What will be on the midterm?

CS 178, Spring 2009

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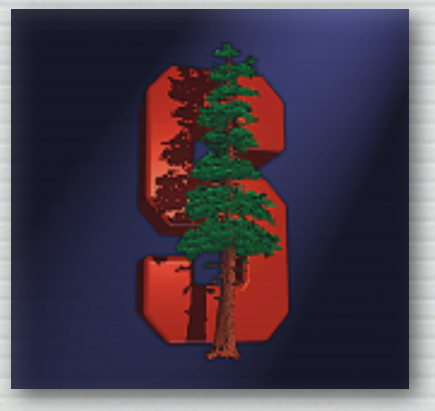

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Image formation

- the laws of perspective
  - especially natural perspective versus linear perspective
- pinhole imaging
  - tradeoffs between sensor distance, FOV, and light intensity
- 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

*optional material is 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)
  - don't worry about Lensmaker's or Newton's formulae
  - understand transverse magnification (longitudinal is optional)
- center of perspective (ignore the other thick lens terms), convex vrs concave lenses, real vrs virtual images optional*
- 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?
- other lens artifacts
  - be able to recognize them by a name or sketch
  - understand the geometry of vignetting, including $\cos^4$ falloff
- diffraction, sharpness, and MTF (qualitatively)
  - what are they, and what factors do they depend on?
- special-purpose lenses
  - principles (not detailed derivations) of telephoto, zoom
  - view camera: removing vanishing points, tilting the focal plane

Sampling and pixels

- human field of view and spatial acuity
  - be able to manipulate FOV, dpi, retinal arc, cycles / degree
  - what is vernier acuity, and how does it affect acuity?
- sampling and reconstruction
  - what is aliasing? when does it happen? how can it be avoided?
  - what is reconstruction error? how does it differ from aliasing?
  - raising the sampling rate vrs prefiltering vrs postfiltering
- 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

Photons and sensors

- basic concepts (qualitatively)
  - photons, quantum efficiency, blooming, smearing
  - sampling vrs quantization, analog to digital conversion
  - don't worry about circuits, depletion regions, bandgaps, etc.
- how does spatial convolution map 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)

Autofocus (AF)

- active autofocus techniques
  - tradeoffs between time of flight and triangulation
  - be able to manipulate the geometry of triangulation, at least for right-angle triangles
- 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.

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 mechnical, 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?

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?
- 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!)
- what is denoising and what are some ways to do it?
  - benefit of downsizing an image or averaging multiple shots

Automatic exposure metering (AE)

- what makes metering hard?
  - understand (qualitatively) the dynamic range problem
- gamma, gamma correction, and quantization
  - are gammas of cameras, displays, humans < 1.0 or > 1.0?
  - visual effect of performing (or not) gamma correction
  - relationship of gamma transforms to # of bits required
- metering technologies
  - what problems are caused by having few metering zones?
  - tradeoffs between typical shooting modes (A,P,Av,Tv,M)
  - why is handheld metering independent of object distance?
- high dynamic range (HDR) imaging
  - how do artists solve the tone mapping problem?