

What will be on the midterm?

CS 178, Spring 2014



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General information

- ◆ Monday, 7-9pm, Cubberly Auditorium (School of Edu)
- ◆ closed book, no notes
- ◆ calculators ok, but you won't need them
- ◆ on lectures and assigned chapters in London
- ◆ list of formulas will be provided on exam sheets
- ◆ practice problems in weekly assgns and sections this week
- ◆ attached are some review slides to help you study;
treat these as a non-exhaustive summary of the course
- ◆ look also at the applets and the recap slides in each lecture
- ◆ emphasis will be on the concepts behind the formulas, and
on the tradeoffs they imply for the photographer

Image formation

- ◆ the laws of perspective
 - especially natural perspective versus linear perspective
- ◆ pinhole imaging
 - tradeoff between aperture size and blur
- ◆ imaging uses lenses
 - Gauss's ray tracing construction (be able to draw it)
 - tradeoffs between focal length, sensor size, and FOV
 - changing the focal length vrs changing the viewpoint
- ◆ exposure
 - tradeoffs between aperture, shutter speed, motion blur, and depth of field (study Eddy's diagrams!)
 - tradeoffs that include ISO and noise covered later

Lenses and apertures

orange lecture slides and items
starred (*) here are fair
game for extra-credit Q's

- ◆ qualitative understanding of the approximations we make
 - geometrical optics instead of physical optics
 - spherical lenses instead of hyperbolic lenses
 - thin lens representation of thick optical systems*
 - paraxial approximation of ray angles*
- ◆ the Gaussian lens formula (know it and be able to use it)
 - changing the focal length vrs changing the subject distance
 - understand lens power and transverse magnification
- ◆ center of perspective (ignore the other thick lens terms), convex vrs concave lenses, real vrs virtual images
- ◆ depth of field formula
 - know its parts, how they vary, and the tradeoffs they imply
 - hyperfocal distance and how to use it

Practical photographic lenses

- ◆ aberrations (without the algebra)
 - be able to recognize them by a name or sketch
 - how is each one fixed? which are correctable in software?
which are reducible by stopping down the aperture?
- ◆ other lens artifacts
 - be able to recognize them by a name or sketch
 - understand the geometry of vignetting, \cos^4 falloff*
- ◆ diffraction, sharpness, and MTF (qualitatively)
 - what are they, and what factors do they depend on?
(some of this was covered in the sampling & pixels lecture)
- ◆ special-purpose lenses
 - principles (not detailed derivations) of telephoto, zoom

Autofocus (AF)

- ◆ view cameras
 - understand eliminating vanishing points
 - understanding tilting the focal plane
 - understand real versus fake tilt-shift effects
- ◆ passive autofocus techniques
 - understand the principle of phase detection
 - understand the principle of contrast detection
 - when are they used? what are the tradeoffs?
 - don't worry about the details of lenslets, ray geometry, etc.
- ◆ active autofocus techniques
 - tradeoffs between time of flight and triangulation
 - be able to manipulate the geometry of triangulation, at least for right-angle triangles

Automatic exposure metering (AE)

- ◆ what makes metering hard?
 - understand (qualitatively) the dynamic range problem
- ◆ gamma correction
 - what is it? when is it applied? what effect does it have?
 - when can you compare intensity levels in image files?
- ◆ metering technologies
 - what problems are caused by having few metering zones?
 - tradeoffs between typical shooting modes (A,P,Av,Tv,M)

Sampling and pixels

- ◆ frequency representations of images*
- ◆ resolution and human perception
 - be able to manipulate FOV, dpi, retinal arc, cycles / degree
- ◆ sampling and aliasing
 - what is aliasing? when does it happen? (especially in a camera)
 - how can aliasing be avoided? what is prefiltering?
- ◆ definition and uses of spatial convolution
 - understand the integral* and summation forms of this equation
 - be able to work out a simple convolution, like two rects
 - no calculus manipulations will be required on the exam
- ◆ sampling versus quantization
 - understand how aliasing differs from quantization artifacts

Photons and sensors

- ◆ basic concepts (qualitatively)
 - photons, quantum efficiency, blooming, smearing
 - analog to digital conversion
 - relationship of gamma correction to # of bits required
 - don't worry about ADC circuit
- ◆ how does aliasing and filtering apply to a digital camera?
 - fill factor, per-pixel microlenses, antialiasing filters
 - be able to explain how exposure time is a temporal prefilter
- ◆ color sensing technologies
 - be able to recognize them from a name or sketch
 - tradeoffs between the technologies (qualitatively)
 - what is demosaicing?

Noise and ISO

- ◆ what are the sources of noise in digital cameras?
 - be able to recognize them by a name or description
 - which ones grow with exposure time, or with temperature?
 - which ones can be fixed in software?
 - benefit of downsizing an image or averaging multiple shots
- ◆ signal-to-noise ratio and dynamic range
 - be able to apply the formulas correctly (we'll give you a list)
- ◆ ISO
 - what is it, and how is it implemented in digital cameras?
 - tradeoffs between ISO and noise (study Eddy's diagram from the image formation lecture!)

Image stabilization (IS)

- ◆ what are the causes of camera shake?
 - and how can you avoid it (without having an IS system)?
- ◆ treating camera shake as a 2D convolution of the image
 - understand the geometry of this approximation
- ◆ image stabilization systems
 - be able to define mechanical, optical, electronic IS
 - understand the principles of lens-shift vrs sensor-shift IS
 - understanding the ray geometry in detail is not required
 - how much does stabilization help?
 - what is lucky imaging, and how can a photographer use it?

List of important formulas (will be replicated on exam sheets)

$$N = \frac{f}{A}$$

$$D_{TOT} \approx \frac{2NCU^2}{f^2}$$

$$\frac{x_i}{x_t} = \frac{\sin \theta_i}{\sin \theta_t} = \frac{n_t}{n_i}$$

$$U \geq \frac{f^2}{NC} \triangleq H$$

$$\frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{f}$$

$$SNR \text{ (dB)} = 20 \log_{10} \left(\frac{\mu}{\sigma} \right)$$

$$M_T \triangleq \frac{y_i}{y_o} = -\frac{s_i}{s_o}$$

$$SNR = \frac{\mu}{\sigma} = \frac{P Q_e t}{\sqrt{P Q_e t + D t + N_r^2}}$$

$$FOV = 2 \arctan (h / 2f)$$

$$DR = \frac{\text{saturation level} - D t}{\sqrt{D t + N_r^2}}$$