15.Resolution Spatial

Friday, October 23, 2020 5:36 PM

Today:

Resolution - Spatial into temporal

Learning objectives: you will be able to analyze the spatial and temporal resolution of your images. You will be able to manipulate dynamic range of color channels in an editor.

Reading Assignment in the Guidebook: Overview 4: Photography E - Resolution

Resolution

- Spatial
- Temporal

Monday will talk about Measurand, aka Dynamic range, then on to Specific Flow Vis Techniques, starting with Dyes

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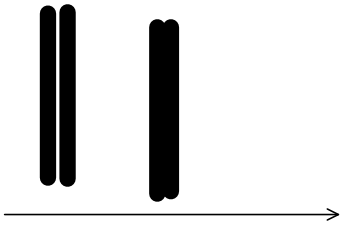
Resolution

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

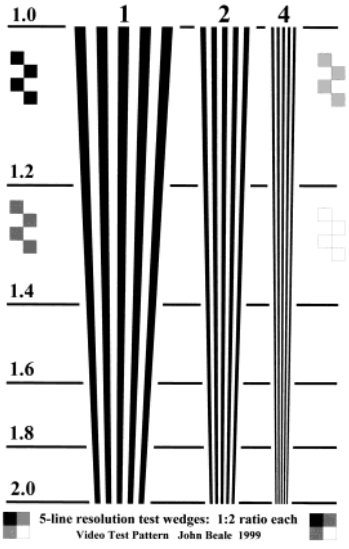
Can two adjacent things be resolved?



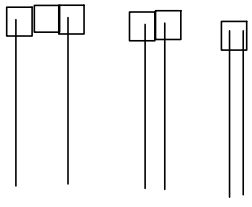
Resolution = minimum distance between two objects for them to be recognized as separate.
Applies to objects (spatial resolution)
and events (temporal or time resolution) and any quantity being measured (measurand)

Spatial resolution can be DEGRADED by

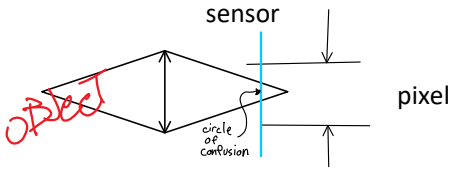
- Low contrast
- Compression artifact (in jpegs)
- ISO noise
- Bad focus
- Motion blur, interacts with time resolution
- Rastering, pixelation
- Diffraction effects



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



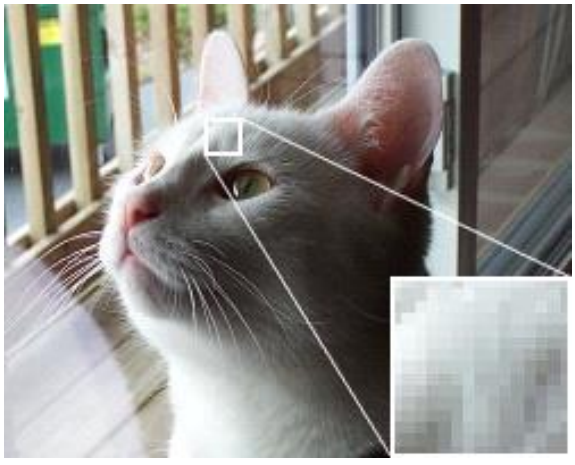
- **Bad focus: is circle of confusion > pixel?**



How to tell motion blur from bad focus?
Think, pair, share

sides of streak will be in focus.
Just being out of focus will be an overall blur.

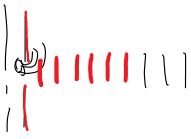
- **Rastering, pixelation**



https://en.wikipedia.org/wiki/Pixelation

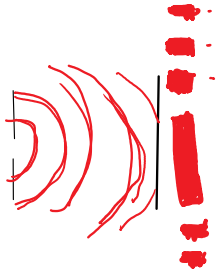
- **Diffraction effects if lens aperture or pixel size < λ wavelength of light**

D > λ
tweeters,
Beamy effect, sharp focus



Double slit

D < λ
woofers, relatively small aperture



fuzz from interference effects

Example: https://luminous-landscape.com/understanding-lens-diffraction/
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!

Homework results: F/ for best sharpness.
1/4 said smallest aperture
2/3 said medium aperture
Rest said large aperture

Many had cell phones, aperture fixed.

Zoom question: 3/4 said zoomed in best macro

'Full Frame' DSLR: sensor size is ~35 mm
~ $1000
Often more MPx (35?), and larger sensor has less diffraction effects

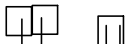
For comparison:
Human eye resolution, 74 to >500 Mpx, depending on how you count.
http://www.clarkvision.com/articles/eye-resolution.html

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 (computational fluid dynamics, simulations of fluid flows):
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

Short answer clicker: In your IV1 image, how many decades of length scale was in your



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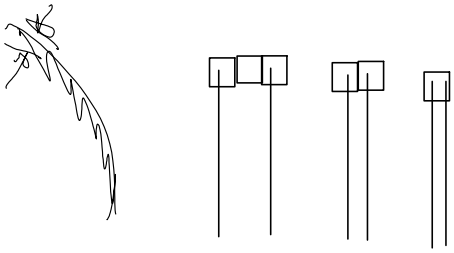

Short answer clicker: In your IV1 image, how many decades of length scale was in your **flow**? Groups/Breakout rooms; share your image and discuss scales in everybody's image.

1) Is there a sharp boundary in the flow that only takes up one or two pixels in the image.
2) Are all the scales of interest in the flow well-resolved in the **image**?In other words, was your flow spatially resolved?
3) What was the major effect that degraded the resolution?