

Today: Photoshop intro  
Spatial and temporal resolution

Get Wet: Post in Dropbox AND as a discussion topic

Buy Photoshop bundled with other Adobe apps

**Adobe Creative Cloud subscription: \$240-\$360 annually**

<http://www.colorado.edu/oit/creative-cloud-faq>

Other options: previous versions of PS on eBay etc., but can't open new camera RAW files.

Photoshop Elements: < \$100, probably adequate for this class.

Adobe Lightroom: not as powerful as PS, is designed for professional photography workflow, making same changes to many images at once.

Gimp: Online, open source image processing software.

Most image processing software will be adequate for this course: crop, brightness, intensity, spotting

### Other Resources

Rent macro lenses and other equipment: Pro Photo Rental on Arapaho

<http://prophotorental.com/>

Canon, Nikon, Olympus bodies and lenses. Also used equipment for sale

New firmware for your Canon; allows much more control

<http://chdk.wikia.com/wiki/CHDK> open source

Canon Hack Development Kit

Mostly non-DSLRs

<http://www.magiclantern.fm/about.html> also open source

"Magic Lantern is a software enhancement that offers increased functionality to the excellent Canon DSLR cameras. We have created an open framework, licensed under GPL, for developing extensions to the official firmware."

Topics in PS that we'll cover today:

1. Desktop nav
2. Contrast
3. Color channels
4. Crop tool
5. Clone stamp
6. Filters
7. Layers; advanced topic, won't really get to.

1. Desktop nav: menus, tools, toolbar info, history,

2. Contrast

Increase contrast in PS:

Use Image>Adjustments>Curves or hotkey ctrl-m

It's all you need. Avoid automatic adjustments; they will rob you of skill.

Look at info, shows RGB values. Also shows equivalent CMYK, used in hardcopy industry.

Curve = 'transfer function'; maps starting pixel values to final.

Increased contrast has 'S' shape.

Avoid saturating highlights and shadows; try to retain information there by having a non-zero slope at bottom and top.

#### 4. Crop tool:

Make sure specs in toolbar are clear.

Can rotate crop using cursor outside of crop area

Choose 'Perspective' in toolbar to change a non-rectangular area into a rectangular one.

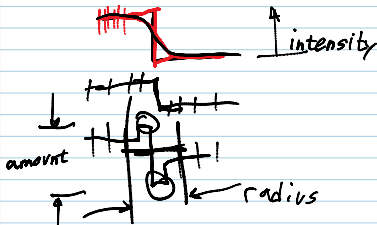
#### 5. Clone stamp

Better than 'healing brush' for corrections, but healing brush really is good for fixing face blemishes.

#### 6. Filters

Can do wild stuff, but algorithms are unknown. When making images for both scientific and artistic purposes, avoid destroying information whenever possible. Try to get desired effects with known transformations instead of mysterious ones.

Sharpen: amplifies difference between adjacent pixels. Old painting technique; edges outlined by black on one side, white on the other. Use Unsharp Mask.



Good tutorial: <http://psd.fanextra.com/tutorials/photoshop-sharpen/>

#### File Formats

Information is **lost** when saving in jpeg

[http://cscie12.dce.harvard.edu/lecture\\_notes/2011/20110309/slide42.html](http://cscie12.dce.harvard.edu/lecture_notes/2011/20110309/slide42.html)

Non-Lossy image file formats. These are acceptable for edited images submitted in class.

RAW, TIF, PNG, PSD

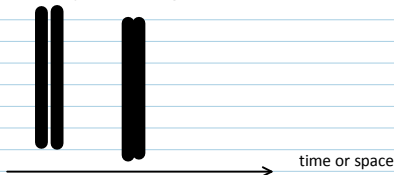
Most PHD cameras store images as jpg. Open in PS, then edit and store as PSD, Photoshop's native format.

DON'T use *Photoshop* RAW. Metadata is lost; images can't be opened.

Camera raw formats, like NEF, CR2 etc, are OK.

#### Resolution: Spatial and Temporal

Can two adjacent things be resolved?

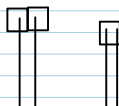


Resolution = minimum distance between two objects for them to be recognized as separate.  
Applies to objects (spatial resolution)  
and events (temporal or time resolution)

"Large resolution" = meaningless  
"Fine resolution" or "Highly resolved"  
= well - resolved.

