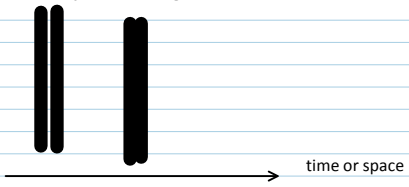
Today
Finish resolution
Lens cleaning
Start specific FV techniques. Dyes

News: Weatherspark shows cloud ceilings now. Use this to check your skew-T interpretations.

Resolution: Spatial and Temporal

Can two adjacent things be resolved?

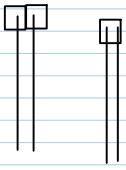


Resolution = minimum distance between two objects for them to be recognized as separate.
Applies to objects (spatial resolution)
and events (temporal or time resolution)

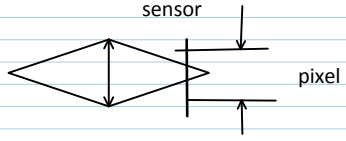
"Large resolution" = meaningless
"Fine resolution" or "Highly resolved"
= well - resolved.

Spatial resolution can be DEGRADED by

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

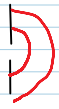


- Bad focus: is circle of confusion > pixel?

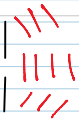


- Diffraction effects if lens aperture or pixel size < λ wavelength of light

λ >d
woofers



λ < d
tweeters,
Beamy
effect



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!

"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.

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.

Time resolution

Shutter nomenclature:

2 = 1/2 sec, 20 = 20 1/20th sec etc.

2" = 2 sec

T = time = actuate open, actuate closed

B = bulb = open as long as actuated. Rare now.

To change exposure,

lighten image, overexpose compared to AE suggestion +++

Darken, underexpose compared to AE, -----

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.

If long shutter is needed, might be too much light. Try a

NDF = Neutral Density Filter. Neutral = all wavelengths equally. Gray.

NDF 1 = 1 /10 light transmission.

NDF 2 = 1/100 etc. Log scale.

http://en.wikipedia.org/wiki/File:Strickland_Falls_Shadows_Lifted.jpg

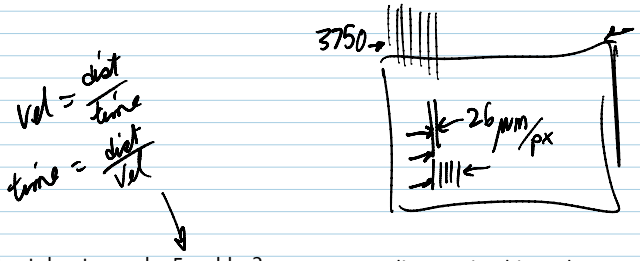
30 seconds. NDF 8x

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.

Example:
Field of view = 10 cm
Fluid moving at 0.5 m/s
10 Mpx sensor

Minute paper: what shutter speed will 'freeze' this flow?



Can tolerate maybe 5 px blur?
10 Mpx ~ 3750 X 2750
0.1 m / 3750 = 2.6 e-5 = 0.000026 m/px = 26μm/px
5 px = 1.3 e-4 m = 0.00013 = 0.13 mm estimated acceptable object displacement *x*
time *t = x/velocity*
1.3e-4 m / (0.5 m/s) = 2.6e-4 seconds
2.6e-4 sec = .00026 sec = 260 μsec= 1/3750 Very short. Can your camera do this?
5/3750 = 0.0013 = 0.13% of image width

distance in object plane

Do this analysis for each image. Motion blur is surprisingly common and annoying.

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

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.

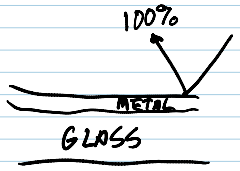
Other brands seem harsh. Rub just until dry, don't rub without moisture present. Check with another breath. Repeat if needed.

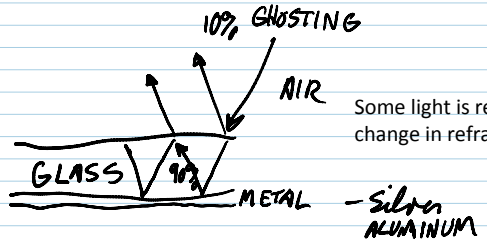
3. If you have a stubborn residue, escalate the solvents. Use isopropyl (rubbing) alcohol next. 70% is OK. Then move to methanol if needed. Acetone as a last resort.

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

First surface mirror				Second surface mirror
				Common household mirrors





Some light is reflected at every change in refractive index