time matters; keep files small (generally, 640x480 or lower resolution)
 - Use **JPEG**, **PNG**, or **GIF**
- Image archiving:
 - Hard disks (yours or cloud), SD cards...
 - **CD** or **DVD** as “archival” storage...
 - Make slideshows as videos, etc.

Non-Traditional Uses (of the camera)

- Computer-controlled capture
- Camera as a presentation device:
 - Can do slide shows of photos taken
 - Upload and then show any images
 - Most cameras output **NTSC** & **PAL**
- Visual note-taking
- **Computational Photography**

My Most Important Disneyworld Photo



Where did you park?

Conclusion

- Digital cameras are way better than film
- They are also cheap enough, if not cheap
- They are more flexible than film
- They aren't hard to use
- There's plenty more info out there...

<http://aggregate.org/DIT/>