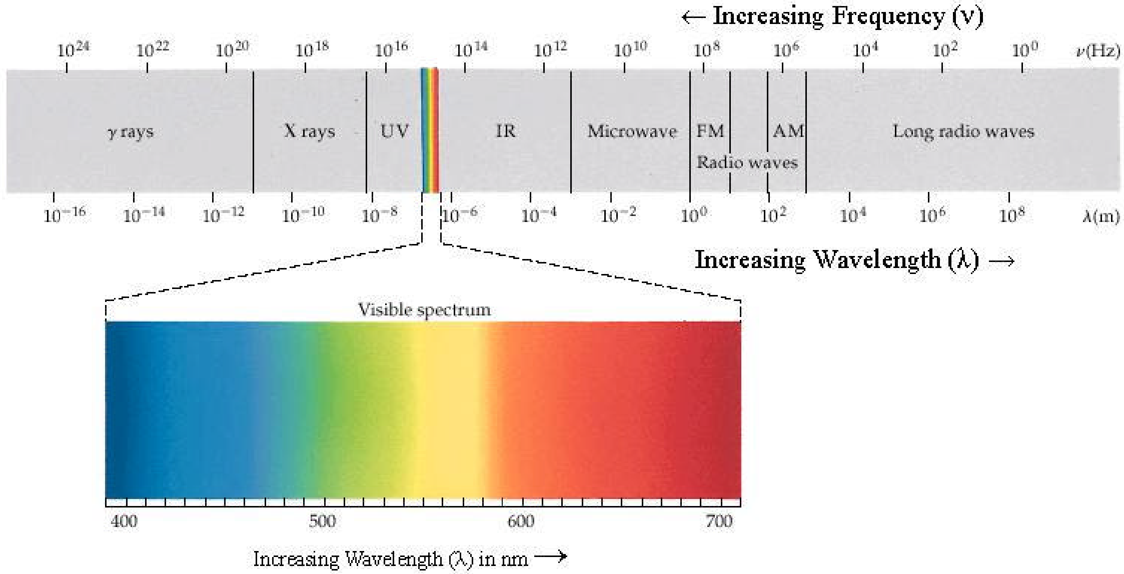
CS 563 Advanced Topics in Computer Graphics
Color and Radiometry

by Robert W Martin

What Is Color?

- Human perception of electromagnetic spectrum
- Human-visible region is ~380nm – 740nm range
- Different wavelengths → different colors



The Importance of Color

- Driving force behind rendering
- Renders are very boring without color

No Color...

... or Color?

- Photorealism → accurate color reproduction

Representing Colors

- RGB Color → additive color mixing
- CMYK Color → subtractive color mixing
- HSV Color → used often in art, more natural
- HSL Color → differentiates ‘brightness’ from ‘lightness’

Color in Nature

- Color propagation through space
  - Photons zip through space
  - Bounce off of things
  - Energy → wavelength, frequency
- Color-space encoding vs. EM radiation
- GPU-based realtime rendering vs. Photorealistic rendering
- Color “encoded” in photons, not bits
- This allows for more realism/effects

Sources of Color

- Specular reflection
- Diffuse scattering
- Absorption
- Variances create illusion of "color"
- Emission of light
  - Heat → incandescence
  - Chemicals → chemoluminescence
  - Absorb and Reflect → fluorescence & phosphorescence

Colors in PBRT

- Spectral Power Distribution (SPD)
  - Amount of light at each wavelength
  - Basis Function: 8 -dimensional space maps to low-dimensional space of coefficients
  - PBRT uses 3 samples of visible spectrum
- SPD colors are better for simulating "real light" → higher realism
- Convert SPD → XYZ color for film processing

Radiometry

- Set of ideas/rules that govern light propagation
- Based on light particles, not waves
- Certain limitations due to this
- Geometric optics → light/object interaction at the macroscopic level
- Quantum mechanics → light/atom interaction

PBRT Radiometry

- PBRT assumes Geometric optics are sufficient
- Radiometric assumptions of PBRT
  - Linearity
  - Energy Conservation
  - No polarization
  - Steady state
  - No phosphorescence/fluorescence
- Lack of certain effects due to these assumptions

Radiometric Quantities

- Radiant Flux (F)
  - Amount of energy passing through a region per unit time (joules / second, Watts)
- Irradiance (E)
  - Area density of Flux (Watts / meter^2)
- Intensity (I)
  - Flux density per solid angle
- Radiance (L)
  - Flux density per unit area, per solid angle

Radiance Functions

- Incident Radiance Function
  - Distribution of arriving radiance at the point
  - L_i (p, ?)
- Extant Radiance Function
  - Distribution of departing radiance at the point
  - L_o (p, ?)
- In general, L_i (p, ?) ? L_o (p, ?)
- At a point in space with no surface & no participating media, L_i (p, ?) = L_o (p, -?)

Surface Reflection

- BRDF → Bidirectional Reflectance Distribution Function
- Relates the Extant Radiance Function and the Incident Radiance Function
- BTDF → Bidirectional Transmittance Distribution Function
- Describes distribution of transmitted light
- BSDF → Bidirectional Scattering Distribution Function

Surface Reflection

- $L_o(p,?_o) = ?_{S^2} f(p,?_o,?_i)\, L_i(p,?_i)\, |\cos ?_i|\, d?_i$
- Fundamental to rendering
- Transform incident distribution → extant distribution based on the surface of reflection
- Often called *scattering equation*

References

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