Vision Review: Miscellaneous

Course web page:

www.cis.udel.edu/~cer/arv

Announcements

- Homework 2 due today by midnight. Remember to submit just one file, with your name in the filename.
- Project proposal due Thursday; meet with me first
- Thommen Korah & Bill Ulrich will present "Automatic Mosaic Creation of the Ocean Floor" on Thursday—you should have read it by then

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Computer Vision
Review Outline

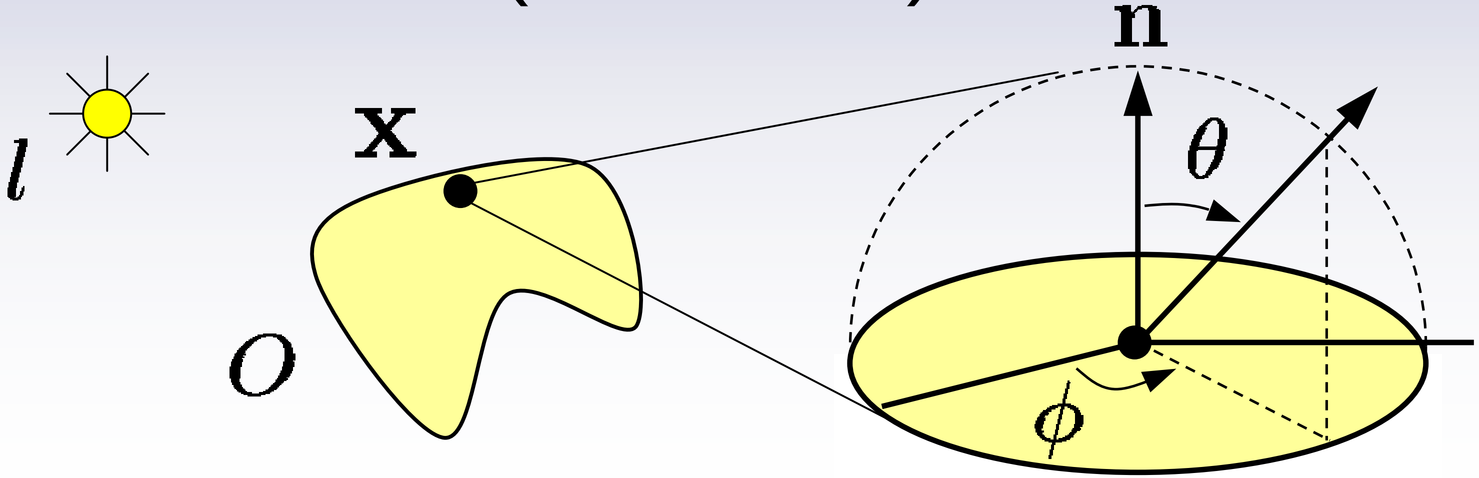
- Image formation
- Image processing
- Motion & Estimation
- Classification
- **Miscellaneous**

Outline

- Radiometry
  - Image formation explained location of scene point in image, but what about its intensity?
- Sampling
  - Moving from the continuous to the discrete

Radiometry

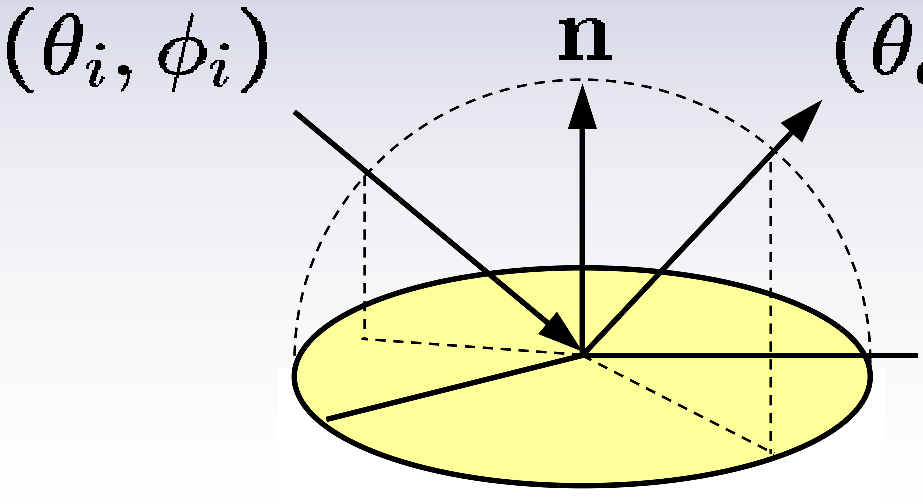
- **Radiance** L: Energy at a point in space in a given direction, foreshortened ($Wm^{-2}sr^{-1}$)
- **Irradiance** E: Arriving light from all directions (Wm^{-2})



BRDF

- Bidirectional Reflectance Distribution Function (BRDF): Ratio of energy radiated in one direction to energy received in another

$$f(\theta_i, \phi_i, \theta_e, \phi_e) = \frac{\delta L(\theta_e, \phi_e)}{\delta E(\theta_i, \phi_i)}$$



