17. Resolution 3: Measurand

Wednesday, October 28, 2020 3:55 PM

Today :

Admin
Finish motion blur calculation
Measurand resolution
Dye Techniques

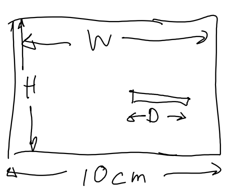
Admin:

- On Flowvis.org, edit your post date to be October X 2022, with X = your team number. This way your team's posts will appear together on the gallery and collections pages.
- Reading assignment in Guidebook: Boundary Techniques and Dye Techniques 1

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

Groups/Breakout rooms: will 1/1000 sec shutter speed 'freeze' this flow? How many pixels will motion blur be? Calculate on group whiteboard please. Save for discussion; available from annotate tools.

FLOW V = .05 m/s
Distance D = V × SS = 0.5 m/s × $\frac{1}{1000}$ sec = .0005 m
D = .05 cm Streak length
D = ? in px ⇒ $\frac{px}{cm\ IRL}$
W = pixel width = 5184 Google
W × H = 18 × 10^6 px
Aspect ratio $\frac{W}{H} = \frac{3}{2}$ APS-C sensor
H = $\frac{2}{3}$ W
W = $\sqrt{(\frac{3}{2})(18\times10^6)}$
= 5196



Conversion factor
$\frac{5196\ px}{10\ cm} = \frac{?\ px}{.05\ cm}$
D = 25 px

Flow = .5 m/s
.5 m/s × $\frac{1}{1000}$ sec = .0005 m
= streak length

Given: 18 Mpx = W × H
FOV = 10 cm
shutter = $\frac{1}{1000}$ sec = t
B = Blur = 25 px

Flow = .5 m/s

$.5\ m/s \times \frac{1}{1000}\ sec = .0005\ m$

$.05\ cm$ = streak length = distance object moved

6k × 3k

object: $\frac{10\ cm}{6000\ px} = 1.67e^{-7}\ cm/px$

$\frac{.05\ cm}{1.67\ e^{-7}\ px} = 30\ px$ $\frac{30\ px}{6000\ px} = \frac{1}{200}$ of image

18 MPx ⇒ 5184 X 3456 px

In flow, particle will move $0.5\ m/s \times \frac{1}{1000}\ sec$ = .5/1000=0.0005 m = .05 cm

How many pixels will it cover?

$\frac{5000\ px}{10\ cm} = \frac{?\ px}{.05\ cm}$

.05*5000/10=25.0 px = smear length.

5000 px; 10 cm FOV; 0.5 m/s for 1/1000 sec = ? pixels

Given: 18 Mpx = W × H; FOV = 10 cm; shutter = 1/1000 sec = t; B = Blur = 25 px

Assume aspect ratio standard for aps-c sensors (3 : 2)

Image width W in px?

$H = \frac{2}{3}W$

$18\ Mpx = W \times H = (W)(\frac{2}{3}W)$

$W = \sqrt{(\frac{3}{2})(18 \times 10^6)}$

W= (18e6*3/2)^.5=5,196

Google says image width of 18 Mpx image is 5184. OK, sure, because 18 Mpx is an approximation.

Now we have: 10 cm FOV; 5184 px; Blur = 25 px

How long is Blur IRL?

$\frac{B_{IRL}}{25\ px} = \frac{10\ cm}{5184\ px}$

$B_{IRL} = (10\ cm)(\frac{25\ px}{5184\ px}) =$ 10*25/5184=0.0482

Feature moved 0.0482 cm in $t = \frac{1}{1000}$ sec

$Velocity = \frac{distance}{time} = \frac{0.0481\ cm}{1/1000\ sec} = 48.1\ cm/s$

$V = 0.48\ m/s$

Do this analysis for each image; put in your report. Motion blur is surprisingly common and annoying.

Resolution in the Measurand: Light

Part 1: Dynamic range

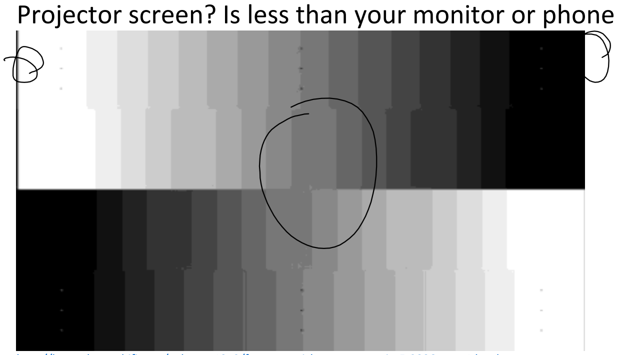
Human eye sensitivity, dark adapted ~ 800 ISO

http://clarkvision.com/imagedetail/eye-resolution.html

Human contrast range detection: 14 to 24 EV, but is dynamic.

Sheet of paper: at most 7 EV (factors of 2 in brightness) from black to white.

Projector screen? Is less than your monitor or phone screen.



http://hometheaterhifi.com/volume_13_2/feature-article-contrast-ratio-5-2006-part-1.html

What can your camera detect?

Test: image a gray card. At low ISO, see how many stops of underexposure will make it black, and how many of overexposure will make it white. Probably a total range of 6-9. Best cameras can do 14.

