

Today:

- Review exposure
- Resolution
 - Spatial
 - Temporal

Monday will talk about Measurand, aka Dynamic range

Admin: What to do about unprofessional work behavior? Gentle nagging has not been effective

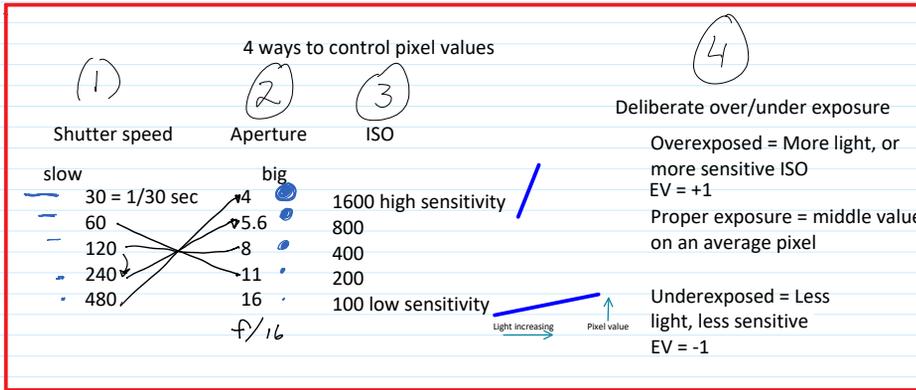
- Missed deadlines,
- Critique absences
- incorrect Flowvis.org posting
 - wrong dates,
 - no featured image or wrong post type,
 - Videos missing title, author and/or music credits
- Canvas: no archival format or original image on Canvas.
- Poor team behavior (not responding to meeting requests, missing meetings)

Want course to be a joy to all, but require cooperation and professional behavior to make it all work. Each fussy little requirement has a purpose.

New policies, starting with Team Second submission:

- Late work will not be accepted for critique. Full 3 points must be earned at time of submission
 - Attendance at all critique sessions is expected. If you are absent during your critique slot, that's it.
 - Medical issues, family emergencies and religious holidays will be accommodated. Job interviews, sick pets, other 'more important' assignments will not. Everybody has a life to deal with and everybody has to make choices.
- Expect an email about this.

Review of Exposure Choices



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.

$$f\# = \frac{f}{D}$$

Resolution

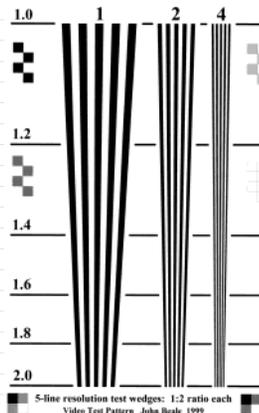
Any measurement requires 3 types of resolution: spatial, temporal, measurand (dynamic range)
Making an image is equivalent to making a measurement of light (measurand)

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



What is a decade? 10^x ; AKA order of magnitude $O(x)$
 Largest scale = whole frame, takes 3000 px.
 Smallest resolvable scale = feature that takes up 3 px or so.
 $3 \rightarrow 30$ One decade
 $30 \rightarrow 300$ 2nd decade
 $300 \rightarrow 3000$ 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?

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 μ sec? At best.
 High speed camera 30,000 fps $\sim 3 \times 10^{-5}$ sec = 30 μ 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 10^{-6} sec = 1-10 μ sec
 Pulsed laser 3×10^{-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 Canvas

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.