BRDF Properties

- Generally, only difference between incident and emitted angles is significant
  - Dependence on absolute $\phi \rightarrow$ *Anisotropy*
- Lambertian (matte):

$$f(\cdot) = \frac{1}{\pi}$$

- Specular (shiny):

$$f(\cdot) = \frac{\delta(\theta_e - \theta_i)\delta(\phi_e - \phi_i - \pi)}{\sin\theta_i \cos\theta_i}$$

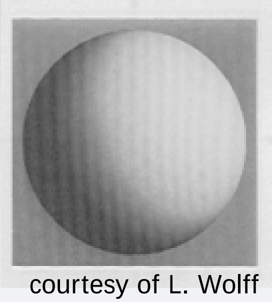
Image Irradiance

- Assume that *Scene radiance = Image irradiance:* $E(\mathbf{x}_{im}) = L(\mathbf{x}_{cam}) = L(\theta_e, \phi_e)$
- Lambertian surface:
  - Point light source: $L(\theta_e, \phi_e) = I_0 \cos\theta_s / \pi$

    total illumination of patch — light source direction

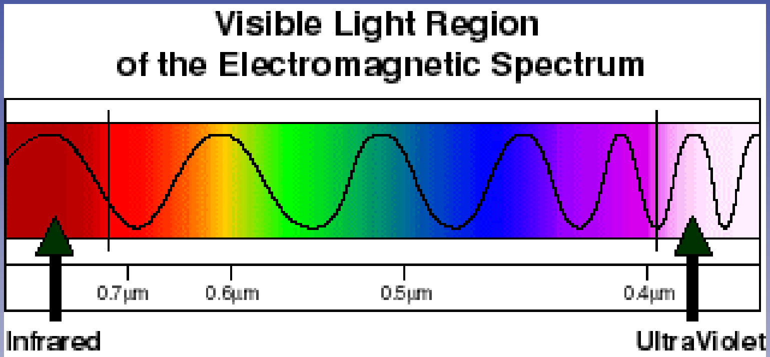
    - Brightest where **n** aligned with light direction
  - Uniform light: $L(\theta_e, \phi_e) = I_0$
- Specular reflectance:

$$L(\theta_e, \phi_e) = I(\theta_e, \phi_e - \pi)$$


courtesy of L. Wolff

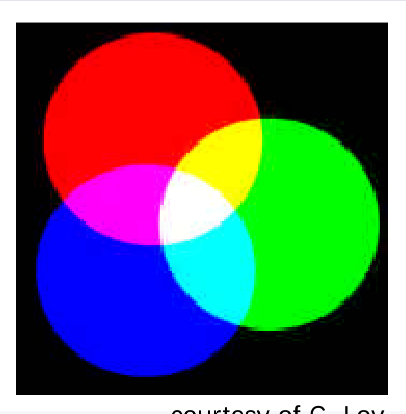
- Applications: Shape from shading, etc.

Color



courtesy of NASA

- Radiance, irradiance, BRDF are all actually wavelength dependent
- Trichromacy: Where do R, G, and B come from?
  - Additive mixing of a few *primary* colors matches many arbitrary colors well
  - In a sense, RGB space is a PCA-reduced-dimension version of true color space, where data is from natural world



courtesy of G. Loy

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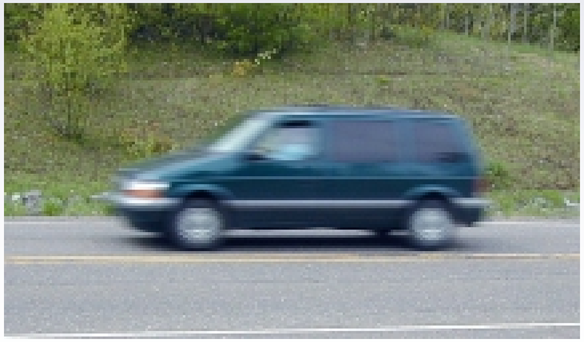
Analog → Digital

- Sampling: Limited spatial resolution of capture devices results in visual artifacts (i.e., aliasing)
  - Nyquist theorem: Must sample 2x highest frequency component of signal to reconstruct adequately
- Quantization → Banding
- Limited dynamic range → Clipping
- Temporal integration → Motion blur
- Noise