Part 2: Resolution=Bit Depth

This total dynamic range then gets *quantized*/digitized into steps. The more steps, the finer the resolution. (http://www.peachpit.com/articles/article.aspx?p=1709190&seqNum=2. Nice discussion of dynamic range vs bit depth)

Counting steps

Bit = off or on, 0 or 1. Binary digit.

Binary= numbers in base 2, a series of bits. 0 1 1 0 = 6 in base 10

8 4 2 1

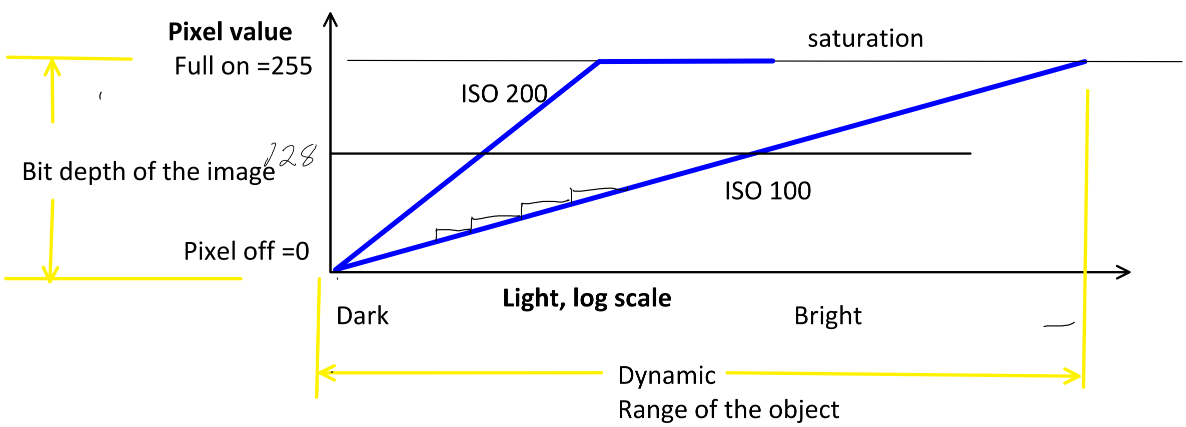
With 4 bits, can count to 2^4=16

With 8, can count to 256 = one byte

Hexadecimal: single digit goes up to 16: 0-9, then A B C D E F

16^2=256 , so can express full range of a byte in two digits.

Camera A/D is likely 10-24 bits. That's the number of different levels possible but not the range of brightnesses



HDR = High Dynamic Range

Take multiple images with varied (bracketed) exposures of the same scene, some under exposed, some over exposed. In -camera or post-processing algorithm assembles them together to provide additional measurand (light) resolution in highlight and shadow areas . Can make nighttime images look like daylight.

Here is an HDR image (made with 5 images from -3 to +3 EV) by Phil Nystrom 2018.

The word *pixel* is based on a contraction of *pix* ("pictures") and *el* (for "element");

Pasted from <http://en.wikipedia.org/wiki/Pixel>

On a screen, = 1 red, 1 blue, & 1 green light emitter.

In editing software, access them separately in *color channels*

i.e. can control all blue pixels by themselves

RGB is a common color space, good for screens. http://en.wikipedia.org/wiki/File:Closeup_of_pixels.JPG
CMYK (Cyan, Magenta, Yellow and blacK is another color space, good for printing

R,G,B = 0,0,0 = black, off.
R,G,B, = 255, 255, 255 = all full on = white (8 bits = 2^8 = 256 possible levels)
R,G,B = 0,0, 256 = blue

FFFFFF = full white in hexadecimal, one digit can count to 16; 0-9, then a-f
0000FF= blue
808080=gray

Color channels
- Red channel: Can address just the red elements in all the pixels. See histograms, adjust range and contrast

Suggested experiment:
Test the dynamic range of your camera: take images of a gray card. At low ISO, see how many stops of underexposure will make it black, and how many of overexposure will make it white. Probably a total range of 6-9. What happens at high ISO?

SPECIFIC FV techniques

Boundary techniques. Boundary between 'seeded' and unseeded fluid.

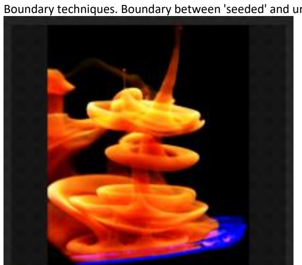


Figure 1: Dyed mineral oil injected into clear mineral oil forms layers of vortex rings. Jacob Varhus, Get Wet, Spring 2013

So here's how this section on boundary techniques is organized

- Dye (Molecular) Techniques
  - How to ensure the dye does NOT disturb the flow
  - How to make the dye show up – to have HIGH VISIBILITY. We'll have to talk about how light interacts with matter in general, and then how those interactions can be tweaked to make the best of our boundary techniques. We'll come back to the light/matter physics a few more times later, in the context of other techniques.
  - Glowing fluids: special techniques we can do with other molecular markers, specifically what happens with fluids that end up *emitting* light; still a boundary technique, but with flames!
- Particle Techniques
  - Particle physics: flow and light
  - Particles for seeding air
  - Particles for seeding water

From <https://www.flowvis.org/Flow%20Vis%20Guide/boundary-techniques-intro/>

Group Minute paper: How to not disturb flows with dye?