

Computational Photography HDR

Frank Dellaert
School of Interactive Computing
Georgia Institute of Technology

Many Figures from Ron Brinkmann's Book
Many figures from Debevec's paper

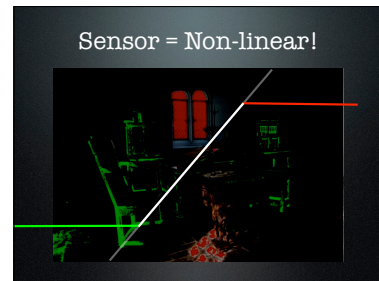
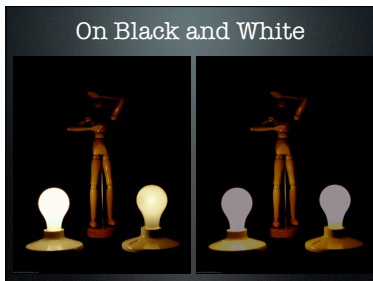


Intro

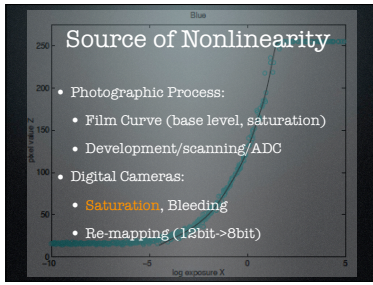
- HDR useful in many domains
- Image = "brightness"
- Rarely true radiance!!!
- unknown, **nonlinear**, mapping

Recovering High Dynamic Range Radiance Maps from Photographs

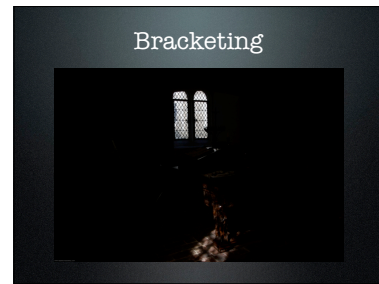
Paul E. Debevec Jitendra Malik



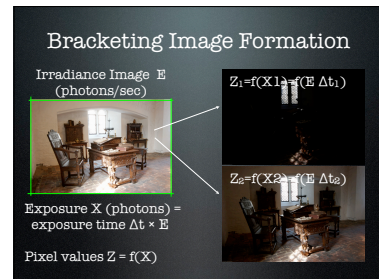
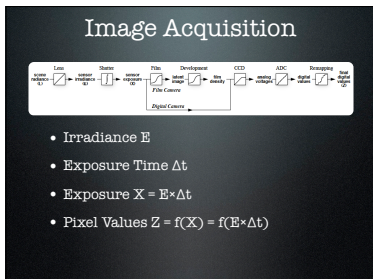
0-1 convention
 255 = 1.0, not 255/256 !
 digital brightness reduction does not do a good job



Q: How do you expose detail in shadows ?
 A: increase exposure time, increase aperture



Technique = Bracketing, E-split
 Lesson:
 white <> white !!!
 black <> black !!!



HDR Acquisition

$E = f^{-1}(Z_i) / \Delta t_i$
 Average
 $E = f^{-1}(Z_2) / \Delta t_2$

Caveats:
 • Known camera model f
 • Inverse of f does not exist for extremes
 • Treat superwhite/superblack differently

Estimating f

$$Z_{ij} = f(E_i, \Delta t_j)$$

$$f^{-1}(Z_{ij}) = E_i \Delta t_j$$

$$\ln f^{-1}(Z_{ij}) = \ln E_i + \ln \Delta t_j$$

$$g(Z_{ij}) = \ln E_i + \ln \Delta t_j$$

pM measured!
 Known!
 256 unknowns?
 1M unknowns?
 Taking the log makes time additive

My Iterative Procedure

- $f^{-1}: Z \rightarrow X$ is lookup table of size 256
- Guess f^{-1} (linear in certain range)
- Estimate E with first guess: OK result
- Re-estimate f^{-1} from (Z, X) pairs...
- Iterate until converged

Estimating f , Debevec...

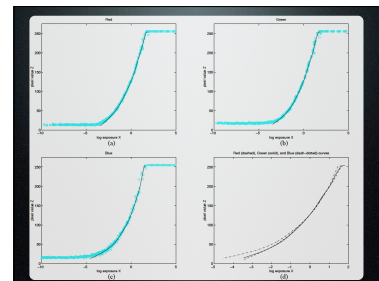
$$O = \sum_{i=1}^N \sum_{j=1}^P [g(Z_{ij}) - \ln E_i - \ln \Delta t_j]^2$$

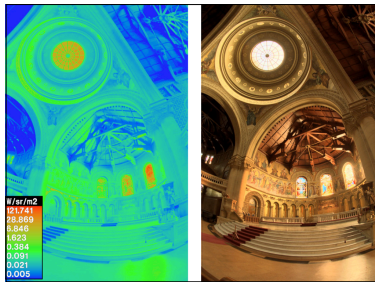
$$+ \lambda \sum_{z=Z_{min}+1}^{Z_{max}-1} g''(z)^2$$

Just linear least-squares!!!

Results from Paper

Figure 6: Seven photographs of a church interior of a long perspective from N to n stops. The one to the right behind the rightmost panel also includes a matching exposure range. The blue markers are in some of the image corners, are related to the image registration process.





Debevec HRD Examples

- <http://gl.ict.usc.edu/Data/HighResProbes/hdrvr/uffizi.html>

Hugin

- <http://hugin.sourceforge.net/>

"Floating Point" HDRI

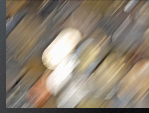
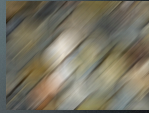
Note: the DISPLAY shows everything above 1.0 as white

Float/2

Fixed/2

HDR and FP subtly different

HDR Motion
Blur



Real vs. Fake Out-of-focus