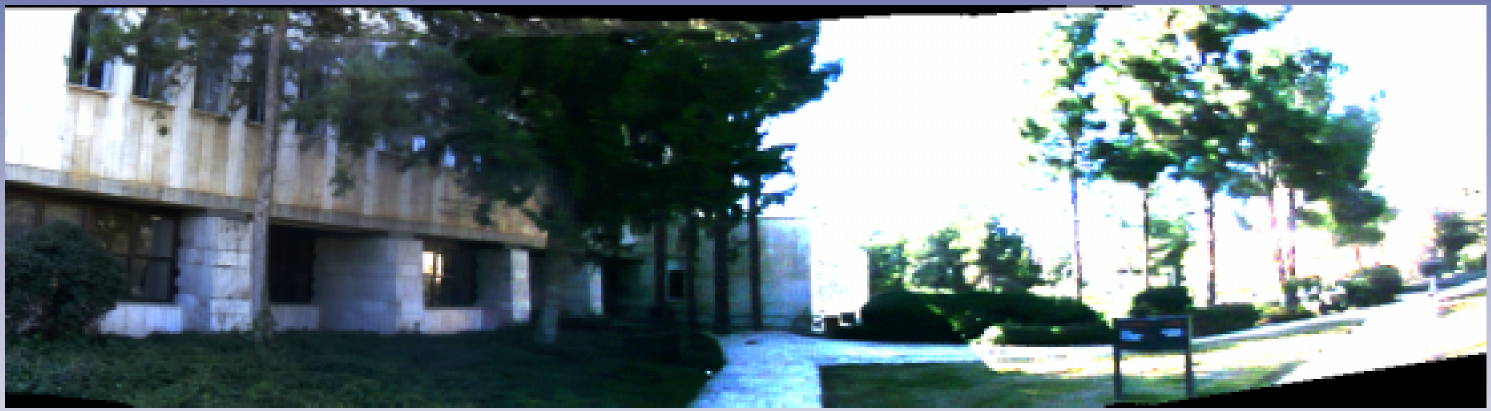
1/30th sec. exposure

Multi-sampling

- Image mosaics provide a way to overcome some sampling issues through multiple views of scene points
  - Different exposures $\rightarrow$ High dynamic range
  - Subpixel registration $\rightarrow$ Super resolution

High Dynamic Range Panoramas

Under- and over-exposed mosaic



HDR mosaic

courtesy of D. Lischinski

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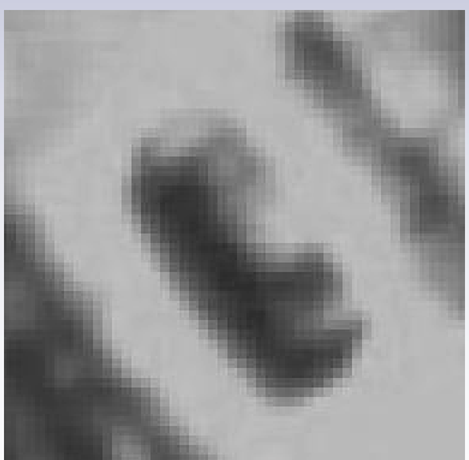
UAV-based Mosaicing

courtesy of S. Srinivasan

Super-Resolution from a UAV



Normal

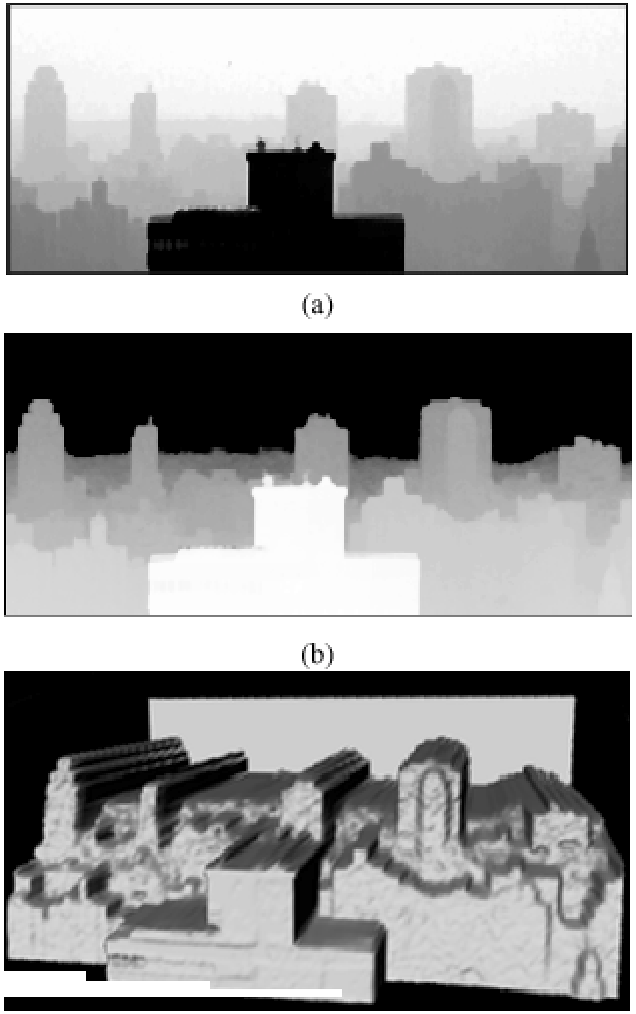
Super-resolved

courtesy of
S. Srinivasan

Medium

- Vacuum is generally assumed
- Scattering, haze can have important effects
  - Attenuation
  - Airlight
- Medium’s light absorption may affect color perception, refraction may affect perceived geometry, etc.

Depth from Airlight



(a)

(b)

(c)

from Nayar
& Narasimhan