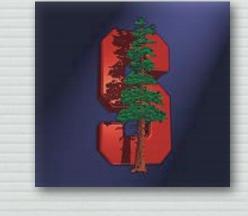
What will be on the midterm?

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

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- 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, cos⁴ 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

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• 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?

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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

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- 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)

$$N = \frac{f}{A} \qquad D_{TOT} \approx \frac{2NCU^2}{f^2}$$
$$\frac{x_i}{x_t} = \frac{\sin\theta_i}{\sin\theta_t} = \frac{n_t}{n_i} \qquad U \ge \frac{f^2}{NC} \triangleq H$$

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

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

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

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

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

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

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