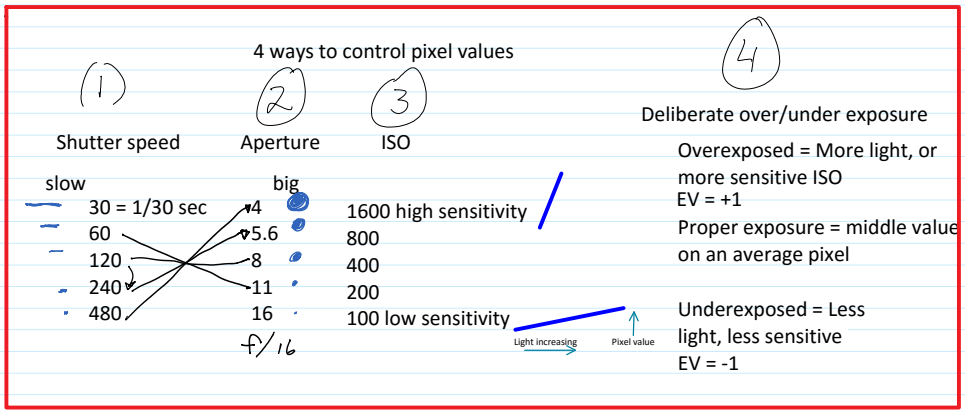
11.Resolution1

Sunday, January 23, 2011 3:27 PM

Today:

Schedule
Ansel Adams
Finish exposure
Resolution

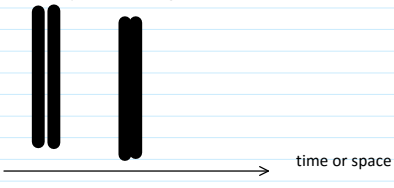


List the side effects of each method, beyond the effect on exposure:
Shutter speed: motion blur at slow speeds
Aperture: low depth of field at large aperture
ISO: Noise at high ISO
Deliberate under/over: Camera will change one or more of the other three settings, with attendant side effects.

Any measurement requires 3 types of resolution: spatial, temporal, measurand (dynamic range)
Making an image is equivalent to making a measurement of light (measurand)

Resolution: Spatial

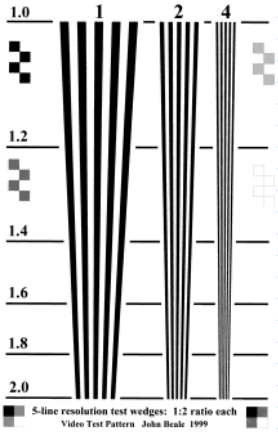
Can two adjacent things be resolved?



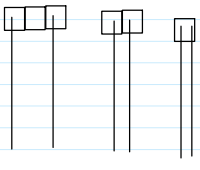
Resolution = minimum distance between two objects for them to be recognized as separate.
Applies to objects (spatial resolution) and events (temporal or time resolution) and any quantity being measured (measurand)

Spatial resolution can be DEGRADED by

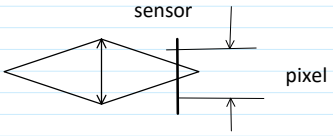
- Bad focus
- Rastering, pixelation
- Diffraction effects
- Low contrast
- Compression artifact (in jpegs)
- Motion blur



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



- **Bad focus: is circle of confusion > pixel?**



- **Diffraction effects if lens aperture or pixel size < λ wavelength of light**

λ < d
tweeters,
Beamy effect, sharp focus

λ >d
woofers, relatively
small aperture

fuzz from interference effects

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 µm.
Red λ = 0.7 µm. Pretty close!

'Full Frame' DSLR: sensor size is ~35 mm
http://www.whatdigitalcamera.com/roundup/camera-roundups/best-full-frame-dslrs-2016-9263.

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?

About 1/2 thought their resolution was adequate. A couple didn't understand the question.

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 µsec? At best.
- High speed camera 30,000 fps ~ 3 x 10-5 sec = 30 µsec

Freeze the flow with short light source (won't work for light emitting fluids, i.e. flames)
- Strobe, camera flash ~ 10-5 or -6 sec = 1-10 µsec
- Pulsed laser $3x10^{-9}$ sec = 3 nsec or less

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

If long shutter is needed, might be too much light, even at low ISO.
Try a
NDF = Neutral Density Filter. Neutral = all wavelengths equally. Gray.
NDF 1 = 1 /10 light transmission, 3 stops
NDF 2 = 1/100 etc. Log scale. 7 stops
http://en.wikipedia.org/wiki/File:Strickland_Falls_Shadows_Lifted.jpg
30 seconds. NDF 8x = 1/100,000,000 = 27 stops

$10^8 = 2^x$

$8 \ln 10 = x \ln 2$

$x = 8 \frac{\ln 10}{\ln 2}$

$= 26.6$

Need a tripod for macros, or shutters > 1/30 sec
Full size start at $25. Highly recommended.

Several available for checkout.

Estimate motion blur *in pixels* to guide choice of shutter speed.

Resolution Homework for Monday: Write short answers and submit in Dropbox.

1) In your Get Wet image, are all the scales of interest in the flow well-resolved in the image?
Is there a sharp boundary in the flow that only takes up one or two pixels in the image? What was the major effect that degraded the resolution?
2) At what f/ does your lens produce the sharpest image? Take an object that you can easily focus on (a ruler?), and image it with a range of f/. Then zoom in and check the focus. Try to minimize the effects of motion blur and ISO noise so your testing is valid. Submit at least three images illustrating your results.