**Spatial resolution** can be DEGRADED by

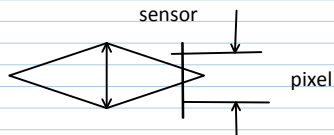
- Bad focus
- Rastering, pixelation
- Diffraction effects
- Low contrast
- Compression artifact (in image)



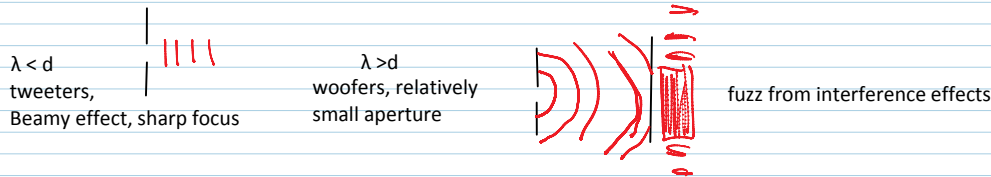
- Rastering, pixelation
- Diffraction effects
- Low contrast
- Compression artifact (in jpegs)
- Motion blur



- Bad focus: is circle of confusion > pixel?



- Diffraction effects if lens aperture or pixel size <  $\lambda$  wavelength of light



Example : <http://www.luminous-landscape.com/tutorials/understanding-series/u-diffraction.shtml>. Moral of the story: high f number has better depth of field, but sharpness can be defeated by diffraction effects.

Current sensor sizes range 35 - 3 mm. For 3k px wide, 1 pixel = 10 -1  $\mu\text{m}$ .  
Red  $\lambda = 0.7 \mu\text{m}$ . Pretty close!

"Canon Develops 35 Mm Full-frame CMOS Sensor for Video Capture."  
Accessed March 5, 2013.  
[http://www.opli.net/magazine/imaging/2013/canon\\_35\\_mm\\_full\\_frame\\_CMOS.aspx](http://www.opli.net/magazine/imaging/2013/canon_35_mm_full_frame_CMOS.aspx).

### How much resolution is needed?

Consider range of scales:

3000 px wide image, can see 1:1000 = 3 decades of scales

What is a decade? 10x; AKA order of magnitude

$O(x)$

Largest scale = whole frame, takes 3000 px.

Smallest resolvable scale = feature that takes up 3 px or so.

3 → 30 One decade

30 → 300 2nd decade

300 → 3000 3rd decade.

We can resolve features that range across 3 decades of scales.

In flow, scales can be 3 minimum,

For turbulence need 4 or 5 decades minimum

Same scale considerations as for CFD:

If resolution is increased, is new information seen?

Is it important information?

In CFD, could have different physics; even large scale results could be wrong

In Flow Vis, missing small scales could lead to misinterpretation of physics

Minute paper: In your GW image, how many

decades of length scale was in your flow?

How many did your image capture?

Was your flow spatially resolved?

Examples from GW images; resolved vs not

resolved. What if there aren't two things close together, how to estimate from an edge gradient?

Human eye resolution, 74 to >500 Mpx, depending on how you count.

<http://www.clarkvision.com/articles/eye-resolution.html>

## Time resolution

### Other considerations of shutter speed:

Short enough to 'freeze' flow= TIME RESOLVED

VS long enough to get desired particle tracks

or long enough to be TIME AVERAGED.

Calculate motion blur. If unacceptable, increase time resolution= shorter exposure time

Increase shutter speed

Max is 1/10,000? 0.1 msec, 100  $\mu$ sec? At best.

High speed camera 30,000 fps  $\sim 3 \times 10^{-5}$  sec = 30  $\mu$ sec

Freeze the flow with short light source (won't work for light emitting fluids, i.e. flames)

Strobe, camera flash  $\sim 10^{-5}$  or  $\sim 6$  sec = 1-10  $\mu$ sec

Pulsed laser  $3 \times 10^{-9}$  sec = 3 nsec or less

Good resource for high speed photography: <http://www.hiviz.com/index.html>

## Lens cleaning

1. Use gentle air blast to remove loose particles. 'Canned air' is OK if you don't overdo it: don't let liquid propellant come out. Blower brush is OK, but beware dirty brushes.
2. Start with gentlest solvent; condensed breath. Examine lens surface for smudges. If it looks clean and smooth, just let condensate evaporate. If smudges seen, gently rub with balled up FRESH SHEET of Kodak lens tissue. Other brands seem harsh. Rub just until dry, don't rub without moisture present. Check with another breath. Repeat if needed.
3. If you have a stubborn residue, escalate the solvents. Use isopropyl (rubbing) alcohol next. 70% is OK. Then move to methanol if needed. Acetone as a last resort. This is OK for lenses, even AR (anti-reflection) coated optics.

NOT OK for First Surface Mirrors. Surface is too fragile. Common for DSLR mirrors, overhead projectors